



MAPPING THE STEM EDUCATION RESEARCH IN THE PHILIPPINES

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Abstract

This study presents an analysis of Science, Technology, Engineering, and Mathematics (STEM) education research in the Philippines, drawing from 251 documents published between 1959 and 2025 retrieved from the Scopus database. Using data from the Scopus database and visualization tools such as VOSviewer, the study explores publication trends, intellectual structures, thematic patterns, and the evolution of research priorities over time. Results reveal a marked increase in scholarly output post-2010, peaking in 2024, coinciding with national education reforms, the COVID-19 pandemic, and advances in digital learning. The citation analysis shows a parallel rise in research impact, indicating increasing academic engagement and visibility. Co-citation mapping identifies two core intellectual traditions: empirical, data-driven methodologies centered on assessment and benchmarking, and constructivist learning theories grounded in pedagogical foundations. Keyword co-occurrence analysis yielded five thematic clusters: engineering education and development, student learning in digital environments, pedagogy and teacher preparation, emerging technologies in STEM, and instructional design systems. The overlay visualization underscores a clear thematic evolution from foundational teaching and curriculum concerns toward digital transformation, AI integration, and learner-centered innovation. The study further highlights the underrepresentation of regional State Universities and Colleges (SUCs), underscoring the need for more inclusive and decentralized research development. The findings suggest that STEM education research in the Philippines is transitioning into a mature, future-ready domain, increasingly responsive to both global trends and localized educational needs.

Keywords: *bibliometric analysis, co-citation analysis, digital learning, educational policy, STEM education*

Introduction

STEM education has become a foundation of global educational and economic agendas. In an increasingly complex and technologically advanced world, STEM skills are non-negotiable, critical to innovation, readiness, and resilience as a society (Tytler, 2020; Walker & Zhu, 2013). The inclusion of STEM in national curricula is viewed as a key measure to counter rapid developments in areas such as artificial intelligence, automation, climate science, and data-informed decision-making (World Economic Forum, 2020). Countries that effectively grow and sustain their STEM workforce are more competitive in the global market, better equipped to address the immediate and evolving challenges of their time, and more resilient to the complex pattern of economic downturns (Oliss et al., 2023).

The Philippine national government has officially acknowledged that STEM education is crucial for national progress (Dela Cruz, 2022). Key reforms, including the K to 12 Basic Education Program, the introduction of the Senior High School STEM strand, and the Commission on Higher Education's outcomes-based education policy, which emphasizes research-based instruction, are designed to reinforce the STEM pipeline. In addition, agencies such as the Department of Science and Technology, via the Science Education Institute, and the Philippine Council for Industry, Energy, and Emerging Technology Research and Development, continue to back STEM scholarships, professional development, and the enhancement of labs and facilities.

Despite the efforts to revamp STEM education, the country still has staggering obstacles to surmount. In the most recent Programme for International Student Assessment (PISA) 2022, the Philippines ranked significantly below the Organisation for Economic Co-operation and Development (OECD) average across mathematics, reading, and science, with only a minority of students reaching minimum proficiency levels (*PISA 2022 Results (Volume I and II) - Country Notes: Philippines*, 2023). These results highlight persistent challenges in STEM education and underscore the urgency of strengthening science and mathematics teaching in the country. To make matters worse, a report on learning poverty by the World Bank's Human Capital Index (HCI) indicates that more than 90% of 10-year-old Filipino children cannot read and understand a simple text (Cimene et al., 2024). This problem in literacy limits students' capacity to read and engage with STEM content, which is highly reliant on language, but also conceptually difficult.

Equity in STEM education is also a significant concern. Geographic inequities in resources, quality teachers, and technological infrastructure leave rural and underserved students at a disadvantage (*Reimagining Our Futures Together: A New Social Contract for Education*, 2021). Elite urban institutions have led educational innovation and research, while many State Universities and Colleges (SUCs) and regional institutions are often absent from both national conversation and research publication (Armas, 2025; Lunag et al., 2024). The Philippine STEM education ecosystem will not reach its fullest potential without closing this gap in research and participation. While research related to STEM has been rapidly expanding, much less is known about the trajectory of this research over time, the intellectual and thematic patterns of the research, and how the research responds to and interacts with both national policy directions and global educational changes (Sahito & Wassan, 2024).

Most of the current reviews in STEM education are largely at the instruction or curriculum level and do not orient themselves at the macrosystem level to understand the trends of the field as a whole. In particular, there is a dearth of evidence on how STEM research in the Philippines has been responsive to global disruptions such as the pandemic of COVID-19, the physics of online learning platforms, and the increasing importance of artificial intelligence in education (Reyes et al., 2021). In order to fill these gaps, this study employs bibliometric analysis of STEM education research in the Philippines for the 66-year period (1959–2025).

This study has aimed to fill these gaps by conducting a bibliometric analysis to track the development of STEM education research in the Philippines over a period of 66 years (1959–2025). Through data from the Scopus database and visualized with VOSviewer, publication types and dataflow of research will be mapped, analyze the structures of the intellectual landscape in STEM education research, thematically cluster the field, and chronologically represent the shifts in research focus. Co-citation and co-keyword analysis will investigate the field's dominant themes, prominent works, and emerging focal areas. Beyond offering a historical and intellectual mapping of STEM education research, this study has generated important findings for policymakers, educators, and researchers to understand STEM education scholarship and help achieve more equitable, innovative, and future-oriented research trajectories.

Using data retrieved from the Scopus database and visualized through VOSviewer, the study maps publication trends, intellectual structures, thematic clusters, and the evolution of research focus areas. Through co-citation and keyword co-occurrence analysis, it identifies the dominant themes, influential works, and emerging areas of inquiry that define the field. This study not only offers a historical and intellectual overview but also surfaces critical insights for policymakers, educators, and researchers who seek to understand the current state of STEM education scholarship and chart pathways for more equitable, innovative, and future-oriented research.

Research Questions

1. What are the publication trends, institutional contributors, and funding sources shaping STEM education research in the Philippines from 1959 to 2025?
2. What are the foundational works and intellectual structures that underpin STEM education research in the Philippines based on co-citation patterns?
3. What are the dominant themes and emerging research trends in STEM education in the Philippines, as revealed through keyword co-occurrence?
4. How have the themes and focus areas on STEM education research in the Philippines evolved over time?

