
**Mapping a Bounded Scopus Corpus on STEAM-Related Learning Processes: A
Bibliometric Analysis (2015–2026)**

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ABSTRACT

This study maps the development and thematic structure of a bounded Scopus corpus on STEAM-related learning processes through bibliometric analysis. Data were retrieved from the Scopus database on March 26, 2026, using a predefined TITLE-ABS-KEY search strategy restricted to English-language journal articles in the final publication stage. The final corpus consisted of 115 documents published between 2015 and 2026. The analysis combined performance indicators and author-keyword co-occurrence analysis to examine publication growth, leading countries, affiliations, sources, productive authors, influential documents, and thematic structures within the retrieved corpus. The results show that publication output increased substantially after 2020 and reached its highest level in 2025, while the 2026 count remained provisional, as it reflected a partial publication year. The United States emerged as the leading contributor, whereas the International University of La Rioja and Universitas Negeri Jakarta were the most productive affiliations. Computer Applications in Engineering Education was the most productive source. Document-level citation analysis showed that teacher professional development, educational robotics, challenge-based learning, computational thinking, project-based learning, and technology-enhanced learning environments constitute influential foundations of the corpus. Author-keyword co-occurrence analysis identified thematic concentrations related to multilingual pedagogical practices, teacher knowledge, teacher professional development, inclusive science education, digital pedagogy, literacy development, and educational equity. These findings indicate that the retrieved corpus is characterized less by broad STEAM research in general and more by pedagogical, teacher-capacity, literacy, and learning-process-oriented issues. This study contributes a transparent bibliometric profile of a bounded Scopus corpus and demonstrates how retrieval logic influences thematic structures in bibliometric mapping.

Keywords: Bibliometric analysis; Learning process; Scopus; STEAM education; VOSviewer

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INTRODUCTION

Science, technology, engineering, arts, and mathematics (STEAM) has become an influential framework for interdisciplinary education because it seeks to connect disciplinary knowledge with creativity, design, and authentic problem-solving. In recent scholarship, STEAM is no longer



understood simply as STEM with an added artistic component; rather, it is increasingly positioned as a pedagogical orientation that supports integrative learning, creative production, and richer forms of student engagement across educational settings. Recent review studies have further shown that STEAM can broaden opportunities for meaning-making and creativity, although the depth and quality of integration still vary substantially across contexts and implementations (Aguilera & Ortiz-Revilla, 2021; Belbase et al., 2022; Rodrigues-Silva & Alsina, 2023).

Over the last five years, STEAM research has moved beyond conceptual advocacy toward more implementation-oriented inquiry. Recent studies have linked STEAM to challenge-based learning, project-based learning, robotics, instructional design, and other technology-rich learning environments, suggesting that the field is increasingly concerned with how interdisciplinary learning is enacted in practice rather than whether it should be adopted in principle. This shift also reflects growing interest in learning designs that combine real-world relevance, collaboration, and creative problem solving across disciplinary boundaries (Conde et al., 2021; McLure et al., 2022; Halawa et al., 2024).

Despite this expansion, an important conceptual tension remains unresolved. Recent teacher-focused research indicates that scholars and practitioners do not always share a stable understanding of what counts as STEAM, what degree of interdisciplinarity is required, or how arts integration should be operationalized in classroom practice. Likewise, recent systematic review evidence from primary education reports generally positive outcomes for students' attitudes, knowledge, and skills, while also emphasizing continuing uncertainty regarding implementation and the meaningful place of the arts within interdisciplinary learning designs. Such ambiguity matters because inconsistent definitions can weaken curricular coherence, limit comparability across studies, and make claims about the effectiveness of STEAM pedagogy more difficult to interpret (Boice et al., 2024; Yim et al., 2025).

A second issue concerns the structure of the evidence base itself. Existing syntheses have clarified several important subdomains of STEAM and integrated STEM education, but many of these contributions are thematic or pedagogical reviews rather than corpus-level mappings of publication patterns and conceptual structure. Where bibliometric studies do exist, they generally profile STEAM education at a broad level, which is valuable for identifying macro trends but leaves room for more focused analyses of bounded corpora defined by narrower retrieval logics. Such analyses are especially useful when a study aims to explain how a specific body of literature develops over time, who its leading contributors are, where it is published, and which themes dominate its internal structure (Marín-Marín et al., 2021).

Against this background, the present study examines a Scopus-indexed corpus retrieved through STEAM- and learning-process-related search terms. The study is intended to provide a transparent bibliometric profile of this bounded literature by addressing three questions: how publication output has evolved, which countries, affiliations, authors, and sources are most prominent, and what thematic clusters emerge from keyword co-occurrence patterns. Rather than claiming to represent the entirety of global STEAM scholarship, this article offers a clearly delimited mapping of a specific Scopus corpus and uses that mapping to identify current research emphases and directions for future inquiry.

Previous bibliometric studies have generally mapped STEAM education as a broad research domain and have highlighted themes such as interdisciplinary integration, creativity, engineering design, robotics, and innovation-oriented learning environments (Leavy et al., 2023; Perignat & Katz-Buonincontro, 2019; White & Delaney, 2021). However, relatively little attention has been given to literature retrieved through learning-process-oriented search strategies. Consequently, it remains unclear whether the conceptual structure of learning-process-related STEAM research resembles the broader STEAM landscape or reveals distinct thematic priorities. Addressing this gap is important because learning processes constitute the pedagogical core through which interdisciplinary STEAM principles are enacted in educational practice.

Against this background, the present study examines a bounded Scopus corpus retrieved using predefined STEAM- and learning-process-related search terms. Rather than claiming to represent the entire body of STEAM scholarship, this article offers a transparent bibliometric profile of a

clearly delimited dataset. The study addresses three questions: how publication output has evolved, which countries, affiliations, sources, authors, and documents are most prominent, and what thematic structures emerge from author-keyword co-occurrence analysis. By doing so, the study contributes not only to understanding STEAM-related learning-process literature but also to methodological discussions on how search strategy and corpus delimitation shape bibliometric findings.

