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Editorial

Mapping the Spread of Innovation in Multidisciplinary Applied Engineering Fields: A Review and Bibliometric Analysis

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Abstract

Applications of engineering have developed to numerous sectors and generated cross- and multidisciplinary studies in the academic world and among global practitioners. The present study conducts a bibliometric examination and network visualization of applied engineering studies between 2014 and 2024, based on data taken from the Scopus database. Focus on studies included within the subject area of multidisciplinary studies, the examination delves into international linkage research, author-delineated themes, and index keyword arrangements to identify emerging tendencies and conceptual aggregations. Visualization conducted with the help of VOSviewer identifies the dominance of nations like China, the United States, and the United Kingdom by publishing output and collaborative strength, with increasing participation by emerging nations like India, Saudi Arabia, and Iran. Author keyword examination identifies conventional engineering sectors like mechanical, chemical, and electrical engineering, along with computational techniques like machine learning and optimization. On the other side, index keyword examination identifies the dominance of bioengineering themes involving metabolism, genetics, tissue engineering, and gene expression, with these terms possessing the greatest overall link strengths within the collection. The paper outlines the intricate, intertwined character of contemporary applied engineering by charting innovation across conceptual and geographic dimensions.

Keywords: applied engineering, multidisciplinary, bibliometric

INTRODUCTION

In the evolving landscape of science and technology, applied engineering has become increasingly interdisciplinary, reflecting the convergence of physical sciences, life sciences, and computational intelligence. No longer confined to traditional domains such as mechanical or electrical engineering, today's applied engineering integrates complex biological systems [1], machine learning algorithms [2], [3], and novel material sciences [4]. This

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transformation reflects a shift in tools or methodologies and a paradigm change in conceptualizing and addressing engineering challenges. Transdisciplinary Research (TDR) is crucial for addressing complex societal problems. A general framework for TDR has been proposed, emphasizing improved communication between academics and industry professionals [5].

Interdisciplinary integration is reflected in expanded cooperation across nations and disciplines and expanded research themes. Such instruments as bibliometric mapping, with a preference for the application of VOSviewer, were crucial for studying the structural dynamics of knowledge within this highly emerging field [6]. They help to track the dissemination of the type of ideas as metabolism, tissue engineering, or machine learning, from isolated innovations to key components within multidisciplinary engineering settings. Visualizing the bibliography makes it possible to see how some keywords dominate, transform, or serve as connectors between diverse disciplines.

With increasing scientific globalization, historically leading nations with high research outputs remain the driving forces behind the global applied engineering trajectory. However, newly emerging economies significantly contribute to innovation, forming new regional knowledge clusters [7]. The co-authorship networks between countries and the inter-country collaborative networks identify the dominant positions of countries such as China, the United States, and the United Kingdom, along with the increasing cross-border contribution of India, Saudi Arabia, Iran, and Pakistan. These changes further stress the value of cross-border collaborative relationships for constructing the global research agenda.

Against this context, the current study conducts a bibliometric study of multidisciplinary applied engineering literature published between 2014 and 2024. The study seeks to identify dominant keywords, depict international co-authorship, and contrast the frequency and centrality of themes both from author-assigned and index-assigned viewpoints. By contrasting author keywords (indicative of researcher intention) with index keywords (reflecting the classifications by the indexing authorities), the study provides an intricate understanding of thematic priority, knowledge structure, and emerging fronts of research in applied engineering.

SEARCHING STRATEGY AND VISUALIZATION

Scopus searching with the keywords "applied AND engineering" was used, limited to the Multidisciplinary subject area and the publication years 2014 to 2024. The bibliometric visualizations were generated using VOSviewer [8], which enabled the construction of. The data were interpreted using network maps, overlay timelines, and total link strength rankings, revealing topical structure, temporal trends, and conceptual linkages across the field.