Research Methodology

Bibliometric Analysis

This study employed a bibliometric analysis as the primary research method to systematically examine the scholarly landscape of STEM education research in the Philippines. Bibliometric analysis is a quantitative approach used to evaluate the structure, trends, and patterns within a body of academic literature (Passas, 2024). It enables researchers to identify influential themes, frequently occurring keywords, collaborative networks, and emerging areas of inquiry. Data for the study were sourced from Scopus, covering publications in STEM education in the context of the Philippines. Suitable relevant keywords and Boolean search strings were used to find documents meeting the inclusion criteria. The retrieved data were processed and visualized with VOSviewer (version 1.6.20), a software used for constructing and visualizing bibliometric networks. Specifically, a keyword co-occurrence analysis was performed to illustrate conceptual structures and thematic clusters in the literature. The analysis involved normalizing author keywords and clustering the keywords to create research themes through frequency and strength of co-occurrence. This allowed a better understanding of the intellectual landscape in this area and determined the core topics that surround STEM education research in the Philippines.

Search Strategy and Data Collection

A structured search strategy was developed to identify the scope of scholarly output regarding STEM education in the Philippines. The search query included the following Boolean search string: (“STEM education” OR “science education” OR “technology education” OR “engineering education” OR “mathematics education”) AND (“Philippines”). The combination of keywords ensured that literature describing STEM as an integrated field, as well as literature describing each of the components of STEM individually, was included. The search was accomplished using the Scopus database and included articles published between 1959 and 2025; the earliest document retrieved was published in 1959. A total of 251 documents satisfied the inclusion criteria and could be included in the analysis. Citation analyses for 2024–2025 are considered provisional, with robust impact measures restricted to publications up to 2023.

No restrictions were imposed on document type or source, allowing for an extensive collection of journal articles, conference proceedings, book chapters, and reviews. Works that referenced the Philippines in the title, abstract, or keywords were included to ensure that the geographic reference was of relevance to the study. The metadata included (e.g., author names, publication years, titles, abstracts, keywords, source journals) were exported and imported into VOSviewer software for further analysis. This data subsequently required, allowed for bibliometric mapping and keyword co-occurrence analysis.

Analytical Techniques

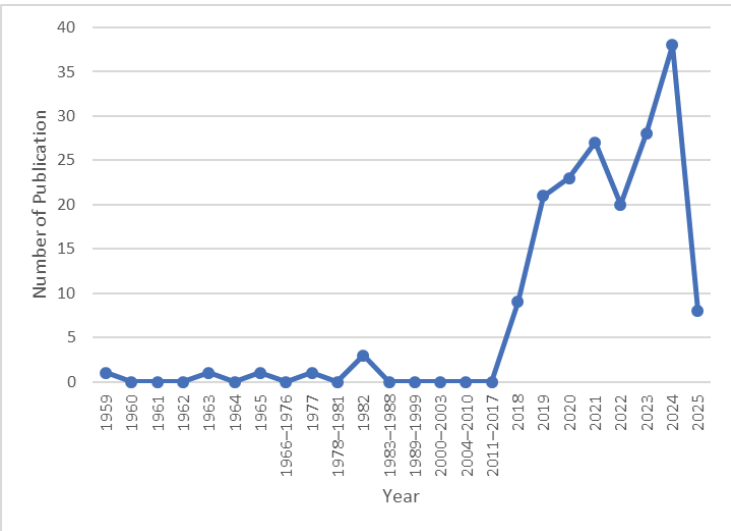
To comprehensively examine the intellectual landscape, structural dynamics, and thematic evolution of STEM education research in the Philippines over the past six decades, this study employed a suite of bibliometric indicators and science mapping techniques. Citation analysis served as the foundational method for evaluating scholarly impact by identifying the most influential publications, authors, and journals that have shaped the field, while also revealing the intellectual anchors guiding discourse in STEM education (Zupic & Čater, 2015). To uncover the intellectual structure, co-citation analysis was conducted to examine how frequently pairs of documents were cited together, allowing the identification of conceptual linkages, theoretical foundations, and evolving schools of thought within the literature (Surwase et al., 2012). Complementing this, co-word analysis provided a semantic perspective by mapping the frequency and co-occurrence of keywords, which helped identify recurring concepts, emerging topics, and research priorities in areas such as engineering education, digital pedagogy, and teacher development (Khasseh et al., 2020). Lastly, thematic evolution analysis traced how research topics have emerged, transformed, or declined across distinct publication periods, offering insights into how STEM education research in the Philippines has evolved in response to educational reforms, technological advances, and global developments. Together, these techniques offered a comprehensive and multidimensional understanding of the field’s knowledge base, thematic progression, and future research trajectories.

Research Results

Descriptive Analysis

Figure 1 illustrates the distribution of Scopus-indexed journal articles on STEM education published between 1959 and 2025.

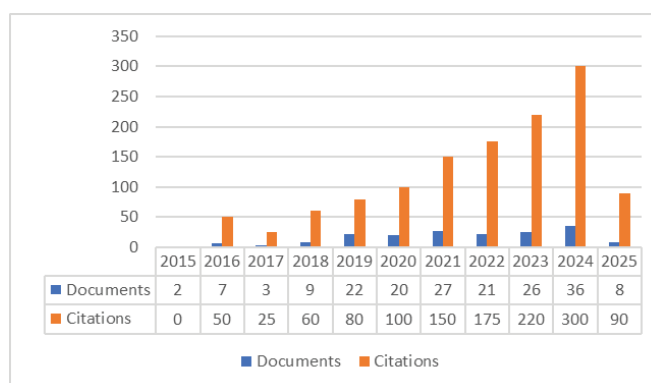
Figure 1
Scopus Journal Article from 1959-2025 on STEM Education



The temporal classification of documents published between 1959 and 2025 also shows an upward trend in publications about STEM education research in the Philippines. For several decades, from 1959 through the early 2000s, the volume of published work remained relatively low and steady, with typically zero to three documents recorded per year. A gradual increase is observable, beginning in the early 2000s, with a more noticeable rise from 2010 onwards. The most dramatic growth occurred after 2018, with annual publication counts surging into double digits. Notably, the peak was recorded in 2025 with nearly 40 documents, marking the highest number of outputs in a single year. While 2025 shows a slight dip likely due to incomplete data at the time of analysis, the trend strongly indicates a growing scholarly interest in STEM education, driven by developments in digital learning, national educational reforms, and increased research capacity within Philippine institutions (Saro et al., 2023)

Figure 2 presents the citation overview of Scopus-indexed STEM education publications from 1959 to 2025.