METHODS

Research design

This study employed a descriptive bibliometric design to map the development, productivity, and conceptual structure of research on STEAM-related learning processes. Bibliometric analysis was selected because it enables a systematic and reproducible examination of publication trends, influential contributors, source distribution, and thematic relationships within a bounded body of literature. In line with established bibliometric practice, the study combined performance analysis and science mapping to capture both the productivity profile and the intellectual structure of the retrieved corpus (Donthu et al., 2021; Zupic & Čater, 2015).

Data source and search strategy

The data were retrieved from the Scopus database on March 26, 2026. Scopus was selected because it provides structured bibliographic metadata suitable for bibliometric analysis, including information on authors, titles, publication years, sources, affiliations, citations, author keywords, index keywords, and document identifiers. The search was conducted in the TITLE-ABS-KEY field using the following query: TITLE-ABS-KEY (“Science Technology Engineering Art AND Mathematics”) AND TITLE-ABS-KEY (“learning process”).

To ensure corpus consistency, the search was restricted to journal articles, English-language documents, and the final publication stage. These filters were applied to obtain a focused and relatively homogeneous dataset for bibliometric examination. Based on this retrieval strategy, the final corpus consisted of 115 documents published between 2015 and 2026.

Corpus Construction and Retrieval Workflow

To enhance transparency and reproducibility, the corpus was constructed using a predefined Scopus retrieval strategy based on STEAM- and learning-process-related search terms. The retrieval workflow consisted of executing the Scopus query, applying database filters for document type, language, and publication stage, exporting the dataset, and retaining the final corpus.

No manual title–abstract relevance screening was conducted after retrieval. Instead, all records meeting the predefined database retrieval criteria were retained for analysis. This approach was adopted to maximize reproducibility, allowing future researchers to regenerate the corpus directly from the reported search query and database filters.

The final dataset consisted of 115 documents published between 2015 and 2026. Because this study aims to map a bounded Scopus corpus rather than construct a manually curated representation of the field, the retrieved records were analyzed as a complete dataset.

The workflow in Figure 1 represents database-based retrieval and filtering rather than manual relevance screening. Therefore, the final corpus should be interpreted as a bounded Scopus dataset generated through the reported query and filters.

Data extraction, screening, and normalization

The records were exported in CSV format and were complemented by Scopus Analyze outputs for year, source, author, affiliation, and country. Before analysis, the dataset was screened for duplicate entries using article titles and DOI information. No duplicate records were retained in the final corpus.

To improve analytical consistency, several normalization procedures were applied. Author names were standardized using Scopus author identifiers where available in order to reduce

fragmentation caused by name variants, initials, and indexing inconsistencies. Institutional names and country labels were aligned with the Scopus Analyze outputs to preserve database-level normalization. For thematic mapping, keywords were transformed to lowercase and minor lexical variants were harmonized to reduce artificial separation between semantically similar terms. These steps were intended to improve the validity and reproducibility of the bibliometric results (Donthu et al., 2021).

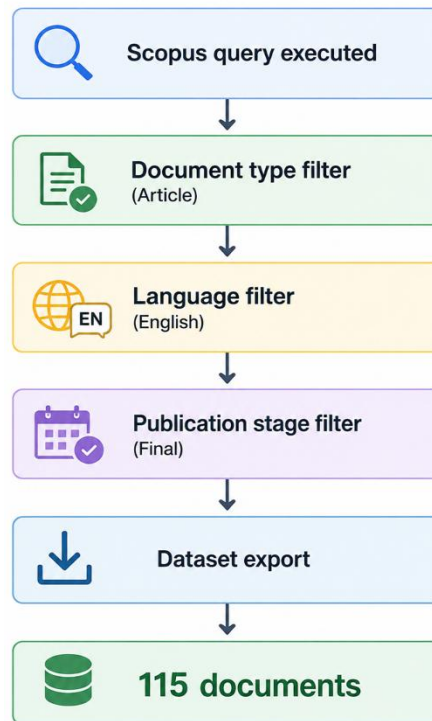


Figure 1 Retrieval workflow for constructing the bounded Scopus

Bibliometric analysis procedure

The bibliometric analysis consisted of two complementary components: performance analysis and science mapping. Performance analysis was used to identify annual publication growth, leading countries, productive affiliations, publication sources, productive authors, influential authors, and highly cited documents. Science mapping was conducted to examine the conceptual structure of the retrieved corpus through author-keyword co-occurrence analysis.

A full-counting approach was adopted in the analysis of authors, affiliations, and countries. Under this approach, each author, institution, or country represented in a publication received one full credit regardless of the number of co-authors or affiliations involved. Full counting was selected because it provides an intuitive overview of participation within the retrieved corpus. However, this method may overestimate contributions in multi-authored or multi-affiliated publications. Therefore, the resulting rankings should be interpreted as indicators of participation rather than precise measures of proportional contribution.

The overall analytical workflow adopted in this study is illustrated in Figure 2. The procedure consists of study design, data collection, bibliometric analysis, visualization, and interpretation, ensuring a systematic transition from corpus construction to thematic interpretation.

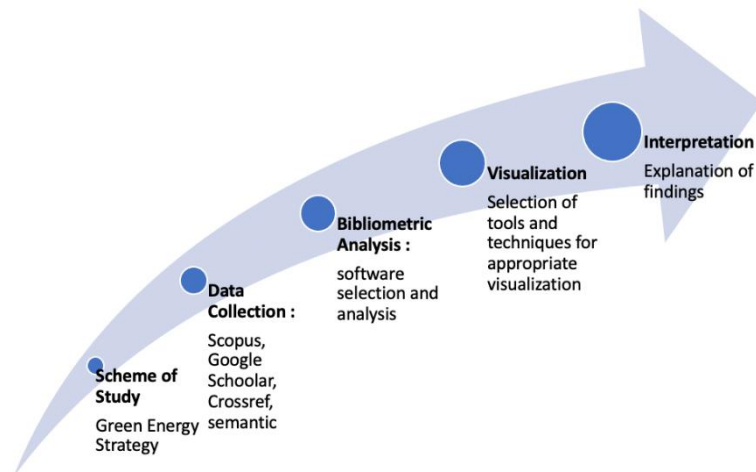


Figure 2 Bibliometric analysis workflow adopted in this study

Author-keyword co-occurrence analysis was performed using VOSviewer to identify thematic clusters and conceptual relationships among keywords. Author keywords were prioritized because they more directly represent the conceptual framing intended by the authors. The resulting network consisted of 58 keywords grouped into nine interconnected clusters. The original VOSviewer network visualization was used to support the interpretation of thematic structures in the corpus.