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GENERAL OVERVIEW

Global Collaboration Landscape

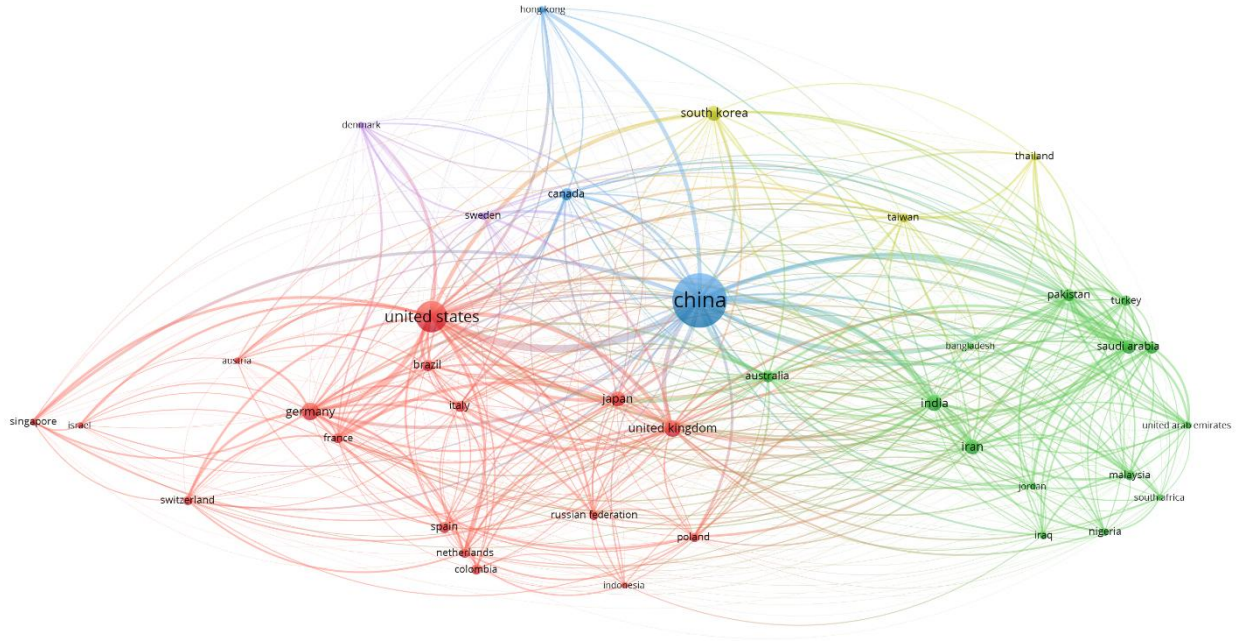

Figure 1. Network country visualization provides an insight into the world collaborative studies on applied engineering

Figure 1 and Table 1 provide an insight into the world's collaborative studies on applied engineering. The largest total link strength (16,741) and the largest document numbers (998) come from China, followed by the United States (14,823 link strength, 346 documents). The United Kingdom, Saudi Arabia, and Germany also demonstrate the widespread international linkage, with every country indicating more than 5,800 link strengths for each of them. The figures suggest that China has been incredibly productive with output and globally highly interconnected, with extensive bilateral and multilateral associations. China's extensive bilateral and multilateral engagements underscore its strategic efforts to enhance global interconnectedness and influence. Through initiatives like the Belt and Road Initiative (BRI) [9], Shanghai Cooperation Organization (SCO) [10], [11], and Asian Infrastructure Investment Bank (AIIB) [12], China has not only bolstered its economic output but also positioned itself as a key player in global governance and international relations

Other newly emerging players, such as India, Pakistan, Iran, and South Korea, show high linkage strengths (2,900 to 4,300), showing these nations' increasing presence in applied engineering. The collaborative density among Asian, Middle Eastern, and Western countries shows an internationally balanced ecosystem in which scientific giants and developing countries with rising capacity for research largely contribute to the growth of the field [7].

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Table 1. Total link strength indicating global collaboration patterns in applied engineering research.

Country	Documents	Citations	Total Link Strength
China	998	14125	16741
United States	346	28603	14823
United Kingdom	101	5138	7432
Saudi Arabia	71	1515	7233
Germany	114	4946	5858
Australia	53	2214	5373
Pakistan	54	934	5249
India	92	2012	4367
Egypt	50	804	3823
Iran	80	2138	3655
South Korea	77	4441	2929
France	40	2104	2757
Japan	76	3963	2670
Italy	47	1273	2636
Canada	49	4170	2614
Poland	34	740	2328
Netherlands	32	1565	2271
Taiwan	29	1633	2191
Brazil	42	538	2069