Figure 2
Citation Overview



The citation overview for STEM education research in the Philippines, covering the period from 2015 to 2025, includes a total of 152 documents, which have collectively received 1,260 citations and achieved an h-index of 16. The graph demonstrates a clear upward trend in both research productivity and citation impact over the last decade. From 2015 to 2018, the number of publications remained relatively low, averaging fewer than 10 documents per year, with minimal citation activity. A significant turning point occurred in 2019, with a notable increase in publications (over 20 documents), followed by a consistent rise through 2021 and 2022. Citation counts also began to increase steadily from 2019, mirroring the growth in scholarly output. The year 2024 stands out as the peak, recording the highest number of documents (close to 40) and the most citations in a single year, exceeding 300 citations. This surge likely reflects the impact of recent developments in education, particularly the integration of technology in learning environments, and research responding to COVID-19 disruptions and digital transformation. A slight drop is observed in 2025, both in publication count and citations. This is likely due to the year still being in progress at the time of data extraction, and many newly published works not yet accumulating citations. Overall, the trend indicates accelerating momentum and growing influence of STEM education research in the Philippines, driven by policy reforms, technological advancements, and increased institutional investment in scholarly work.

Table 1 shows the distribution of Scopus-indexed STEM education journal articles according to subject area.

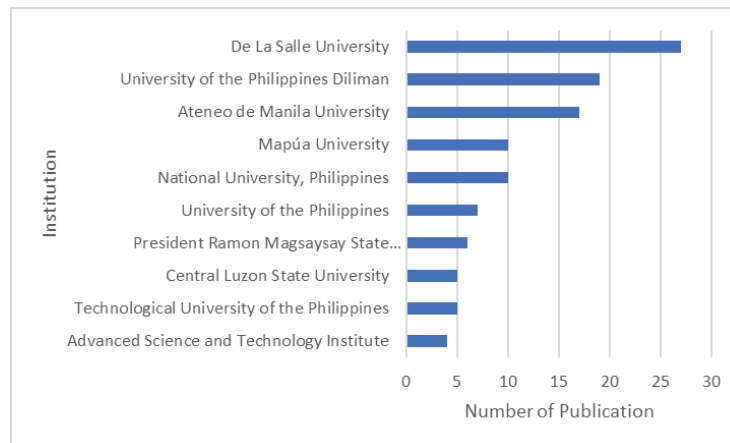
Table 1
Scopus Journal Articles by Subject Area

Discipline/Field	Percentage (%)
Social Sciences	31.4
Computer Science	17.5
Engineering	14.8
Other	11.6
Decision Sciences	5.5
Mathematics	5.1
Business, Management	3.6
Psychology	3.0
Arts and Humanities	2.5
Environmental Science	2.5
Physics and Astronomy	2.5

The distribution of documents by subject area reveals a multidisciplinary orientation in STEM education research in the Philippines. The Social Sciences dominate the field, accounting for 31.4% of the total publications, highlighting the prominence of educational, behavioral, and societal aspects in STEM research. This is followed by Computer Science (17.5%) and Engineering (14.8%), both of which reflect the technical and applied dimensions of the field. Other notable contributions come from Decision Sciences (5.5%), Mathematics (5.1%), and Business Management (3.6%), suggesting intersections between quantitative analysis, organizational strategies, and curriculum development. Less represented but still relevant are areas such as Psychology (3.0%), Arts and Humanities (2.5%), Environmental Science (2.5%), and Physics and Astronomy (2.5%). The “Other” category accounts for 11.6%, indicating a variety of niche or interdisciplinary studies. Overall, the data reflect a robust integration of both technical and human-centered disciplines in advancing STEM education research across Philippine academic institutions.

Figure 3 displays the distribution of Scopus-indexed STEM education journal articles categorized by author affiliation.

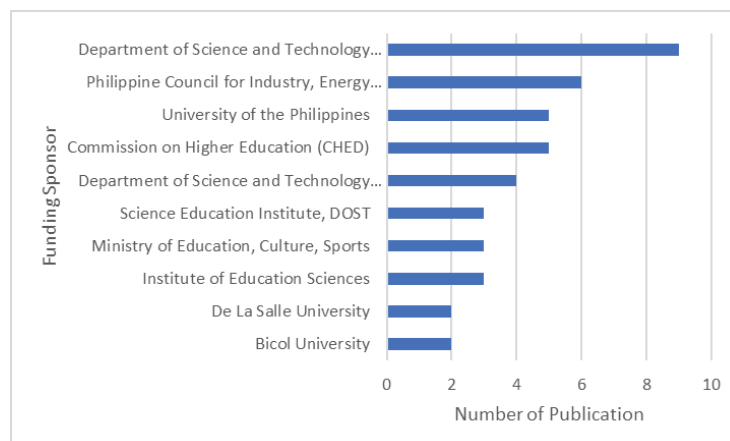
Figure 3
Scopus Journal Article Related to STEM Education by Affiliation



An analysis of the main institutional affiliations of published evidence related to STEM education research in the Philippines shows De La Salle University with the highest number of documents (28 publications) and strong output for STEM Education research. It is followed by the University of the Philippines Diliman and Ateneo de Manila University with 18 documents and 17 documents, respectively, both of which are leading research universities in the country. Mapúa University and the National University of the Philippines each had 10 documents, indicating their involvement in engineering and technological education. Some other institutions had between four and six documents: University of the Philippines (system level), President Ramon Magsaysay State University, Central Luzon State University, Technological University of the Philippines, and Advanced Science and Technology Institute. This distribution shows there is a considerable level of participation from national and regional institutions in contributing to the areas of STEM Education research, although the majority of output is focused on the established universities in Metro Manila.

Figure 4 illustrates the distribution of Scopus-indexed STEM education journal articles by funding sponsor.