To complement the thematic analysis, citation-based indicators were used to identify influential authors and highly cited documents within the retrieved corpus. The integration of performance analysis and science mapping enabled the study to capture both the productivity profile and conceptual structure of the literature.

Although the analysis provides a structured overview of productivity, citation influence, and thematic configuration, it was limited to performance analysis and keyword co-occurrence mapping. More advanced techniques, such as co-authorship analysis, co-citation analysis, bibliographic coupling, thematic evolution, and overlay visualization, may provide additional insights and are recommended for future research.

Data analysis and presentation

The results were organized into two major components. First, the performance analysis described the productivity and impact profile of the corpus, including annual publication counts, top authors, leading countries, affiliations, and sources, as well as citation accumulation. Second, the science-mapping component examined keyword co-occurrence patterns to identify major thematic concentrations within the retrieved literature.

The findings were presented through narrative explanation supported by tables and figures. This combined presentation was intended to strengthen interpretive clarity by linking descriptive bibliometric indicators with thematic patterns emerging from the co-word network.

Reproducibility and limitations

To strengthen reproducibility, the study reports the database, retrieval date, search field, search string, document filters, counting method, keyword analysis procedure, and final corpus size. Such transparency is essential because bibliometric findings are highly sensitive to corpus construction, database coverage, and search logic.

The findings of this study should be interpreted within the boundaries of the retrieved corpus. Rather than representing the entirety of STEAM scholarship, the study maps a bounded Scopus corpus generated through a predefined retrieval strategy. Consequently, the thematic structure identified through bibliometric analysis reflects the characteristics of the retrieved dataset and is influenced by corpus construction and retrieval logic.

Several limitations should be acknowledged. First, the corpus was restricted to English-language journal articles in the final publication stage. This restriction improves consistency but may exclude relevant studies published in other languages, conference proceedings, book chapters, and review articles. Second, no manual relevance screening was conducted after retrieval, meaning that some records may have been included because they matched the search terms without focusing primarily on STEAM-related learning processes. Third, the use of full counting may overestimate contributions in multi-authored or multi-affiliated publications. Finally, the analysis was limited to performance indicators and author-keyword co-occurrence mapping. Future studies may address these limitations through broader retrieval strategies, curated screening procedures, and additional bibliometric techniques such as co-authorship analysis, co-citation analysis, bibliographic coupling, and thematic evolution analysis.

RESULT AND DISCUSSION

Temporal growth of the field

The annual distribution of publications shows the development of the bounded Scopus corpus on STEAM-related learning processes from 2015 to 2026 (Figure 3). Publication output remained relatively limited during the early period. Between 2015 and 2019, the number of documents fluctuated at a low level, indicating that the retrieved topic had not yet formed a stable publication stream within the Scopus corpus.

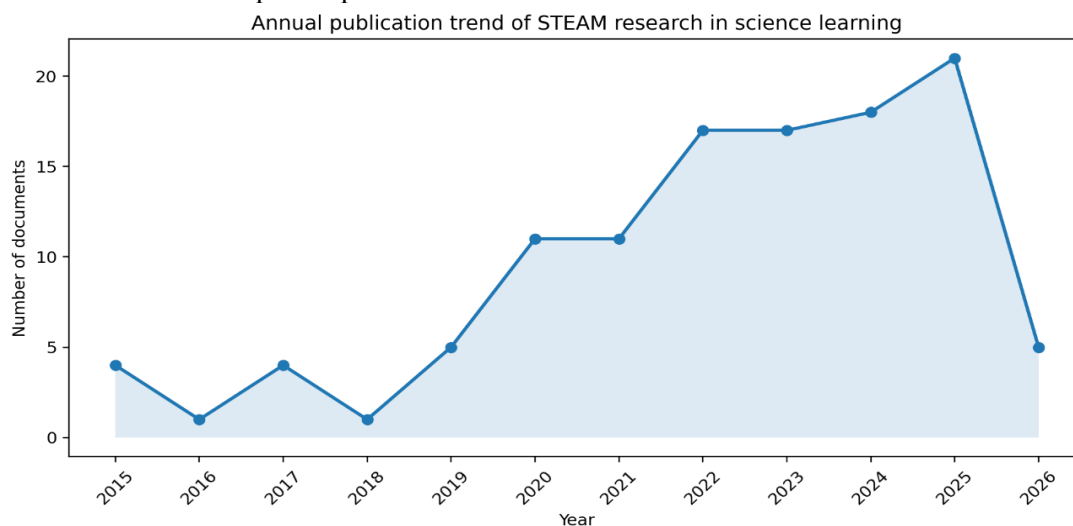


Figure 3 Annual publication trend of the bounded Scopus corpus on STEAM-related learning processes (2015–2026)

The pattern in Figure 3 suggests that literature captured through the STEAM- and learning-process-related retrieval strategy has gained increasing visibility since 2020. However, because the dataset was constructed using a predefined and bounded Scopus query, the observed growth should not be interpreted as representing the complete global development of STEAM research. Rather, it reflects the growth of documents retrieved through the specific search logic used in this study.

This distinction is important because bibliometric trends are strongly influenced by database coverage, search terms, document filters, and corpus construction decisions. Therefore, the publication trend shown in Figure 3 should be read as evidence of growth within the retrieved corpus, not as a comprehensive measure of the entire STEAM education research landscape.

In general, publications on STEAM learning have shown an increasing trend from year to year. This tendency can be explained by the fact that STEAM is no longer regarded merely as a variation of STEM, but rather as an interdisciplinary learning approach that integrates science, technology, engineering, arts, and mathematics to foster students' creativity, critical thinking,

problem-solving skills, collaboration, and innovation. In the context of modern education, the integration of the arts into STEM provides opportunities for students not only to understand scientific concepts cognitively, but also to express ideas, design solutions, and connect knowledge with real-life contexts.

