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MAPPING THE GLOBAL LANDSCAPE OF STEM EDUCATION RESEARCH: A BIBLIOMETRIC ANALYSIS OF SCOPUS PUBLICATIONS (2010–2024)

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ABSTRACT

This study explores the global research landscape of STEM education using a bibliometric analysis of publications indexed in Scopus from 2010 to 2024. A total of 1,148 documents from 466 different sources were analyzed with the support of VOSviewer and Biblioshiny to examine publication trends, productivity indicators, and keyword co-occurrence networks. The results reveal a steady increase in research output, beginning with fewer than 50 documents in 2010 and reaching more than 250 publications by 2024, which reflects the growing recognition of STEM education as an important area of academic inquiry. Productivity analysis shows that the United States is the most dominant contributor, particularly through institutions such as Texas A&M University and Purdue University, while significant contributions also come from China, Hong Kong, Malaysia, and Australia. At the author level, scholars such as Li Yeping, Morris Siu Yung Jong, and Lyn D. English are identified as influential in advancing the field. The keyword co-occurrence analysis identifies five thematic clusters, namely pedagogy and curriculum, technology integration, equity and sustainability, disciplinary approaches, and learning outcomes. These findings demonstrate that STEM education has become a multidisciplinary and collaborative field of research that is both pedagogically grounded and responsive to societal challenges, offering valuable insights for future research and policy.

Keyword: *STEM education; bibliometric analysis; research productivity; keyword co-occurrence; global research trends*

A. Introduction

In the 21st century, STEM education has emerged as a cornerstone for fostering critical thinking, innovation, and global competitiveness, underpinning advancements across various sectors and preparing future generations for an increasingly complex world. The emphasis on science, technology, engineering, and mathematics is crucial not only for cultivating problem-solving and analytical skills but also for driving sustainable development and technological innovation. Governments, policymakers, and educational institutions worldwide have prioritized STEM initiatives, acknowledging their role in addressing challenges such as climate change, digital transformation, and the demand for a highly skilled workforce (Bybee, 2020; Marginson, 2022). This positioning of STEM education at the intersection of educational practice and socio-economic development highlights its strategic importance for global progress.

Despite its centrality, STEM education remains a dynamic and evolving field shaped by technological advances and societal needs. The integration of emerging technologies such as artificial intelligence, robotics, and digital platforms has transformed teaching and learning practices, while also raising issues of equity, inclusivity, and accessibility across diverse educational contexts (English, 2021; Leung, 2020). Moreover, interdisciplinary approaches that expand STEM into STEAM by incorporating the arts have emphasized creativity and innovation as vital complements to scientific literacy, signaling a broader shift in pedagogical frameworks (Henriksen et al., 2021; Perignat & Katz-Buonincontro, 2019). These trends underscore the growing complexity of STEM education as both a research domain and a practical framework for preparing learners for the future.

Consequently, a bibliometric study offers a rigorous and systematic approach to map the intellectual terrain of STEM education research, thereby identifying prevailing trends, influential works, and nascent areas of inquiry (Rojas–Galeano et al., 2022). Unlike traditional narrative reviews, bibliometric analysis allows for the quantitative assessment of scholarly output, uncovering hidden patterns of authorship, collaboration, and thematic development that qualitative reviews might overlook (Swacha, 2021). By employing this methodology, it becomes possible to delineate the structure of knowledge production in STEM education, highlight its evolution, and identify conceptual frontiers that define its current trajectory (Jamali et al., 2022).

In this context, the present study seeks to provide a comprehensive mapping of the global research landscape in STEM education between 2010 and 2024. Specifically, it aims to characterize temporal publication trends, identify the most productive countries, institutions, and authors, and analyze collaboration patterns and citation impacts. Beyond these objectives, the study also endeavors to uncover major research themes, conceptual clusters, and emerging topics that drive scholarly discourse in STEM education. Ultimately, this bibliometric analysis contributes to a deeper understanding of the structural and dynamic characteristics of STEM education, offering valuable insights into its evolution, current state, and future research directions (Kuzhabekova, 2021; Gumilar et al., 2022; Li et al., 2023; Wang & Wang, 2023).