Figure 4
Scopus Journal Article on STEM Education by Funding Sponsor



The description of the sources funding STEM education research in the Philippines reveals that government sources and other higher education institutions had a pivotal role in research development (Lunag et al., 2024). The national government and academic institutions are arguably the most significant sources of sponsorship, with the Department of Science and Technology (DOST) being the most prominent. DOST supported nine documents, and the award for the second most prominent sponsor goes to the Philippine Council for Industry, Energy, and Emerging Technology Research and Development (PCIEERD) with six documents. Both agencies are the leading organizations related to the advancement of the country's research agenda for science and technology. The next in line were the Commission on Higher Education (CHED) and the University of the Philippines, with five documents each. These four sponsoring organizations demonstrate the commitment to developing higher education research in the Philippines by funding STEM education research. Funders that supported three to four documents included the Department of Science and Technology-Science Education Institute (DOST-SEI), Institute of Education Sciences, and the Ministry of Education, Culture, Sports, Science and Technology. Institutional sponsors supportive of STEM education research include one with two documents and the other with two documents, Bicol University and De La Salle University, respectively. These results highlight the significant role of our national institutions and leading universities in sustaining STEM education research by providing support funding.

Figure 5 presents the co-citation analysis, mapping the influential literature and scholarly connections that have shaped the field of STEM education.

Figure 5

Co-citation Analysis of Literature on STEM Education



The co-citation analysis of literature on STEM education in the Philippines yielded a total of 29 cited items, which were grouped into two distinct clusters. The visualization generated by VOSviewer shows these clusters represented in red and green. Cluster 1 (Red) consists of 20 items and includes authors and works primarily focused on statistical analysis, educational measurement, and large-scale assessment. Prominent entries in this cluster include Cohen J. (noted for work on statistical power), Buoncristiani M., and Taasoobshirazi G. H.. Documents related to PISA 2018 assessment results and related analyses are also central to this cluster. Cluster 2 (Green) comprises nine items and contains foundational theoretical and pedagogical works. Key items in this cluster include Vygotsky L. S. (*Mind in Society*), Bransford J. D., and Brown A. L., which focus on cognitive development, sociocultural learning, and instructional improvement. A total of 211 links and total link strength of 378 were recorded, indicating the co-citation strength among the items. The network also shows inter-cluster connections, particularly between Vygotsky's work and several authors from both clusters, suggesting points of convergence between empirical and theoretical domains.

Co-occurrence

A co-word analysis was conducted to identify prominent themes and relationships among keywords within the STEM education research corpus. Out of a total of 1,560 keywords, 57 met the threshold of at least four occurrences, forming five distinct clusters that represent major areas of focus in the field. The keyword “engineering education” emerged as the most dominant, appearing 88 times and achieving the highest total link strength of 291, signifying its central role in STEM education discourse in the Philippines. This was followed by “students” (58 occurrences, 254 total link strength), “Philippines” (72, 217), and other pedagogically significant terms such as “teaching”, “curricula”, and “education computing”. The inclusion of digital learning-related terms like “e-learning”, “online learning”, and “Covid-19” indicates a responsive shift in research priorities due to the pandemic’s impact on education delivery. Additionally, concepts such as “science education”, “teachers”, “integration”, and “developing countries” suggest an increasing interest in both systemic and instructional aspects of STEM, particularly in the local and regional development contexts. These high-frequency keywords and their link strengths underscore the interconnected nature of research themes in Philippine STEM education, with a clear emphasis on innovation, inclusivity, and adaptation to technological and societal changes.

Table 2 displays the top 15 keywords generated from the co-occurrence analysis, reflecting the most prominent research topics and focal areas in STEM education.

Table 2
Ranking Keyword Occurrences Total link strength

Ranking	Keyword	Occurrences	Total link strength
1	Engineering education	88	291
2	Students	58	254
3	Philippines	72	217
4	Teaching	23	111
5	e-learning	20	82
6	Curricula	20	80
7	Education computing	16	75
8	Education	20	70
9	Science education	31	48
10	Teachers'	9	48
11	Online learning	9	33
12	Covid-19	8	32
13	Developing countries	8	30
14	Higher education	6	30
15	Integration	6	29

The co-occurrence analysis identifies key themes and conceptual linkages in STEM education research in the Philippines by examining the frequency and relationships between keywords in the literature. Using VOSviewer, a total of 57 keywords were analyzed and organized into five distinct thematic clusters, each visually represented by color. The size of the nodes corresponds to the frequency of keyword occurrence, while the thickness of the lines (links) indicates the strength of co-occurrence relationships.

Figure 6
Co-occurrence Identified Key Themes and Conceptual Linkages in STEM Education



Cluster 2: Student Learning and Online Education (Purple Cluster)

Cluster 3: Pedagogy, Curriculum, and Teacher Preparation (Green Cluster)

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“curricula”, “science education”, “mathematics education”, and “conceptual understanding”, and indicates a focus on educators effectively delivering content when using STEM. Emerging terms like “prospective teachers”, “higher education”, and the inclusion of all 28 papers related to a “teacher preparation program” suggest this literature is primarily concerned with pre-service teacher preparation programs. This cluster illustrates how foundational knowledge and pedagogical approaches in science and math underpin the STEM education system in the Philippines (Tañedo et al., 2024).

Cluster 4: Emerging Technologies in STEM Education (Yellow Cluster)

In yellow, this cluster presents a new perspective in the literature with keywords that include “artificial intelligence”, “augmented reality”, “machine learning”, and “technology adoption”. Their usage indicates an emergent research interest in studying how advanced technologies can foster new ways to teach and learn. The presence of “adversarial machine learning”, “federated learning”, and “contrastive learning” suggests that some studies are exploring highly technical innovations that are still in early stages of adoption in Philippine classrooms. While this cluster is less dense, it signals future directions for STEM education research aligned with Industry 4.0 and digital transformation trends.

Cluster 5: Systems Integration and Instructional Design (Blue Cluster)

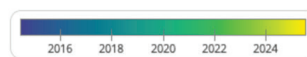
The blue cluster centers on the implementation and support structures behind STEM education. Keywords such as “integration”, “computer-aided instruction”, “educational technology”, and “personnel training” point to efforts in embedding digital tools into educational systems and preparing educators for their use. The appearance of “learning experiences”, “perception”, and “professional aspects” suggests that researchers are examining both the technical and human elements of instructional design. This cluster highlights the importance of holistic system readiness, including infrastructure, training, and perception for the effective integration of STEM innovations in educational practice.

Table 3 presents the results of the co-occurrence analysis, outlining the key themes and conceptual linkages that structure the research landscape in STEM education.