Empirical support for the increasing number of STEAM publications is strongly reflected in international bibliometric studies. [Marín-Marín et al. \(2021\)](#) analyzed 1,116 manuscripts from the Web of Science database and found that studies on STEAM in education began to emerge in 2006 and continued to appear consistently throughout the period covered in their study.

Recent findings further strengthen the argument that publications on STEAM learning have experienced growth. [Nurazmi et al. \(2025\)](#), through a bibliometric analysis, reported a substantial increase in scientific output, particularly during the period from 2019 to 2024.

A similar trend was reported by [Pal et al. \(2026\)](#), who stated that annual publications on STEAM have shown a consistent increase. This indicates that STEAM has increasingly been accepted as a global research agenda, not only within the domain of curriculum theory, but also in relation to collaborative learning, teacher readiness, technology integration, creativity, sustainability, and pedagogical innovation.

Institutional, national, and source-level structure

The retrieved corpus exhibits an international but uneven distribution of contributions. At the affiliation level, the most productive institutions were International University of La Rioja and Universitas Negeri Jakarta, each contributing four documents, followed by Johannes Kepler University Linz with three documents. Other leading affiliations contributed two documents each. This pattern indicates that publication activity within the bounded Scopus corpus is relatively dispersed and not dominated by a single institutional center. The top affiliates by number of documents are listed in Table 1.

Table 1 Top affiliations by number of documents

Affiliation	Documents
International University of La Rioja	4
Universitas Negeri Jakarta	4
Johannes Kepler University Linz	3
University of Pennsylvania	2
Universidad Cardenal Herrera-CEU	2
Universidad Santo Tomas, Santiago	2
Queen's University	2
Universidad de La Serena	2
University of Toronto	2
Universidad Rey Juan Carlos	2

STEAM learning in studies involving researchers from the International University of La Rioja, also known as Universidad Internacional de La Rioja (UNIR), demonstrates a strong tendency toward the enhancement of digital literacy, computational thinking, and data-driven evaluation. [Dúo-Terrón \(2023\)](#) positions Scratch as a visual programming environment that is relevant for developing computational thinking while simultaneously connecting learning with STEM/STEAM fields. In line with this perspective, [Medina-Zuta et al. \(2023\)](#) emphasize that learning analytics, adaptive feedback, and artificial intelligence support can strengthen formative assessment in STEAM education.

Meanwhile, research from Universitas Negeri Jakarta (UNJ) reflects a more applied orientation through the implementation and testing of STEAM models within school learning contexts. [Sigit et al. \(2022\)](#) demonstrate that the integration of project-based e-learning with STEAM can improve students' mastery of ecological concepts through independent practicum activities and the creation of biogeochemical cycle animations. In the field of chemistry, [Ananda et al. \(2023\)](#) integrated Design Thinking with STEAM-PjBL to develop students' critical thinking skills, particularly through the stages of empathize, define, ideate, prototype, and test, which are

directed toward solving contextual problems. The study by [Adriyawati et al. \(2020\)](#) further reinforces these findings by showing that STEAM-PjBL on the topic of alternative energy can enhance elementary school students' scientific literacy through project-based activities that connect science, technology, engineering, arts, and mathematics.

Based on these two research tendencies, STEAM learning can be understood as an integrative approach that not only combines multiple disciplines but also builds a learning ecosystem grounded in projects, design, digital technology, formative assessment, and real-world problem solving.

At the country level, the United States appeared as the leading contributor with 21 documents, followed by Spain with 16 documents, Indonesia with 11 documents, and China with 10 documents (see Table 2). Australia and Malaysia also showed visible participation, while Turkey, Chile, Mexico, and Thailand formed a second tier of contributing countries. These findings suggest that the corpus has a broad international distribution, although research visibility remains concentrated in a limited number of national contexts.

Table 2 Top countries by number of documents

Country	Documents
United States	21
Spain	16
Indonesia	11
China	10
Australia	8
Malaysia	7
Turkey	5
Chile	4
Mexico	4
Thailand	4

These country and affiliation rankings should be interpreted as indicators of participation within the retrieved corpus rather than precise measures of proportional contribution. This is because the study used a full-counting approach, in which each country or institution represented in a publication receives one full credit. Consequently, contributions from multi-authored or multi-affiliated publications may be overestimated.

The dominance of the United States can be understood in light of its research ecosystem, which is supported by relatively well-established universities, schools, journals, and collaborative networks in the development of STEM toward STEAM. Researchers affiliated with institutions in the United States have not only produced a high number of publications but have also shaped the conceptual direction and instructional practices of STEAM education. For example, [Quigley and Herro \(2016\)](#) provided implementation-based evidence of STEAM practices in middle school science and mathematics classrooms, while [Perignat and Katz-Buonincontro \(2019\)](#) demonstrated that STEAM is largely oriented toward fostering students' creativity, problem-solving skills, and interest in STEM fields. Thus, the strong contribution of researchers from the United States does not merely indicate quantitative dominance; it also reflects their substantive role in formulating pedagogical frameworks, implementation strategies, and the global STEAM research agenda.

The source-level distribution further clarifies the publication profile of the corpus. Computer Applications in Engineering Education was the most productive source, contributing five documents. Education Sciences, Eurasia Journal of Mathematics, Science and Technology Education, Journal of Technology and Science Education, and Sustainability each contributed four documents. The presence of these sources indicates that the retrieved corpus is positioned at the intersection of educational innovation, science education, engineering education, technology-enhanced learning, and interdisciplinary pedagogy. The top sources by number of documents are listed in Table 3.