B. Method

Research Design

This study employs a quantitative bibliometric design to systematically map and analyze the global research landscape of STEM education. Bibliometric analysis is particularly suitable for identifying trends, collaboration patterns, and intellectual structures in a given field because it allows for the evaluation of large datasets of scholarly output using statistical and network-based approaches (Donthu et al., 2021;

Moral-Muñoz et al., 2020). The design of this research is descriptive and exploratory, seeking to provide both a macro-level overview of STEM education scholarship and insights into emerging research frontiers.

Data Source and Retrieval Strategy

The primary source of data for this study is the Scopus database, which was chosen due to its wide coverage of peer-reviewed literature across disciplines, including education, social sciences, and applied sciences. Compared to other databases such as Web of Science, Scopus offers broader coverage of educational research journals, particularly in STEM-related domains (Aria & Cuccurullo, 2020).

A search query was constructed to capture publications explicitly related to STEM education, using the following Boolean string :

(TITLE (stem) AND TITLE-ABS-KEY (education))

The search was limited to publications between 2010 and 2024. Only peer-reviewed articles, reviews, and conference papers were included, while editorials, book reviews, and notes were excluded to ensure academic rigor. Search results get the total 1.148 Article

Data Processing and Analysis

The bibliographic data extracted from Scopus (authors, titles, abstracts, keywords, affiliations, and references) were exported in CSV and RIS formats. Microsoft Excel was used for preliminary cleaning, frequency counts, and descriptive statistics. For advanced bibliometric mapping, the study employed VOSviewer and Biblioshiny (R-based interface for Bibliometrix).

C. Result and Discussion

Overview of Search Results

The bibliometric search of STEM education publications in Scopus covering the period 2010–2024 yielded a total of 1,148 documents drawn from 466 different sources, including journals, books, and conference proceedings. This broad range of outlets highlights the inherently multidisciplinary character of STEM education research, which spans domains of education, technology, and applied sciences. The dataset shows an annual growth rate of 24.36%, reflecting a robust and accelerating expansion of scholarly attention to the field over the past 15 years. A relatively low average document age of 4.71 years further indicates that STEM education is a dynamic and fast-evolving area of study, with a significant concentration of recent contributions (Halawa, 2024; Li et al., 2023).

In terms of impact, the dataset reveals an average of 16.08 citations per document, which demonstrates a moderate yet growing scholarly influence. The conceptual richness of the field is also evident in the inclusion of 2,242 Keywords Plus (ID) and 4,214 Author’s Keywords (DE), which capture a wide thematic diversity ranging from pedagogy and curriculum development to digital learning and equity in STEM. Moreover, the involvement of 5,893 unique authors underscores the extensive collaboration within the field, reflecting its global and networked nature (Kuzhabekova, 2021; Wang & Wang, 2023). Collectively, these indicators confirm that STEM education has developed into a well-established and impactful research domain, while continuing to expand through new thematic clusters such as sustainability, interdisciplinary integration, and emerging technologies (English, 2021; Donthu et al., 2021).

Table 1. Search Result

Description	**Results**
Timespan	2010-2024
Sources (Journals, Books, etc)	466
Documents	1148
Annual Growth Rate %	24,36
Document Average Age	4,71
Average citations per doc	16,08
Keywords Plus (ID)	2242
Author's Keywords (DE)	4214
Authors	5893

Publication Trend

Figure 1 illustrates a steady increase in the number of publications on STEM education indexed in Scopus from 2010 to 2024. During the initial period (2010–2015), the volume of research output was relatively low, averaging fewer than 50 documents per year, which reflects the formative stage of scholarly interest in STEM education. From 2016 onwards, publication output began to rise more noticeably, surpassing 100 documents annually by 2020. This steady growth coincided with the global expansion of STEM-related policies and curricular reforms, indicating a transition from exploratory studies toward broader empirical and applied research (English, 2021; Li et al., 2023).