Author Keywords: Conceptual Framing of Research

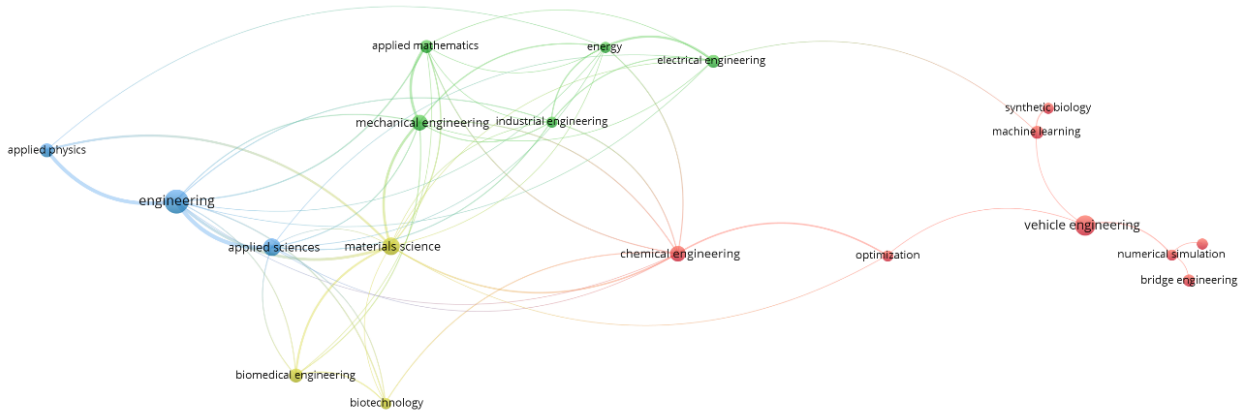

Figure 2. Author-defined keywords network visualization

Author-defined keywords (Figure 2 and Table 2) provide a direct window into how researchers conceptualize their work. The most frequent and central keyword is "engineering" (79 occurrences, 78 total link strength), anchoring most thematic clusters. Materials Science and Applied Sciences (41 occurrences each), linked to topics like biomedical engineering, biotechnology, and energy. Mechanical Engineering, Chemical Engineering, and Electrical Engineering represent domain-specific pillars. Machine Learning and

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Optimization reflect the growing influence of computational tools in solving engineering problems.

Interestingly, Vehicle Engineering (55 occurrences) is highly frequent but has a low link strength (2), suggesting a narrower topical or collaborative scope. Similarly, Synthetic Biology and Bridge Engineering appear less integrated, with minimal linkage to other topics.

Table 2. The link strength of author-defined keywords shows how researchers conceptualize their work in applied engineering.

Author Keywords	Occurrences	Total Link Strength
engineering	79	78
materials science	41	51
applied sciences	41	39
mechanical engineering	34	35
applied physics	25	32
applied mathematics	24	23
energy	16	21
chemical engineering	34	20
biomedical engineering	27	17
electrical engineering	23	16
industrial engineering	16	15
biotechnology	16	11
optimization	16	6
machine learning	23	4
numerical simulation	18	4
vehicle engineering	55	2
synthetic biology	16	1
bridge engineering	19	1
road engineering	17	1

Indexed Keywords: Emergent Trends and Knowledge Structure

Indexed keywords (Figure 3 and Table 3) present a slightly different perspective, as they are standardized terms Scopus uses to catalog articles. The most dominant indexed keyword is "metabolism" (245 occurrences, 1605 link strength), followed by "genetics" (211 occurrences, 1354 link strength) and "chemistry" (180 occurrences, 1179 link strength). This reveals a significant bioengineering and biochemical orientation in applied engineering research [13].

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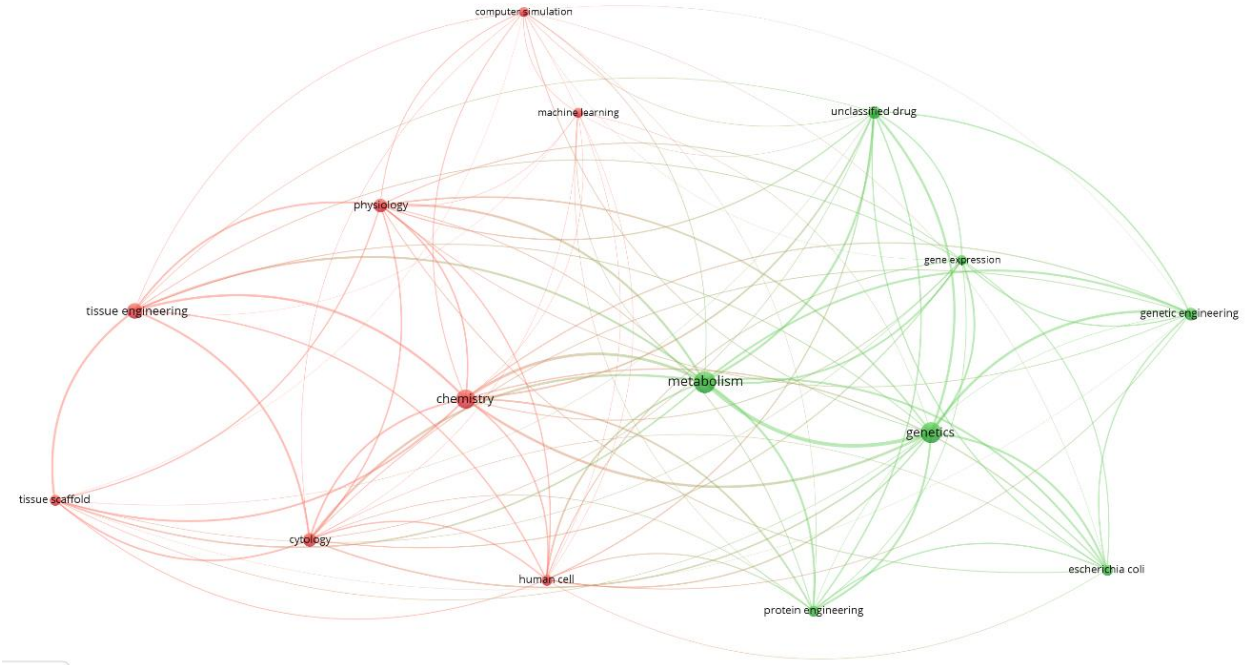