Table 3 Top sources by number of documents

Source	Documents
Computer Applications in Engineering Education	5
Education Sciences	4
Eurasia Journal of Mathematics Science and Technology Education	4
Journal of Technology and Science Education	4
Sustainability Switzerland	4
Discover Education	3
Asia Pacific Science Education	2
Frontiers in Education	2
Frontiers in Psychology	2
IEEE Transactions on Education	2

This interpretation is consistent with [Perignat and Katz-Buonincontro \(2019\)](#), who emphasized that STEAM is widely used to foster creativity, problem-solving skills, and students' interest in STEM fields through the integration of the arts, science, technology, engineering, and mathematics. Furthermore, [Quigley et al. \(2017\)](#) conceptualized STEAM as a transdisciplinary practice grounded in disciplinary integration, problem-based learning, and the development of problem-solving abilities. Similarly, [Herro et al. \(2018\)](#) demonstrated the importance of technology integration in STEAM units as an essential component of meaningful instructional design.

Overall, the institutional, national, and source-level patterns show that the bounded corpus is internationally distributed but structurally uneven. The relatively low institutional concentration suggests that STEAM-related learning-process literature captured by the search strategy is produced across multiple research settings rather than by a small number of dominant institutions. At the same time, the prominence of applied education and technology-oriented journals indicates that the corpus is closely related to pedagogical implementation, instructional innovation, and learning design.

However, these patterns should not be generalized to the entire STEAM research landscape. They reflect the structure of the bounded Scopus corpus generated through the specific retrieval strategy and database filters used in this study.

Author productivity, citation influence, and Highly Cited Documents

The author-level results reveal a clear distinction between publication productivity and citation influence within the bounded Scopus corpus. In terms of accumulated citation counts, Danielle Herro and Cassie Quigley were the most influential authors, each receiving 186 citations (see Table 4). They were followed by Natalia Reich-Stiebert and Friederike Eyssel, with 125 citations each. Other influential authors included Conde, Rodríguez-Sedano, Fernández-Llamas, Gonçalves, Lima, and García-Peñalvo, each accumulating 118 citations.

Table 4 Top authors by accumulated citations

Author	Citations
Herro, Danielle	186
Quigley, Cassie	186
Reich-Stiebert, Natalia	125
Eyssel, Friederike	125
Conde, Miguel Á.	118
Rodríguez-Sedano, Francisco J.	118
Fernández-Llamas, Camino	118
Gonçalves, José	118
Lima, José	118
García-Peñalvo, Francisco J.	118

By contrast, the productivity profile was less concentrated. Lavicza, Zsolt was the only author with three documents, whereas several authors contributed two documents each. This indicates that the corpus is shaped by a small number of highly cited contributors but does not show strong dominance by a single author or author group in terms of publication volume. The top authors by number of documents are listed in Table 5.

Table 5 Top authors by number of documents

Author	Documents
Lavicza, Zsolt	3
Videla, Ronnie	2
Aguayo, Claudio	2
Rahmawati, Yuli	2
DeLuca, Christopher	2
Dubek, Michelle	2
Rickey, Nathan	2
Montés, Nicolás	2
Barquero, Sara	2
Orcos, Lara	2

To complement author-level citation indicators: the most cited documents within the retrieved corpus were also examined. This additional analysis was conducted because author-level citation counts may be disproportionately influenced by a single highly cited publication. Document-level citation analysis therefore provides a more direct representation of the intellectual foundations shaping the corpus. The most cited documents in the retrieved corpus are listed in Table 6.

Table 6 Most cited documents in the retrieved corpus

No	Document	Year	Source	Citations
1	Exploring Teachers' Perceptions of STEAM Teaching Through Professional Development: Implications for Teacher Educators	2017	Professional Development in Education	186
2	Learning with Educational Companion Robots? Toward Attitudes on Education Robots, Predictors of Attitudes, and Application Potentials for Education Robots	2015	International Journal of Social Robotics	125
3	Fostering STEAM Through Challenge-Based Learning, Robotics, and Physical Devices: A Systematic Mapping Literature Review	2021	Computer Applications in Engineering Education	118
4	At the Dawn of STEAM Education: Prospects, Priorities, Processes, and Problems	2022	International Journal of Mathematical Education in Science and Technology	117
5	Educational Robotics in the Stage of Secondary Education: Empirical Study on Motivation and STEM Skills	2019	Education Sciences	99
6	Enhancing 21st Century Skills with AR: Using the Gradual Immersion Method to Develop Collaborative Creativity	2017	Eurasia Journal of Mathematics, Science and Technology Education	82
7	Computational Thinking Development Through Physical Computing Activities in STEAM Education	2021	Computer Applications in Engineering Education	79
8	Project-Based Learning Oriented STEAM: The Case of Micro-bit Paper-Cutting Lamp	2022	International Journal of Technology and Design Education	73

No	Document	Year	Source	Citations
9	Project Based Learning Pedagogical Design in STEAM Art Education	2020	Asian Journal of University Education	64
10	Out-of-the-Box Learning: Digital Escape Rooms as a Metaphor for Breaking Down Barriers in STEM Education	2023	Sustainability	51

The most cited documents indicate that teacher professional development, educational robotics, challenge-based learning, computational thinking, project-based learning, augmented reality, and technology-enhanced learning environments constitute important intellectual foundations of the retrieved corpus. These highly cited works show that the corpus is shaped not only by conceptual discussions of STEAM but also by applied pedagogical and technology-supported learning interventions.

Based on these data, the most cited documents indicate that the research corpus is shaped not only by conceptual discourse on STEAM, but also by applied pedagogical foundations that emphasize teacher readiness, active learning design, and the use of technology as a medium for exploration. The dominance of teacher professional development as a theme suggests that the effectiveness of STEAM largely depends on teachers' capacity to translate the integration of science, technology, engineering, arts, and mathematics into transdisciplinary classroom practices. This is consistent with [Herro and Quigley \(2017\)](#) and [Quigley et al. \(2017\)](#), who emphasize the importance of professional development and conceptual models of STEAM in enabling teachers to design problem-based, collaborative, and contextual learning. Meanwhile, the emergence of educational robotics and computational thinking reflects a shift in the corpus toward learning that goes beyond conceptual understanding to foster algorithmic thinking, problem solving, design, and artifact construction through hands-on experiences ([Benitti, 2012](#); [Lye & Koh, 2014](#)). Challenge-based learning and project-based learning further reinforce this orientation, as both position students as authentic problem solvers through investigation, group work, reflection, and the production of solutions relevant to real-life contexts ([Gallagher & Savage, 2023](#); [Kokotsaki et al., 2016](#)). In addition, augmented reality and technology-enhanced learning environments indicate that the STEAM corpus is also influenced by the need to provide stronger visualization, interactivity, simulation, and learning flexibility, particularly when abstract or complex concepts must be connected to students' concrete experiences ([Akçayır & Akçayır, 2017](#); [Schmid et al., 2014](#)). Thus, this citation pattern confirms that the intellectual foundation of the corpus lies at the intersection of strengthening teachers' pedagogical competence, active learning through project- and challenge-based approaches, computational thinking, and educational technology innovation. In other words, the STEAM literature retrieved through the search strategy tends to move toward learning implementation, intervention design, and the use of technology to produce learning experiences that are creative, collaborative, and oriented toward problem solving.