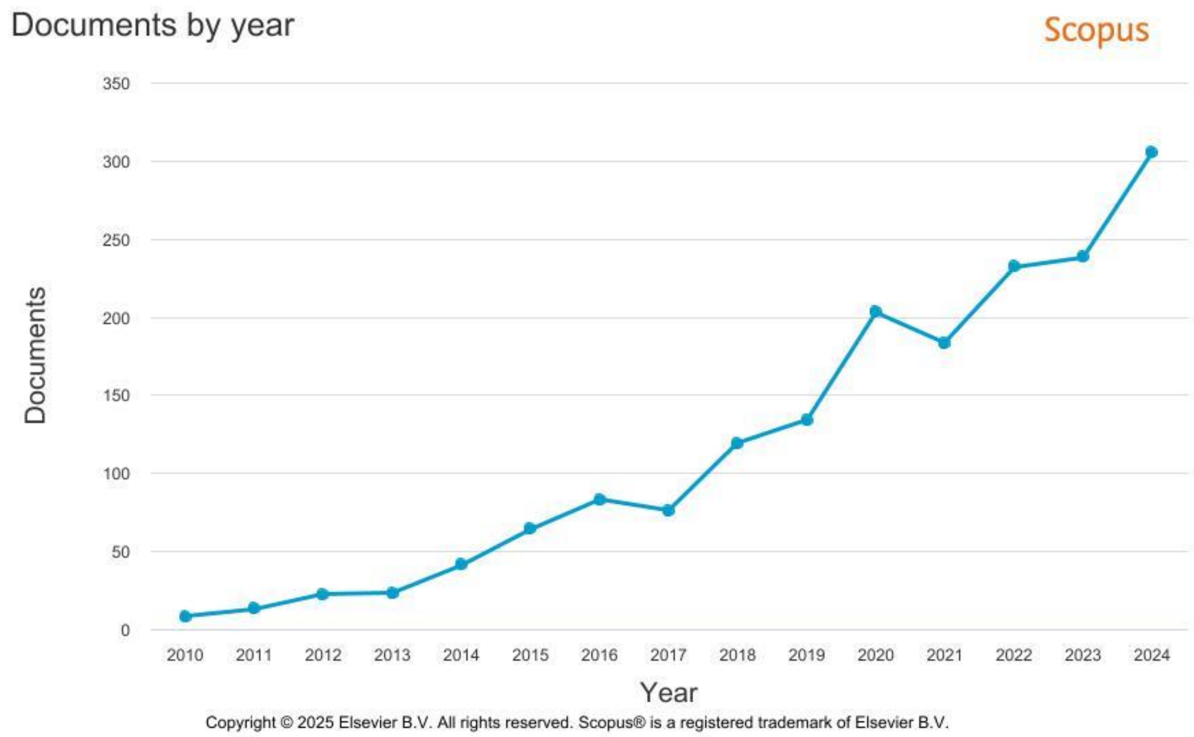

Figure 1. Annual Publication Growth

A significant acceleration occurred after 2020, with publications doubling between 2020 and 2022, largely driven by the COVID-19 pandemic, which intensified research on digital learning and online STEM pedagogy. The sharpest increase is observed in the most recent years, where publications surged beyond 250 documents in 2024, marking the highest growth rate in the period under study. This surge demonstrates the consolidation of STEM education as a critical area of academic inquiry and suggests an ongoing expansion of research themes, including equity, sustainability, and the integration of emerging technologies in teaching and learning.

Productivity Indicators

At the country level (Figure 2), the United States dominates STEM education research output with more than 600 documents, far surpassing other contributors. Turkey, Australia, China, and Spain follow, each producing between 100 and 150 publications, while countries such as Malaysia, Canada, Hong Kong, and Germany contribute in smaller but still significant numbers. This distribution reflects the strong investment and prioritization of STEM education in North America, as well as the increasing engagement of countries in Europe and Asia. The prominence of emerging economies like Turkey and Malaysia highlights the global diffusion of STEM education initiatives, where both developed and developing nations recognize its strategic role in preparing a future-ready workforce.

At the institutional level (Figure 3), Texas A&M University and Purdue University stand out as the most productive institutions, with over 30 documents each. Other leading universities include the Chinese University of Hong Kong, National Taiwan Normal University, and Beijing Normal University, which indicate Asia's growing contribution to STEM education scholarship. The presence of multiple institutions from Hong Kong and Taiwan underscores the region's strategic emphasis on STEM-related reforms, aligning with broader educational modernization policies. Similarly, institutions from North America (University of Minnesota, University of Calgary) and Southeast Asia (Universiti Kebangsaan Malaysia) demonstrate how institutional-level productivity mirrors national priorities and investments in STEM education research.