Table 3
Co-occurrence Identified Key Themes and Conceptual Linkages in STEM Education

Cluster no. and color	Cluster label	Number of keywords	Representative keywords
1 (Red)	Engineering Education and National Development	13	science and technology”, “technology education”, “engineering program”, and “sustainable development”
2 (Purple)	Student Learning and Online Education	12	“students”, “e-learning”, “online learning”, “learning systems”, and “educational technology” self-efficacy”, “surveys”, and “learning experiences”
3 (Green)	Pedagogy, Curriculum, and Teacher Preparation	12	“teaching”, “teachers”, “curricula”, “science education”, “mathematics education”, and “conceptual understanding”,
4 (Yellow)	Emerging Technologies in STEM Education (Yellow Cluster)	10	artificial intelligence”, “augmented reality”, “machine learning”, and “technology adoption”. “adversarial machine learning”, “federated learning”, and “contrastive learning”
5 (Blue)	Systems Integration and Instructional Design (Blue Cluster)	10	as “integration”, “computer-aided instruction”, “educational technology”, and “personnel training” learning experiences”, “perception”, and “professional aspects”

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Discussion

The evolution of STEM education research in the Philippines over the past six decades reflects a broader global narrative: one where educational priorities shift from basic capacity-building toward innovation, equity, and future-readiness. This transformation signifies more than just changing priorities, but it reflects a profound reimagining of the purposes of education and the approaches through which it is designed, delivered, and assessed (Custodio, 2025). The marked rise in scholarly output from the early 2010s onward coincides with structural reforms, such as the implementation of the K to 12 curriculum and the Commission on Higher Education's outcomes-based education policy, that redefined the goals and scope of education in the country. These policy milestones echo international movements emphasizing competency-based learning and research-informed practice (OECD, 2023; UNESCO, 2021). They signaled a paradigm shift in Philippine higher education from content transmission to learner-centered, skills-oriented pedagogy, driving demand for empirical evidence to guide curriculum design, instructional innovation, and teacher professional development (Rege Colet, 2017).

The COVID-19 pandemic further accelerated this momentum by exposing systemic vulnerabilities and catalyzing rapid transformation across the educational landscape. Much like global counterparts, Filipino researchers responded with intensified focus on digital pedagogy, student engagement, and technology-mediated instruction (Holmes et al., 2022; Tanucan et al., 2021; Mercado & Ayala, 2024; UNESCO, 2022). The surge in publications and citations post-2019 reflects a broader reorientation of research priorities in response to unprecedented disruptions, aligning with global patterns observed in countries like South Korea, Singapore, and Finland, where research agendas similarly pivoted toward digital resilience, remote learning, and inclusive access (OECD, 2022). This responsiveness illustrates not only the growing maturity of STEM education research in the Philippines but also its increasing integration into global discourses on educational transformation.

Despite this progress, the unevenness in institutional participation highlights persistent structural inequities. The concentration of research output among elite universities such as De La Salle University, the University of the Philippines, and Ateneo de Manila University mirrors a pattern seen in many developing countries, where research ecosystems are heavily centralized in metropolitan or flagship institutions (Altbach & Salmi, 2016). This imbalance limits the diversity of perspectives and contextual insights, particularly from State Universities and Colleges (SUCs) serving rural and underserved regions. Without deliberate policy interventions, including equitable funding distribution, targeted capacity-building programs, and mentorship networks, the national research agenda risks perpetuating regional disparities rather than addressing them (Lee & Kuzhabekova, 2019; Quitoras & Abuso, 2021; World Bank, 2023).

The co-citation analysis reveals a dual intellectual structure underpinning STEM education research in the Philippines: one grounded in empirical, data-driven methodologies and another rooted in constructivist and sociocultural theories of learning. The prominence of large-scale assessment research, including studies referencing PISA and statistical power analyses (Cohen, 2013), illustrates a national preoccupation with global benchmarking and comparative performance. This reflects a strategic policy imperative: participation in international assessments offers valuable diagnostic insights into systemic weaknesses and informs reforms aimed at improving educational quality and competitiveness (OECD, 2023). However, this empirical orientation is increasingly complemented by a parallel body of scholarship drawing from foundational educational theorists such as Vygotsky (1978), Bransford et al. (1999), and Dewey, which emphasizes the social, cognitive, and experiential dimensions of learning. These theoretical perspectives, long central to global STEM education discourse, foreground the importance of context, collaboration, and meaning-making in shaping learner outcomes

(Bruner, 1996; Sawyer, 2014). The coexistence of these two strands suggests a maturing research ecosystem that values both measurement and meaning, outcome and process. As scholars integrate assessment-focused methodologies with theory-driven inquiry, Philippine STEM research becomes better positioned to inform not just policy and standards but also pedagogy and practice (Morales et al., 2022; Nivera et al., 2021)

This synthesis also reflects a growing alignment with contemporary educational paradigms such as inquiry-based learning, problem-based instruction, and design thinking, which are approaches that are widely endorsed in international research for their potential to cultivate higher-order thinking, creativity, and innovation (Bybee, 2013; OECD, 2022). By grounding empirical findings within these theoretical frameworks, researchers can more effectively address enduring challenges in STEM education, such as low student engagement, fragmented curricula, and disparities in achievement.

The co-occurrence analysis underscores a thematic evolution in Philippine STEM research that mirrors global trends, with five major clusters reflecting the field's complexity and dynamism. The first and most dominant cluster, engineering education and national development, reflects the long-standing recognition of STEM as a driver of economic growth, innovation, and competitiveness (National Economic and Development Authority, 2023; World Economic Forum, 2020). Terms such as “sustainable development,” “technology education,” and “accreditation” point to research that interrogates how higher education institutions can better align curricula with labor market demands, industrial needs, and the Sustainable Development Goals (SDGs). This focus resonates with the global emphasis on STEM as an engine for addressing pressing societal challenges, from climate change to digital transformation (UNESCO, 2021; European Commission, 2023).

The second major theme, student learning in digital environments, reflects a significant pedagogical shift toward learner-centered, technology-enhanced instruction. The prominence of terms like “e-learning,” “self-efficacy,” and “learning experiences” highlights a growing research interest in the cognitive, affective, and behavioral dimensions of online learning, which is a trend consistent with international scholarship exploring the impact of digital technologies on student motivation, agency, and outcomes (Zawacki-Richter et al., 2021). Moreover, this thematic focus aligns with sociocultural learning theories that emphasize the centrality of interaction, collaboration, and social presence in digital spaces (Garrison & Anderson, 2011). Filipino research studies in this domain contribute valuable insights into how digital inequities, including disparities in access, digital literacy, and support, shape learners' experiences in technology-mediated contexts (Reyes & Grajo, 2021).

