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# Mapping, Measuring, and Interpreting Scientific Knowledge in Global Health and Mathematics Education Through Advanced Bibliometric Frameworks

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## Abstract

*Bibliometric analysis has become one of the most influential methodological foundations for understanding how scientific knowledge is produced, structured, disseminated, and evaluated across disciplines. In recent decades, the growing volume of scientific publications, the expansion of digital indexing platforms, and the increasing emphasis on accountability in research systems have created an urgent need for robust, transparent, and theoretically grounded approaches to research evaluation. This article presents an integrated and comprehensive examination of bibliometric frameworks as they apply to two complex and socially significant domains, namely mathematics education and One Health research. Drawing strictly on the provided corpus of references, the study situates classical bibliometric indicators such as the h index within broader epistemological debates about scientific impact, national research performance, and disciplinary identity, while also incorporating advanced science mapping and visualization techniques that reveal the cognitive and collaborative structures of knowledge production.*

*The article first establishes the theoretical foundations of bibliometrics by examining how citation based metrics emerged as proxies for scholarly influence and how they have been adapted to evaluate national and institutional research systems, as demonstrated in the assessment of Turkey scientific output through the h index approach as discussed by Al in 2008. It then expands the analysis to include the role of large scale bibliographic databases such as Web of Science, whose coverage and classification practices significantly shape what is measured and how it is interpreted, as critically analyzed by Birkle and colleagues in 2020 and by Mongeon and Paul Hus in 2016. These infrastructural dimensions of bibliometrics are linked to methodological innovations in science mapping, including co citation analysis, bibliographic coupling, and co word analysis, which provide distinct yet complementary perspectives on the intellectual organization of research fields as articulated by Boyack and Klavans in 2010, Ding and colleagues in 2001, and Borner and colleagues in 2003.*

Keywords: Bibliometrics, Science mapping, Mathematics education, One Health, Research evaluation, Web of Science.



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## 1. Introduction

The modern scientific enterprise is defined not only by the generation of new knowledge but also by the continuous evaluation of that knowledge. As scientific activity has expanded in scale, diversity, and complexity, the question of how to measure, compare, and understand research output has become central to academic governance, funding allocation, and intellectual legitimacy. Bibliometrics emerged historically as a response to this need, providing quantitative techniques for analyzing publications, citations, and collaboration patterns. Yet bibliometrics is far more than a technical toolkit. It is a powerful

epistemological lens through which science itself is observed, classified, and judged.

One of the most widely recognized bibliometric indicators is the h index, which attempts to capture both productivity and impact by identifying the number of publications that have received at least the same number of citations. Al demonstrated how the h index can be used to evaluate the scientific performance of an entire country by examining the case of Turkey, showing that such indicators can be scaled from individual researchers to national research systems (Al, 2008). This scaling, however, is not merely a matter of aggregation. It reflects deeper assumptions about what counts as valuable scientific work and how that value should be distributed across institutions and disciplines.

The increasing reliance on bibliometric indicators has been accompanied by the growing dominance of large citation databases, particularly Web of Science and Scopus. These platforms serve as the empirical foundations of most bibliometric analyses, yet their coverage, classification schemes, and indexing policies exert a profound influence on what is visible and what remains invisible within global science. Birkle and colleagues showed that Web of Science is not simply a neutral repository of scholarly output but a curated data source whose selection criteria shape patterns of inclusion and exclusion across disciplines and regions (Birkle et al., 2020). Mongeon and Paul Hus further demonstrated that the journal coverage of Web of Science and Scopus differs systematically, leading to variations in how disciplines and countries are represented in bibliometric analyses (Mongeon and Paul Hus, 2016).

Within this infrastructure, bibliometric methods have evolved from simple citation counts to sophisticated techniques for mapping the intellectual structure of science. Borner and colleagues described how knowledge domains can be visualized through networks of citations, co citations, and shared keywords, revealing the cognitive architecture of research fields (Borner et al., 2003). Ding and colleagues introduced co word analysis as a way of mapping the thematic content of research, showing how the co occurrence of terms in publications can be used to identify conceptual clusters and research trends (Ding et al., 2001). Boyack and Klavans compared different citation based approaches and argued that direct citation, co citation, and bibliographic coupling each offer distinct perspectives on the research front, meaning the active, cutting edge areas of scientific inquiry (Boyack and Klavans, 2010).

These methodological advances have been systematized and operationalized through science mapping tools such as those reviewed by Cobo and colleagues, who demonstrated how software platforms can support the detection, quantification, and visualization of research field evolution (Cobo et al., 2011a; Cobo et al., 2011b). VOSviewer, in particular, has become a widely used tool for constructing and interpreting bibliometric maps, as described by Van Eck and Waltman (Van Eck and Waltman, 2010).

Despite this methodological sophistication, significant gaps remain in how bibliometric techniques are applied to interdisciplinary and socially embedded fields. Mathematics education is one such field. It lies at the intersection of mathematical content and educational practice, a duality that has long been recognized as both its strength and its conceptual challenge. Aydin emphasized that mathematics education cannot be reduced to either pure mathematics or general pedagogy, but must be understood as a distinct domain with its own epistemological and methodological foundations (Aydin, 1990). Dorfler further argued that the relationship between mathematics and mathematics education is characterized by both continuity and difference, meaning that bibliometric analyses must be sensitive to the hybrid nature of the field (Dorfler, 2003). Drijvers and colleagues demonstrated how bibliometrics can be used to study specific theoretical constructs within mathematics education, such as instrumental orchestration, but also highlighted the complexities of capturing such constructs within citation based frameworks (Drijvers et al., 2020).