Thematic configuration of the corpus

To examine the conceptual structure of the retrieved corpus, an author-keyword co-occurrence analysis was conducted using VOSviewer. Unlike the previous visualization, which provided a general representation of keyword relationships, the revised analysis employed the original VOSviewer network to improve transparency and support the interpretation of thematic clusters. The resulting network consisted of 58 keywords grouped into nine interconnected clusters (Figure 4).

training alone, but rather as a professional learning process shaped by interactions among teachers, schools, and professional learning activities (Opfer & Pedder, 2011). Such development is also more effective when it emphasizes content focus, active learning, program coherence, adequate duration, and teachers' collective participation (Garet et al., 2001).

Meanwhile, the interconnection among the themes of teacher education, science education, equity, diversity, and computational thinking suggests that teacher education is increasingly oriented toward preparing educators who are able to design science learning that is inclusive, culturally relevant, and adaptive to computational literacy. This is consistent with the notion of culturally relevant pedagogy, which positions academic success, cultural competence, and critical consciousness as integral elements of teaching practice (Ladson-Billings, 1995), as well as with the importance of equipping teachers with computational thinking knowledge so that they can integrate it into elementary and secondary education (Yadav et al., 2014; Voogt et al., 2015). The emergence of digital pedagogy and instructional competence further emphasizes that contemporary teacher competence involves not only mastery of content and pedagogy, but also the ability to integrate technology meaningfully through the technological pedagogical content knowledge/TPACK framework (Mishra & Koehler, 2006).

The smaller clusters related to language learning, multiliteracy, literacy practices, the science of reading, pandemic-related educational challenges, and pedagogical adaptation further show that the corpus also responds to the expansion of literacy concepts and the dynamics of learning crises. Multiliteracies emphasize that literacy should be understood within social, cultural, and multimodal contexts (The New London Group, 1996), whereas the science of reading calls for literacy practices grounded in scientific evidence (Petscher et al., 2020). At the same time, the pandemic experience has reinforced the need for pedagogical adaptation, particularly in the transition to online learning and in the strengthening of flexible learning design (Carrillo & Flores, 2020). Thus, the thematic structure indicates that the mapped literature moves at the intersection of teacher education, educational equity, science learning, literacy, and digital transformation, suggesting that the intellectual core of the corpus can be interpreted as an effort to strengthen teachers' capacity to teach in ways that are inclusive, evidence-based, and responsive to changing educational contexts.

Integrated discussion

Across the different indicators, three broader patterns emerge. First, the corpus shows sustained growth, especially after 2020, indicating that STEAM-related learning process research has moved beyond an exploratory phase and is now producing a more regular stream of scholarship. Second, the field is international but structurally uneven. The contribution base spans multiple countries and institutions, yet output is still concentrated in a limited number of national contexts and journals. Third, the conceptual structure shows a field that is simultaneously stabilizing and diversifying: while core terms such as STEAM and STEAM education remain central, the surrounding literature increasingly engages with project-based pedagogies, immersive technologies, inclusion, creativity, and artificial intelligence.

The present study does not demonstrate the universal structure of all STEAM scholarship; rather, it profiles a specific Scopus corpus produced by a bounded search strategy. Nevertheless, the internal consistency across publication growth, source profile, author structure, and keyword clustering strengthens the interpretation that the retrieved literature is moving toward more applied, design-intensive, and pedagogically explicit forms of inquiry. In this sense, the bibliometric evidence does not simply show that the field is growing; it shows how it is growing, where it is being published, and which thematic directions are becoming more visible.

These findings also clarify the contribution of the present study relative to prior reviews. The value of this analysis lies not in claiming exhaustive coverage but in making the internal structure of a clearly delimited corpus visible and interpretable. By showing the relationship between productivity, influence, outlet concentration, and thematic clustering, the study provides a more integrated account of the retrieved literature than would be possible through descriptive reporting alone. This is precisely where bibliometric analysis becomes most useful for manuscript-level

scholarship: it does not replace systematic review logic but complements it by identifying structural tendencies that can guide more focused substantive reviews in the future.

Implications for future research

The findings suggest several directions for future research. First, broader search formulations are needed to capture studies indexed under acronym variants such as STEAM, STE(A)M, and integrated STEM/STEAM. Second, future bibliometric work should move beyond performance indicators and keyword co-occurrence to examine collaboration networks, co-citation structures, and bibliographic coupling, which would provide a stronger account of how intellectual communities and research fronts are formed. Third, comparative analyses across databases would help determine whether the patterns observed here are robust across indexing systems or partly shaped by database-specific coverage. Finally, a more focused substantive review of the dominant thematic clusters identified here would help clarify how learning processes are conceptualized and assessed across different STEAM implementations.

CONCLUSION

This study mapped the development and thematic structure of a bounded Scopus corpus on STEAM-related learning processes published between 2015 and 2026. Using bibliometric analysis, the study examined publication growth, country and institutional contributions, publication sources, author productivity, citation influence, highly cited documents, and thematic structures derived from author-keyword co-occurrence analysis.