Figure 3. Indexed keywords network visualization

Tissue engineering, physiology, and cytology form a tightly integrated biomedical cluster, reinforcing the earlier observation from author keywords that applied engineering is merging with life sciences. Human cell, gene expression, protein engineering, and Escherichia coli add further depth to this theme, showcasing engineering applications in cellular modeling and synthetic biology.

Computational and AI-based keywords such as computer simulation (187 link strength) and machine learning (174) appear with moderate strength, suggesting growing but still developing roles in the field. The keyword engineering has a relatively lower total link strength (150), implying that it functions more as a broad label than a thematic connector in indexed data.

Table 3. Total link strength of indexed keywords

Index Keywords	Occurrences	Total Link Strength
metabolism	245	1605
genetics	211	1354
chemistry	180	1179
tissue engineering	119	852
physiology	98	741
cytology	90	723
unclassified drug	86	677
human cell	61	587
genetic engineering	83	561
protein engineering	66	531
tissue scaffold	58	511
gene expression	54	415

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escherichia coli	64	388
computer simulation	56	187
machine learning	56	174
engineering	55	150

Keyword Comparison: Author vs Index Perspectives

A comparison between the authors' chosen keywords and the system-generated index keywords reveals clear differences in thematic emphasis and perceived centrality. The index keywords are dominated by biological and biomedical terms such as metabolism, genetics, and cytology. In contrast, the authors' keywords highlight disciplinary and computational concepts like mechanical engineering and machine learning. The strength of connections for bio-related index terms is generally much higher, often exceeding 500, while the computational or mechanical themes defined by the authors typically remain below 100. This pattern indicates that, although researchers frame their work primarily in engineering or computational contexts, the underlying cross-disciplinary linkages captured through the indexed terms show a stronger integration with biomedical and chemical domains. In this way, the authors' keywords convey disciplinary positioning, while the indexed terms reveal broader topic clusters and interconnections shaped by editorial classification practices and citation networks.

CONCLUDING REMARKS

This visualization and bibliometric analysis brings out the multifaceted character of today's applied engineering. The field has transcended the classical silos it occupied, extending to metabolic engineering, synthetic biology, computational modeling, and tissue-based systems. The high linkage strength of biological terms involving metabolism, genetics, and tissue engineering ratifies the proposition that engineering transcends mere mechanical systems to complex integration with living systems today.

Field-defining keywords focus on mechanical engineering, materials science, and optimization, illustrating how researchers frame their studies within traditional categories. However, the indexed keywords expose a latent structure with co-occurrence networks dominated by bioengineering and biomedical applications, indicating a research focus and influence redirection.

At the world level, nations such as the United States, the United Kingdom, and China take significant roles in publishing research and developing global cooperation. New economic giants, especially those of Asia, the Middle East, and Latin America, are entering the global network of applied engineering research, indicating a future with diversified and inclusive participation.

Comparing author and index keyword strategies, this examination offers a dual perspective: what scholars claim to do and what the evidence shows they

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are connected to. Such insights can enlighten funding agencies, research establishments, and policymakers on optimal investment, cooperation, and innovation. The diffusion of innovation within applied engineering is no longer linear but networked, multidisciplinary, and global to a growing degree.

Here, the partnerships between learning institutions and industry serve the key purpose of speeding up the transition of knowledge into practical solutions for the world. The case worth citing is the collaboration between Akademi Inovasi Indonesia and DTECH-ENGINEERING via the teaching factory approach—a converging learning-production space where students, researchers, and industrial practitioners jointly co-create products, prototypes, and engineering solutions. The approach not only hands students hands-on, practical skills applicable to the industry, but also allows firms to access new academic knowledge and innovative ways of thinking. By closing the gap between theory and practice, the partnerships symbolize the potential for applied engineering to flourish both as a teaching field and as an innovation driver for the industrial competitiveness of our multidisciplinary innovation times.

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This editorial employed artificial intelligence (AI) tools to assist the authors in exploring relevant topics, using Scopus AI for literature search and topic exploration, and improving the manuscript's readability and language. The AI tools were not used to replace key authoring tasks such as generating scientific insights, interpreting results, or drawing conclusions. The authors critically reviewed and approved all final content to ensure accuracy, integrity, and originality.

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