Teacher preparation and pedagogical design emerge as another persistent theme, underscoring the critical role of educators in the success of STEM reforms. Despite ongoing reforms, challenges in teacher quality, particularly in under-resourced contexts, remain a significant barrier to STEM advancement (World Bank, 2023). Global research consistently emphasizes that effective STEM education depends not only on content expertise but also on pedagogical content knowledge (PCK), reflective practice, and adaptive teaching strategies (Shulman, 1986; Darling-Hammond et al., 2020). Philippine scholarship contributes to this conversation by examining how teacher education programs can better integrate inquiry-based instruction, interdisciplinary approaches, and digital pedagogies into pre-service and in-service training (Abella & Rosa, 2023; Antonio & Prudente, 2025; Ocampo, 2021).

The final two clusters, emerging technologies and instructional design systems, represent the frontier of STEM education research. The increasing frequency of terms like “artificial intelligence,” “augmented reality,” and “machine learning” reflects a global shift toward integrating Industry 4.0 technologies into educational practice (Luckin et al., 2016; Holmes et al., 2022). These studies are often exploratory, signaling a nascent but rapidly expanding field of inquiry that seeks to harness emerging technologies to personalize learning, automate

assessment, and foster creativity. Simultaneously, research on systems integration, institutional readiness, and faculty development points to the infrastructural and organizational challenges that must be addressed to support sustainable technology adoption (Gayon & Tan, 2021). Together, these themes reveal a research agenda that is increasingly future-focused, interdisciplinary, and aligned with broader global innovation trajectories.

The thematic and intellectual patterns identified in this study demonstrate that Philippine STEM education research is increasingly converging with global trends; however, it also exhibits distinctive characteristics shaped by local contexts. Like many countries in the Global South, the Philippines grapples with persistent disparities in educational quality, access, and outcomes. These structural challenges shape the research agenda, pushing scholars to explore issues such as equity, regional capacity-building, and socio-economic barriers to STEM participation, which are themes that are less prominent in high-income contexts but critical to advancing the global education agenda (UNESCO, 2021; World Bank, 2023).

At the same time, Philippine scholarship is contributing unique perspectives to global conversations, particularly in areas such as digital equity, culturally responsive pedagogy, and education in low-resource settings (Cruz et al., 2025; Rodriguez et al., 2025). These contributions enrich the global knowledge base by offering contextually grounded insights that can inform policy and practice in similarly situated countries across Southeast Asia, Africa, and Latin America (Reyes & Grajo, 2021). Furthermore, the increasing engagement of Filipino researchers with emerging technologies reflects a strategic alignment with international priorities for education in the Fourth Industrial Revolution, including the development of computational thinking, data literacy, and ethical AI literacy (Holmes et al., 2022; UNESCO, 2023).

Limitations and Future Research Directions

This study offers valuable insights into the trajectory of STEM education research in the Philippines, but several limitations must be acknowledged. First, the analysis was limited to Scopus-indexed publications. Future bibliometric studies should expand their scope to include a broader range of sources to provide a more comprehensive view of the national research landscape. Second, the reliance on author keywords as the main unit of analysis introduces variability due to inconsistent terminology and typographical differences. Future studies could employ advanced approaches such as natural language processing (NLP) and text mining to improve the precision of thematic mapping and reveal deeper conceptual relationships (Zawacki-Richter et al., 2021). Additionally, the citation analysis may underestimate the long-term impact of recent publications (2024–2025), which have not yet accumulated substantial citations. Longitudinal tracking of citation trajectories can offer a more accurate picture of evolving research influence. While bibliometric techniques reveal structural patterns, they do not measure research quality, classroom application, or societal impact. Future work should therefore integrate complementary methodologies such as qualitative meta-syntheses, systematic reviews, and case studies to better understand how STEM education research informs pedagogy, policy, and learner outcomes (Darling-Hammond et al., 2020).

Looking ahead, sustaining the momentum of STEM education research will require moving beyond descriptive analyses toward critical, transformative inquiries. Future research should examine structural inequities, cultural contexts, and ethical considerations surrounding emerging technologies (Floridi & Cows, 2022). Interdisciplinary collaboration, involving fields such as data science, psychology, sociology, and economics, will be crucial in designing holistic solutions to complex global challenges such as climate change, sustainability, and artificial intelligence (Bybee, 2013; OECD, 2022). Moreover, integrating indigenous knowledge systems, cultural epistemologies, and community-based perspectives into STEM education can enhance curriculum relevance and inclusivity (UNESCO, 2023). Comparative research

across Southeast Asian contexts can also situate Philippine scholarship within regional and global dynamics, fostering knowledge exchange and collaborative innovation. Finally, future studies should critically explore the ethical and societal implications of integrating advanced technologies like AI and biotechnology into education. Ensuring that these tools promote equity and inclusion, rather than reinforcing existing disparities, is vital to building a more just and future-ready STEM ecosystem (Holmes et al., 2022). By addressing these limitations and pursuing these directions, future research can move beyond mapping trends to shaping transformative practices, contributing not only to national educational reform but also to the broader global discourse on inclusive, innovative, and sustainable STEM education.

Conclusions and Implications

This six-decade bibliometric analysis reveals that STEM education research in the Philippines has transformed from modest beginnings into a dynamic and strategically significant field shaped by national reforms, global disruptions, and technological advancement. Key education policies such as the implementation of the K to 12 curriculum and CHED's outcomes-based education framework have fueled steady growth in scholarly activity, while the COVID-19 pandemic further accelerated research focused on digital pedagogy, student engagement, and technology-mediated learning. These developments signal a maturing research ecosystem that is increasingly responsive to both local educational needs and global trends. The intellectual structure of the field reflects a productive synthesis between empirical, data-driven approaches, aligned with global benchmarking and assessment frameworks, and theoretically grounded perspectives rooted in constructivist and sociocultural learning theories. This dual orientation enhances the credibility and applicability of STEM research, allowing it to inform national policies while enriching classroom practices. Thematic analyses also demonstrate the field's capacity to evolve, with growing attention to engineering education, teacher preparation, and advanced technologies such as artificial intelligence and machine learning. However, persistent disparities, particularly the underrepresentation of State Universities and Colleges (SUCs), highlight the need for more equitable research capacity-building initiatives and funding mechanisms to ensure that scholarship reflects diverse contexts and informs inclusive policy development. These findings underscore the importance of sustained investments in research infrastructure, especially in under-resourced regions, as well as the integration of pedagogical theory and technological competence in teacher education programs. Moreover, interdisciplinary collaborations should be fostered to bridge empirical and theoretical approaches and to explore the ethical, social, and practical implications of emerging technologies. Future research should investigate how Industry 4.0 technologies, such as AI and data science, can be meaningfully embedded in STEM curricula without displacing foundational skills, while also exploring how localized pedagogical practices and indigenous knowledge systems can enhance global relevance. Ultimately, STEM education research in the Philippines is no longer peripheral; it has become a vital, forward-looking field that contributes to national development priorities and enriches global conversations on equity, innovation, and the future of learning.