The findings revealed a noticeable increase in publication output after 2020, indicating growing scholarly interest in literature associated with STEAM-related learning processes. The United States emerged as the leading contributing country, while International University of La Rioja and Universitas Negeri Jakarta were the most productive affiliations. At the source level, Computer Applications in Engineering Education contributed the largest number of publications within the retrieved corpus.

Citation analysis demonstrated that teacher professional development, educational robotics, challenge-based learning, computational thinking, project-based learning, and technology-enhanced learning environments constitute important intellectual foundations of the corpus. Meanwhile, author-keyword co-occurrence analysis revealed thematic concentrations related to teacher knowledge, multilingual pedagogies, professional development, teacher education, literacy development, digital pedagogy, educational equity, and science education.

A notable finding is that the thematic structure identified in this study differs from broader STEAM bibliometric mappings that frequently emphasize engineering design, robotics, creativity, maker education, and interdisciplinary integration. Instead, the retrieved corpus is characterized more strongly by pedagogical concerns, teacher capacity development, multilingual learning, literacy, and instructional competence. These results suggest that learning-process-oriented retrieval strategies may reveal conceptual structures that differ substantially from those reported in broader STEAM education studies.

The findings should be interpreted within the boundaries of the retrieved corpus. Rather than representing the entirety of STEAM scholarship, the present study maps a specific body of literature generated through a predefined Scopus search strategy and database filters. Consequently, the identified publication trends, citation patterns, and thematic structures reflect the characteristics of the retrieved corpus and are influenced by retrieval logic, corpus delimitation, and database coverage.

This study also highlights the importance of methodological transparency in bibliometric research. The results demonstrate that corpus construction decisions can substantially shape the intellectual landscape revealed through bibliometric mapping. Therefore, future studies are encouraged to compare alternative retrieval strategies, incorporate broader document sources, and employ additional bibliometric techniques such as co-authorship analysis, co-citation analysis, bibliographic coupling, and thematic evolution analysis to obtain a more comprehensive understanding of STEAM-related learning-process research.

Overall, this study contributes a transparent bibliometric profile of a bounded Scopus corpus on STEAM-related learning processes while providing methodological insights into how retrieval logic influences the interpretation of bibliometric findings.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

- Adriyawati, A., Utomo, E., Rahmawati, Y., & Mardiah, A. (2020). STEAM-project-based learning integration to improve elementary school students' scientific literacy on alternative energy learning. *Universal Journal of Educational Research*, 8(5), 1863–1873. <https://doi.org/10.13189/ujer.2020.080523>
- Aguilera, D., & Ortiz-Revilla, J. (2021). STEM vs. STEAM education and student creativity: A systematic literature review. *Education Sciences*, 11(7), Article 331. doi:10.3390/educsci11070331.
- Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*, 20, 1–11. <https://doi.org/10.1016/j.edurev.2016.11.002>
- Ananda, L. R., Rahmawati, Y., & Khairi, F. (2023). Critical thinking skills of chemistry students by integrating design thinking with STEAM-PjBL. *Journal of Technology and Science Education*, 13(1), 352–367. <https://doi.org/10.3926/jotse.1938>
- 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. doi:10.1080/0020739X.2021.1922943.
- Benitti, F. B. V. (2012). Exploring the educational potential of robotics in schools: A systematic review. *Computers & Education*, 58(3), 978–988. <https://doi.org/10.1016/j.compedu.2011.10.006>
- Boice, K. L., Alemdar, M., Jackson, J. R., Kessler, T. C., Choi, J., Grossman, S., & Usselman, M. (2024). Exploring teachers' understanding and implementation of STEAM: One size does not fit all. *Frontiers in Education*, 9, Article 1401191. doi:10.3389/educ.2024.1401191.
- Carrillo, C., & Flores, M. A. (2020). COVID-19 and teacher education: A literature review of online teaching and learning practices. *European Journal of Teacher Education*, 43(4), 466–487. <https://doi.org/10.1080/02619768.2020.1821184>
- Chappell, K., Hetherington, L., Juillard, S., Aguirre, C., & Duca, E. (2025). A framework for effective STEAM education: Pedagogy for responding to wicked problems. *International Journal of Educational Research Open*, 9, Article 100474. doi:10.1016/j.ijedro.2025.100474.
- Conde, M. A., Rodríguez-Sedano, F. J., Fernández-Llamas, C., Gonçalves, J., Lima, J., & García-Peñalvo, F. J. (2021). Fostering STEAM through challenge-based learning, robotics, and physical devices: A systematic mapping literature review. *Computer Applications in Engineering Education*, 29(1), 46–65. doi:10.1002/cae.22354.
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296. doi:10.1016/j.jbusres.2021.04.070.
- Dúo-Terrón, P. (2023). Analysis of Scratch software in scientific production for 20 years: Programming in education to develop computational thinking and STEAM disciplines. *Education Sciences*, 13(4), Article 404. <https://doi.org/10.3390/educsci13040404>
- Gallagher, S. E., & Savage, T. (2023). Challenge-based learning in higher education: An exploratory literature review. *Teaching in Higher Education*, 28(6), 1135–1157. <https://doi.org/10.1080/13562517.2020.1863354>

- Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, 38(4), 915–945. <https://doi.org/10.3102/00028312038004915>
- Halawa, S., Lin, T.-C., & Hsu, Y.-S. (2024). Exploring instructional design in K-12 STEM education: A systematic literature review. *International Journal of STEM Education*, 11, Article 43. doi:10.1186/s40594-024-00503-5.
- Herro, D., & Quigley, C. (2017). Exploring teachers' perceptions of STEAM teaching through professional development: Implications for teacher educators. *Professional Development in Education*, 43(3), 416–438. <https://doi.org/10.1080/19415257.2016.1205507>
- Herro, D., Quigley, C., & Jacques, L. A. (2018). Examining technology integration in middle school STEAM units. *Technology, Pedagogy and Education*, 27(4), 485–498. <https://doi.org/10.1080/1475939X.2018.1514322>
- Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools*, 19(3), 267–277. <https://doi.org/10.1177/1365480216659733>
- Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, 32(3), 465–491. <https://doi.org/10.3102/00028312032003465>
- Leavy, A., Dick, L., Meletiou-Mavrotheris, M., Papparistodemou, E., & Stylianou, E. (2023). The prevalence and use of emerging technologies in STEAM education: A systematic review of the literature. *Journal of Computer Assisted Learning*, 39(4), 1061–1082.
- Lucas, T., & Villegas, A. M. (2013). Preparing linguistically responsive teachers: Laying the foundation in preservice teacher education. *Theory Into Practice*, 52(2), 98–109. <https://doi.org/10.1080/00405841.2013.770327>
- Lye, S. Y., & Koh, J. H. L. (2014). Review on teaching and learning of computational thinking through programming: What is next for K-12? *Computers in Human Behavior*, 41, 51–61. <https://doi.org/10.1016/j.chb.2014.09.012>
- Marín-Marín, J.-A., Moreno-Guerrero, A.-J., Dúo-Terrón, P., & López-Belmonte, J. (2021). STEAM in education: A bibliometric analysis of performance and co-words in Web of Science. *International Journal of STEM Education*, 8, 41. doi:10.1186/s40594-021-00296-x.
- McLure, F. I., Tang, K.-S., & Williams, P. J. (2022). What do integrated STEM projects look like in middle school and high school classrooms? A systematic literature review of empirical studies of iSTEM projects. *International Journal of STEM Education*, 9(1), Article 73. doi:10.1186/s40594-022-00390-8.
- Medina-Zuta, P., Soria-Valencia, E., Ulloa-Guerra, O., & Deroncele-Acosta, A. (2023). Evaluación formativa mediada por analíticas de aprendizaje en la educación STEAM: Una revisión sistemática de la literatura. *Meta: Avaliação*, 15(48), 480–508. <https://doi.org/10.22347/2175-2753v15i48.3918>
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054. <https://doi.org/10.1111/j.1467-9620.2006.00684.x>
- Nurazmi, N., Bancong, H., Nurfadilah, N., & Yusal, Y. (2025). Mapping the evolution of STEAM education: A bibliometric analysis of global trends from 2016 to 2025. *International Journal of Learning, Teaching and Educational Research*, 24(9), 940–965. <https://doi.org/10.26803/ijlter.24.9.45>
- Opfer, V. D., & Pedder, D. (2011). Conceptualizing teacher professional learning. *Review of Educational Research*, 81(3), 376–407. <https://doi.org/10.3102/0034654311413609>
- Pal, S., Mitra, P., Mustak, S., Bika, S. L., & Pradhan, B. (2026). Global research trends in STEAM education: A bibliometric analysis. *Discover Education*. <https://doi.org/10.1007/s44217-026-01494-x>
- Perignat, E., & Katz-Buonincontro, J. (2019). STEAM in practice and research: An integrative literature review. *Thinking skills and creativity*, 31, 31–43.
- Petscher, Y., Cabell, S. Q., Catts, H. W., Compton, D. L., Foorman, B. R., Hart, S. A., Lonigan, C. J., Phillips, B. M., Schatschneider, C., Steacy, L. M., Terry, N. P., & Wagner, R. K. (2020).

- How the science of reading informs 21st-century education. *Reading Research Quarterly*, 55(S1), S267–S282. <https://doi.org/10.1002/rrq.352>
- Quigley, C. F., & Herro, D. (2016). Finding the joy in the unknown: Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal of Science Education and Technology*, 25(3), 410–426. <https://doi.org/10.1007/s10956-016-9602-z>
- Rodrigues-Silva, J., & Alsina, Á. (2023). STEM/STEAM in early childhood education for sustainability (ECEfS): A systematic review. *Sustainability*, 15(4), 3721. doi:10.3390/su15043721.
- Saucedo Gonzáles, L., Arbulu Pérez Vargas, C. G., Quenaya Negrete, P. Y., Chiclayo Padilla, H. J., & Vértiz Gracey, O. A. (2025). Research on STEAM education: A bibliometric analysis of the evolution of scientific production. *International Journal of Interdisciplinary Educational Studies*, 20(3), 295–314. doi:10.18848/2327-011X/CGP/v20i03/295-314.
- Schmid, R. F., Bernard, R. M., Borokhovski, E., Tamim, R. M., Abrami, P. C., Surkes, M. A., Wade, C. A., & Woods, J. (2014). The effects of technology use in postsecondary education: A meta-analysis of classroom applications. *Computers & Education*, 72, 271–291. <https://doi.org/10.1016/j.compedu.2013.11.002>
- Sigit, D. V., Ristanto, R. H., & Mufida, S. N. (2022). Integration of project-based e-learning with STEAM: An innovative solution to learn ecological concept. *International Journal of Instruction*, 15(3), 23–40. <https://doi.org/10.29333/iji.2022.1532a>
- The New London Group. (1996). A pedagogy of multiliteracies: Designing social futures. *Harvard Educational Review*, 66(1), 60–92. <https://doi.org/10.17763/haer.66.1.17370n67v22j160u>
- van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2), 523–538. doi:10.1007/s11192-009-0146-3.
- Voogt, J., Fisser, P., Good, J., Mishra, P., & Yadav, A. (2015). Computational thinking in compulsory education: Towards an agenda for research and practice. *Education and Information Technologies*, 20(4), 715–728. <https://doi.org/10.1007/s10639-015-9412-6>
- White, D., & Delaney, S. (2021). Full steam ahead, but who has the map for integration?--A prisma systematic review on the incorporation of interdisciplinary learning into schools. *LUMAT: International Journal on Math, Science and Technology Education*, 9(2), 9–32.
- Yadav, A., Mayfield, C., Zhou, N., Hambrusch, S., & Korb, J. T. (2014). Computational thinking in elementary and secondary teacher education. *ACM Transactions on Computing Education*, 14(1), Article 5. <https://doi.org/10.1145/2576872>
- Yim, I. H. Y., Su, J., & Wegerif, R. (2025). STEAM in practice and research in primary schools: A systematic literature review. *Research in Science & Technological Education*, 43(4), 1065–1089. doi:10.1080/02635143.2024.2440424.
- Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. *Organizational Research Methods*, 18(3), 429–472. doi:10.1177/1094428114562629