At the author level (Table 1), Li Yeping (United States) emerges as the most prolific author with 22 publications, reinforcing the country's leadership in the field. Scholars from Hong Kong, such as Morris Siu Yung Jong and Ching Sing Chai, also appear prominently, consistent with the strong institutional contributions from the region. Meanwhile, Fengkuang Chiang (China) and Lyn D. English (Australia) highlight the role of influential individuals in elevating national and institutional visibility. The alignment across countries, institutions, and authors suggests a clear correlation: highly productive nations tend to host leading institutions, which in turn nurture prolific scholars. This triangular relationship illustrates how national policy priorities, institutional strategies, and individual research leadership collectively shape the global landscape of STEM education scholarship.

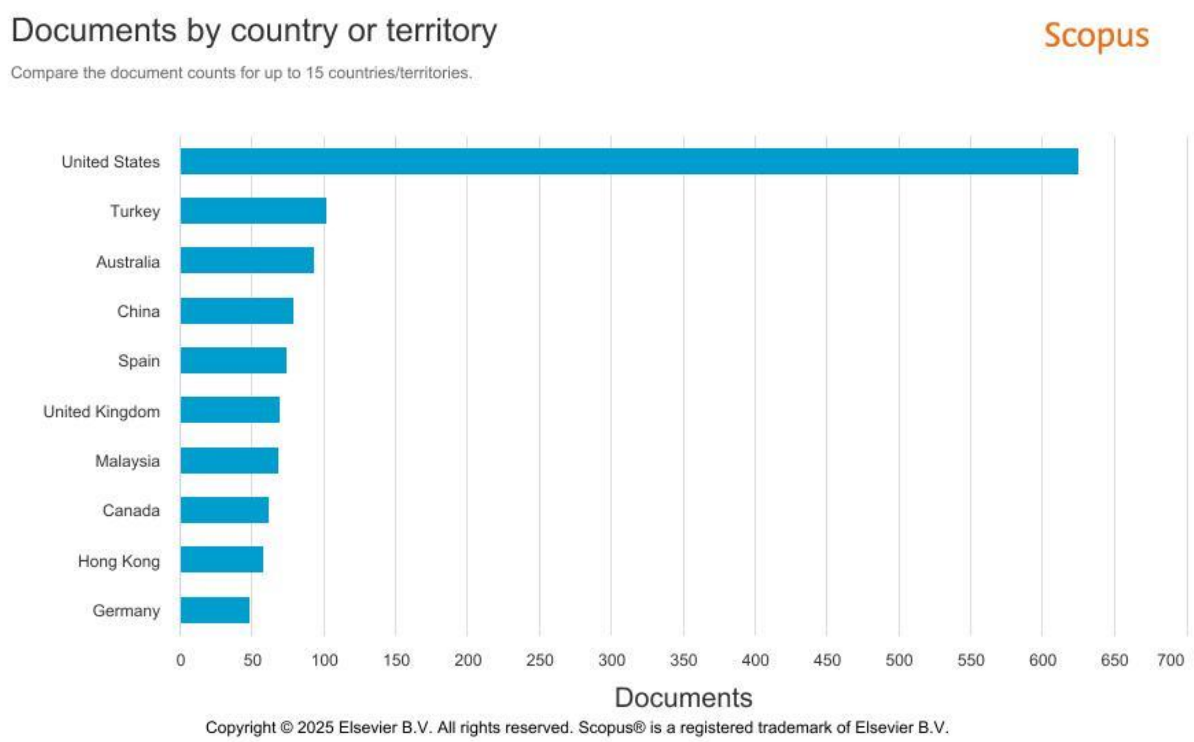

Figure 2. Most Productive Country

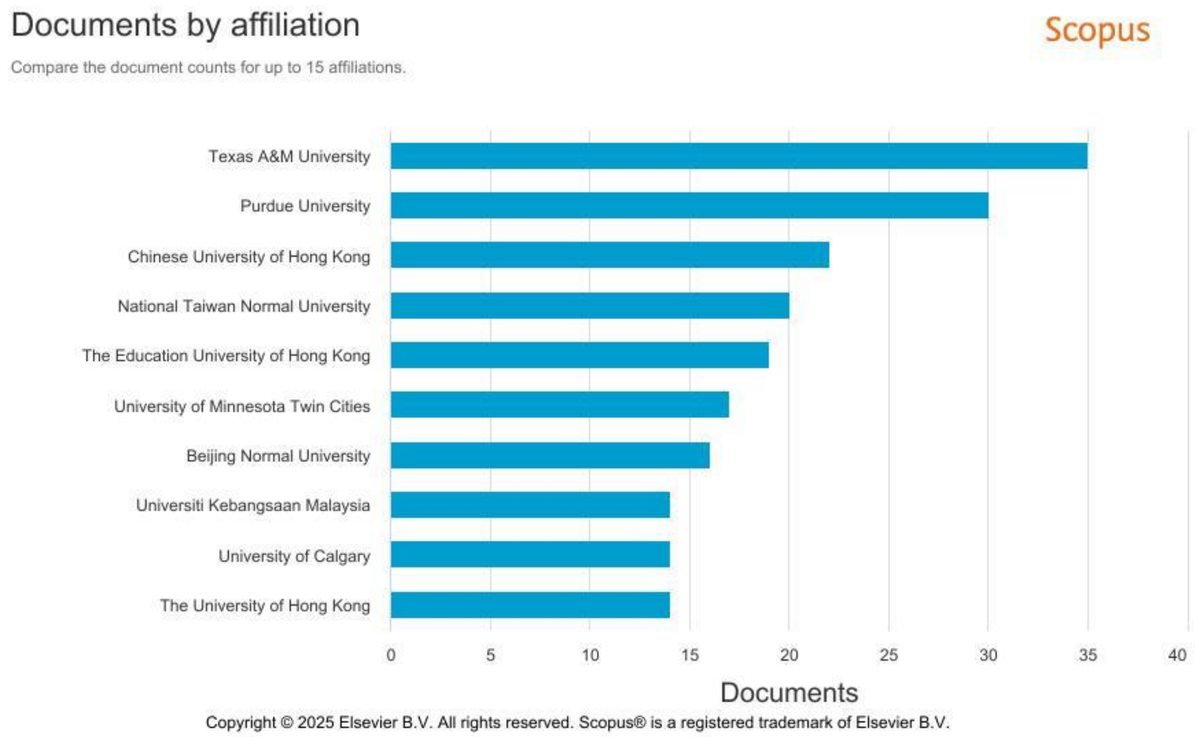

Figure 3. Most Productive Affiliation

No	Author	Country	N. Document
1	Li, Yeping	US	22
2	Jong, Morris Siu Yung	Hongkong	13
3	Chiang, Fengkuang	China	8
4	Chai, Ching Sing	Hongkong	7
5	English, Lyn D.	Australia	7

Keyword Co-Occurrence

The keyword co-occurrence network (Figure X) reveals the thematic structure of STEM education research between 2010 and 2024. The visualization demonstrates several densely connected clusters, each representing a major research focus. The term **"STEM education"** serves as the central node, reflecting its role as the overarching concept that bridges various thematic areas. The prominence of related keywords such as *students, education, teaching, higher education,* and *technology* highlights the multidimensional scope of STEM education, spanning pedagogy, curriculum, policy, and equity issues.

Several important thematic directions can be observed. Keywords like *e-learning, virtual reality, artificial intelligence,* and *educational technology* indicate a growing interest in digital transformation and technology integration in STEM learning environments. Similarly, terms such as *equity, gender, social justice,* and *sustainability* emphasize the increasing attention given to inclusivity and broader societal challenges. Meanwhile, the consistent presence of keywords like *teacher education,* *professional development,* and *curriculum* underscores the ongoing importance of human resource capacity-building within the STEM education system.

The visualization generated by VOSviewer highlights at least **five main clusters**:

1. Cluster 1 (Green) – STEM Pedagogy and Curriculum Development This cluster centers around keywords such as *STEM education, students, teacher education, professional development,* and *curriculum.* It reflects research focusing on instructional strategies, teacher preparation, and classroom practices to effectively implement STEM learning.
2. Cluster 2 (Yellow) – Technology Integration and Digital Learning Dominated by terms like *e-learning, artificial intelligence, virtual reality, educational technology,* and *collaborative learning.* This cluster represents the rapid shift toward technology-enhanced learning and the role of emerging technologies in STEM education.
3. Cluster 3 (Red) – Equity, Diversity, and Societal Impact Keywords such as *equity, gender, social justice, diversity, sustainability,* and *higher education* define this cluster. It highlights research that links STEM education with global challenges, focusing on inclusion, gender equality, and sustainable development goals (SDGs).
4. Cluster 4 (Blue) – STEM Disciplines and Applied Sciences This cluster includes *mathematics education, science education, engineering, technologies,* and *assessment.* It emphasizes subject-specific pedagogy, disciplinary integration, and evaluation frameworks in STEM learning.
5. Cluster 5 (Purple) – Motivation, Learning Outcomes, and School Context Comprised of terms such as *motivation, secondary schools, primary education, academic achievement,* and *systematic review.* This cluster focuses on learners' engagement, assessment of outcomes, and reviews of existing practices across different educational levels.

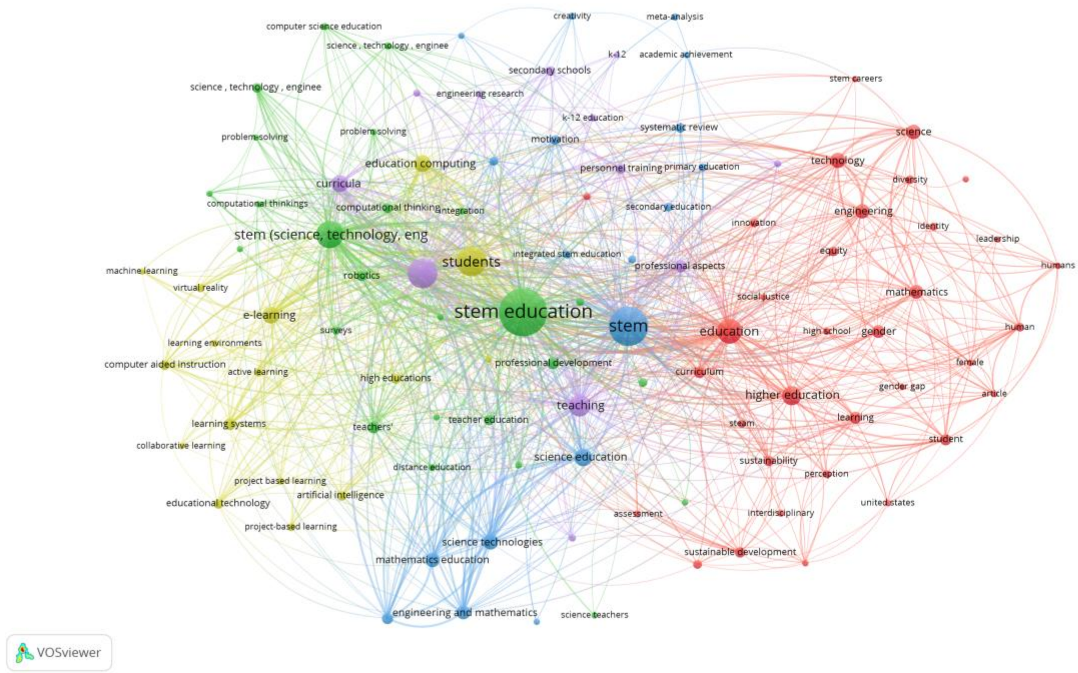

Figure 4. Research Network Visualization

D. Conclusion

The bibliometric analysis of STEM education research from 2010 to 2024 reveals a steadily accelerating publication trend, with output growing from fewer than 50 documents per year in the early 2010s to more than 250 by 2024, reflecting the consolidation of STEM as a global research priority. In terms of productivity indicators, the United States emerges as the most dominant contributor, supported by leading institutions such as Texas A&M University and Purdue University, while Asia-Pacific countries including China, Hong Kong, Malaysia, and Australia also demonstrate strong institutional and author-level productivity, indicating an increasingly internationalized field. The keyword co-occurrence analysis further shows five major thematic clusters: pedagogy and curriculum, technology integration, equity and sustainability, disciplinary integration, and learning outcomes, highlighting that STEM education research is both pedagogically grounded and socially responsive, with a growing emphasis on digital transformation and inclusivity. Collectively, these findings underscore that STEM education has evolved into a dynamic, multidisciplinary, and globally collaborative research domain that continues to expand in scope and impact.

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