Declaration of Interest

The authors declare no competing interest.

References

- Abella, J. L., & Rosa, E. D. (2023). Digital literacy and digital competence of selected Filipino teachers: Basis for a post-pandemic pedagogy. *International Journal of Recent Educational Research*, 4(5), 548–569. <https://doi.org/10.46245/ijorer.v4i5.378>

- Alejandro, I. M. V., Sanchez, J. M. P., Sumalinog, G. G., Mananay, J. A., Goles, C. E., & Fernandez, C. B. (2024). Pre-service teachers' technology acceptance of artificial intelligence (AI) applications in education. *STEM Education*, 5(1), 445–465. <https://doi.org/10.3934/steme.2024024>
- Altbach, P. G., & Salmi, J. (2016). The road to academic excellence: The making of world-class research universities. *World Bank eBooks*. <https://doi.org/10.1596/978-0-8213-8805-1>
- Antonio, R. P., & Prudente, M. S. (2025). Cultivating preservice science teachers' TPAC and self-efficacy beliefs through a pedagogical learning course on technology-integrated metacognitive argument-driven inquiry. *Journal of Science Education and Technology*, 1–25.
- Armas, K. (2025). A comparative study of the research and innovation ecosystems of state and private universities in the Philippines using the quintuple helix framework. *International Journal of Innovative Research and Scientific Studies*, 8(3), 4874–4887. <https://doi.org/10.53894/ijirss.v8i3.7635>
- Bransford, J. D., Brown, A. L., & Cocking, R. R. (1999). How people learn: Brain, mind, experience, and school. In *National Academy Press eBooks*. <https://ci.nii.ac.jp/ncid/BA41844721>
- Bruner, J. S. (1996). *The culture of education*. Harvard University Press.
- Buoncristiani, M., & Buoncristiani, P. (2012). *Developing mindful students, skillful thinkers, thoughtful schools*. <https://doi.org/10.4135/9781483387772>
- Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. NSTA Press.
- Cimene, F. T. A., Casiño, M. V. S., Aspiras, D. D., Cawi, C. S. P., Bahala, A. M., Subingsubing, I. O., & Bahi-an, E. F. (2024). Understanding learning poverty: Teachers' lived experiences in supporting grade IV non-readers. *American Journal of Multidisciplinary Research & Development*, 6(12), 20-30.
- Cohen, J. (2013). *Statistical power analysis for the Behavioral sciences*. Routledge eBooks. <https://doi.org/10.4324/9780203771587>
- Cruz, L. D., Aguinaldo, I., Alzate, L. J., Camero, C., Abiado, K. R., & Gumpal, B. (2025). Fostering intercultural competence through culturally responsive pedagogy: Practices and perspectives in Philippine higher education institutions. *International Journal on Culture, History, and Religion*, 7(SI2), 36-50. <https://doi.org/10.63931/ijchr.v7isi2.187>
- Custodio, R. J. P. (2025). From policies to programs: exploring the evolving landscape of science and technology in the Philippines. *Journal of Science and Technology Policy Management*. <https://doi.org/10.1108/jstpm-06-2024-0222>
- Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2020). *Effective teacher professional development*. Learning Policy Institute.
- De La Cruz, R. J. D. (2022). Science education in the Philippines. *Lecture notes in educational technology*, 331–345. https://doi.org/10.1007/978-981-16-6955-2_20
- European Commission. (2025, March). *A STEM Education Strategic Plan: Skills for competitiveness and innovation*. https://education.ec.europa.eu/sites/default/files/2025-03/STEM_Education_Strategic_Plan_COM_2025_89_1_EN_0.pdf
- Floridi, L., & Cows, J. (2019). A unified framework of five principles for AI in Society. *Harvard Data Science Review*, 1(1). <https://doi.org/10.1162/99608f92.8cd550d1>
- Garrison, D. R., & Anderson, T. (2011). *E-learning in the 21st century: A framework for research and practice* (2nd ed.). Routledge.
- Gayon, R., & Tan, D. (2021). Experiences of higher education institution (HEI) teachers in the implementation of flexible learning. *Science International*, 33(1), 47-52.
- Holmes, W., Bialik, M., & Fadel, C. (2022). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.
- Khasseh Ali, A., Parisa, H., Isfandyari-Moghaddam Ali, R., Faramarz, S., & Afshin, M. C. (2020). Mapping the intellectual structure of chronic heart failure: A co-word analysis. *Science*.
- Lee, J. T., & Kuzhabekova, A. (2019). Building local research capacity in higher education: A conceptual model. *Journal of Higher Education Policy and Management*, 41(3), 342-357.
- Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson Education.
- Lunag, M. N., Posadas, C. L., Lamadrid, R. L., Ducas, A. G., Teehankee, A., De Guzman, M. K. B., Moncada, C. B., & Clemente, M. C. B. (2023). Building sustainable research and innovation ecosystem in Philippine higher education institutions. *Educational Research for Policy and Practice*. <https://doi.org/10.1007/s10671-023-09355-2>

- Mercado, F. M., & Ayala, C. O. J. (2024, March). Development and Validation of IMLMs for Teaching and Learning STEM in Higher Education Institutions in the Philippines. In Proceedings of the 2024 15th International Conference on E-Education, E-Business, E-Management and E-Learning (pp. 30-40).
- Morales, M. P., Avilla, R., Sarmiento, C., Anito, J. J., Elipane, L., Palisoc, C., Palomar, B., Ayuste, T. O., & Butron, B. (2022b). Experiences and practices of STEM teachers through the lens of TPACK. *Journal of Turkish Science Education*, 19(1), 237–256. <https://doi.org/10.36681/tused.2022.120>
- National Economic and Development Authority. (2023). *Philippine development plan 2023–2028*. <https://pdp.depdev.gov.ph/wp-content/uploads/2023/01/PDP-2023-2028.pdf>
- Nivera, G. C., Limjap, A. A., & Edwehna Elinore, S. (2021). STEM teacher education. In G. C. Nivera, A. A. Limjap, & S. Edwehna Elinore (Eds.), *STEM education from Asia: Trends and perspectives* (pp. 41–58). Springer Nature.
- Ocampo, D. M. (2021). 21st-century pedagogical competence of pre-service teachers in the new normal modalities. *Globus Journal of Progressive Education* 11(1), 74-79. <https://doi.org/10.46360/globus.edu.220211014>
- OECD. (2022). *Education at a glance 2022: OECD indicators*. OECD Publishing. <https://doi.org/10.1787/69096873-en>
- OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education* (PISA). OECD Publishing. <https://doi.org/10.1787/53f23881-en>
- Oliss, B., McFaul, C., & Riddick, J. C. (2023). The global distribution of STEM graduates: which countries lead the way. *Center for Security and Emerging Technology*. <https://cset.georgetown.edu/article/the-global-distribution-of-stem-graduates-which-countries-lead-the-way>
- Passas, I. (2024). Bibliometric Analysis: the main steps. *Encyclopedia*, 4(2), 1014–1025. <https://doi.org/10.3390/encyclopedia4020065>
- PISA 2022 Results (Volume I and II) - Country Notes: Philippines. (2023, December 5). *OECD*. https://www.oecd.org/en/publications/pisa-2022-results-volume-i-and-ii-country-notes_ed6fbcc5-en/philippines_a0882a2d-en.html#chapter-d1e11
- Quitoras, M. C. L., & Abuso, J. E. (2021). Best practices of higher education institutions (HEIs) for the development of research culture in the Philippines. *Pedagogical Research*, 6(1). <https://doi.org/10.29333/pr/9355>
- Rege Colet, N. M. (2017). From content-centred to learning-centred approaches: shifting educational paradigm in higher education. *Journal of Educational Administration and History*, 49(1), 72–86.
- Reimagining our futures together: a new social contract for education*. (2021b). <https://doi.org/10.54675/asrb4722>
- Reyes, J. R., & Grajo, J. (2021). Assessment of Filipino higher education students' readiness for e-learning during a pandemic: A Rasch technique application. *The Philippine Journal of Science*, 150(3). <https://doi.org/10.56899/150.03.34>
- Rodriguez, D., Allawey, F. K., Belarde, S., Soriano, R., Carag, E., & Caban, R. (2025). Integrating gender and cultural perspectives in pedagogy: A study of transformative teaching practices in Philippine higher education institutions. *International Journal on Culture, History, and Religion*, 7(SI2), 624–642. <https://doi.org/10.63931/ijchr.v7iSI2.233>
- Sahito, Z., & Wassan, S. H. (2024). Literature review on STEM education and its awareness among teachers: An exploration of issues and problems with their solutions. *SAGE Open*, 14(1). <https://doi.org/10.1177/21582440241236242>
- Saro, J. , Oquilan, J. , Basigsig, E. , Castillo, R. & Lastra, J. (2023). A comprehensive review: Transforming science education in the pearl of the orient- innovations in teaching approaches and technology integration. *Psychology and Education: A Multidisciplinary Journal*, 14(9), 1122-1131. <http://dx.doi.org/10.5281/zenodo.10068809>
- Sawyer, R. K. (2014). *The Cambridge handbook of the learning sciences* (2nd ed.). Cambridge University Press.
- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14. <https://doi.org/10.3102/0013189X015002004>
- Surwase, G., Kademani, B., & Bhanumurthy, K. (2012, February). Mapping the structure and development of science using co-citation analysis. *National Workshop on Using Different Metrics for Assessing Research Productivity* 16-17. Kolkata: Indian Statistical Institute.

- Taasoobshirazi, G., & Carr, M. (2008). A review and critique of context-based physics instruction and assessment. *Educational Research Review*, 3(2), 155–167. <https://doi.org/10.1016/j.edurev.2008.01.002>
- Tañedo, A. G., Valera, J. S., Lazaro, N. J., & Limos-Galay, J. A. (2024). Content knowledge and pedagogy of science teachers' spiral progression approach in teaching in Magsaysay, Occidental Mindoro. *International Journal of Research Studies in Educational Technology*, 8(3). <https://doi.org/10.5861/ijrset.2024.8021>
- Tanucan, J. C. M., Hernani, M. R., & Diano, F. (2021). Filipino physical education teachers' technological pedagogical content knowledge on remote digital teaching. *International Journal of Information and Education Technology*, 11(9), 416–423.
- Tytler, R. (2020). STEM Education for the Twenty-First Century. *Advances in STEM Education*, 21–43. https://doi.org/10.1007/978-3-030-52229-2_3
- UNESCO. (2021). *Reimagining our futures together: A new social contract for education*. UNESCO Publishing. <https://unesdoc.unesco.org/ark:/48223/pf0000379707>
- UNESCO. (2022). *Education for post-pandemic recovery: Transforming systems for resilience*. UNESCO Publishing.
- UNESCO. (2023). *AI and education: Guidance for policymakers*. UNESCO Publishing. <https://doi.org/10.54675/PCSP7350>
- Vygotsky, L. (1978b). *Mind in Society: the development of higher psychological processes*. <https://ci.nii.ac.jp/ncid/BA03570814>
- Walker, I., & Zhu, Y. (2013). The benefit of STEM skills to individuals, society, and the economy. *Report to Royal Society's Vision for Science and Mathematics*, 1–38. World Bank. (2019). *Ending learning poverty: What will it take?* World Bank. <https://www.worldbank.org/en/topic/education/publication/ending-learning-poverty>
- World Bank. (2023). *Ending learning poverty: What will it take?* World Bank. <https://documents1.worldbank.org/curated/en/395151571251399043/pdf/Ending-Learning-Poverty-What-Will-It-Take.pdf>
- World Economic Forum. (2020). The future of jobs report 2020. *World Economic Forum*. https://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—where are the educators?. *International journal of educational technology in higher education*, 16(1), 1–27.
- Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. *Organizational Research Methods*, 18(3), 429–472. <https://doi.org/10.1177/1094428114562629>

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