Another field that presents both an opportunity and a challenge for bibliometric analysis is One Health. This paradigm integrates human health, animal health, and environmental sustainability into a single conceptual framework, reflecting the interconnected nature of contemporary global health challenges. Destoumieux Garzon and colleagues traced the development of the One Health concept over a decade, emphasizing its interdisciplinary ambition and its ongoing struggle for institutional coherence (Destoumieux Garzon et al., 2018). Chen argued that the development of One Health theory and practice is particularly urgent in China, where rapid social and ecological changes have intensified the risks of emerging infectious diseases (Chen, 2020). Nie and colleagues similarly framed One Health as a new approach to controlling emerging infectious diseases, highlighting its relevance to global public health (Nie et al., 2016). The COVID 19 pandemic, analyzed by Velavan and Christian, further underscored the importance of integrated health frameworks, as zoonotic spillovers and global transmission networks exposed the limitations of fragmented health

systems (Velavan and Christian, 2020).

The rapid expansion of One Health research has itself become a subject of bibliometric study. Miao and colleagues conducted a bibliometric analysis of One Health research priorities, revealing how thematic emphases and collaboration patterns have evolved over time (Miao et al., 2022). Humboldt Dachroeden and colleagues provided a cross disciplinary bibliometric assessment of One Health, showing how the field spans multiple sectors and epistemic communities (Humboldt Dachroeden et al., 2020). These studies illustrate the potential of bibliometrics to illuminate not only the volume of research but also its conceptual and institutional structure.

The central problem addressed in this article is that while bibliometric methods are widely used to evaluate and map scientific activity, their theoretical implications and disciplinary sensitivities are often underexplored. There is a tendency to treat bibliometric indicators as objective measures, even though they are deeply embedded in specific data infrastructures, disciplinary cultures, and policy contexts. By integrating the literature on bibliometric theory and methods with detailed analyses of mathematics education and One Health research, this article seeks to fill a critical gap in understanding how bibliometrics both reflects and shapes interdisciplinary knowledge production.

## 2. Methodology

The methodological foundation of this article is grounded in established principles of bibliometric analysis and systematic review. Rather than conducting a new empirical data extraction, the study adopts a meta analytical and interpretive approach that draws exclusively on the provided references as authoritative sources of both methodological guidance and domain specific insight. This approach aligns with the guidelines articulated by Donthu and colleagues, who emphasized that a rigorous bibliometric study must be transparent, replicable, and theoretically informed, even when it focuses on conceptual synthesis rather than primary data collection (Donthu et al., 2021).

The first methodological layer involves the selection and conceptual framing of bibliometric indicators and mapping techniques. The h index, as discussed by Al, serves as a foundational metric for evaluating productivity and impact at the individual and national levels (Al, 2008). However, rather than treating the h index as a standalone measure, the methodology situates it within a broader ecosystem of indicators, including citation counts, collaboration metrics, and thematic clustering. Ellegaard and Wallin argued that the impact of scholarly production cannot be captured by a single metric, but must be understood through a combination of quantitative indicators and qualitative interpretation (Ellegaard and Wallin, 2015).

The second methodological layer concerns the data sources that underpin bibliometric analysis. Web of Science is treated as a paradigmatic example of a global citation database whose structure and coverage shape bibliometric outcomes. Birkle and colleagues provided a detailed analysis of how Web of Science curates and categorizes scholarly output, making it a critical reference point for understanding the epistemic boundaries of bibliometric data (Birkle et al., 2020). Mongeon and Paul Hus complemented this by comparing Web of Science with Scopus, thereby highlighting the methodological implications of database selection (Mongeon and Paul Hus, 2016).

The third methodological layer involves science mapping and visualization. Although this article does not present visual maps, it draws conceptually on the frameworks developed by Borner and colleagues, Cobo and colleagues, and Van Eck and Waltman to describe how knowledge domains are structured and how research fronts evolve over time (Borner et al., 2003; Cobo et al., 2011a; Cobo et al., 2011b; Van Eck and Waltman, 2010). These frameworks provide the theoretical basis for interpreting co citation networks, co word clusters, and bibliographic coupling patterns in the two focal fields.

The fourth methodological layer integrates systematic review principles, particularly those articulated in the PRISMA statement by Moher and colleagues. While PRISMA was originally designed for medical systematic reviews, its emphasis on transparency, inclusion criteria, and methodological rigor is equally relevant to bibliometric synthesis (Moher et al., 2009). By explicitly grounding the analysis in a defined corpus of references, the study ensures that its interpretations remain traceable and reproducible.

Finally, the methodology incorporates a comparative and contextual dimension by examining how national research intensity and international collaboration influence bibliometric patterns. Bordons and colleagues demonstrated that the R and D intensity of countries affects the impact of international collaborative research, suggesting that bibliometric outcomes are deeply intertwined with economic and policy contexts (Bordons et al., 2015). This insight is used to interpret the global distribution of mathematics education and One Health research.

## 3. Results

The descriptive bibliometric interpretation of the provided literature reveals several interconnected patterns that characterize contemporary scientific knowledge production. One of the most striking findings is the centrality of infrastructure in shaping bibliometric visibility. Web of Science, as analyzed by Birkle and colleagues, functions not merely as a database but as a gatekeeper that defines which journals, disciplines, and regions are counted as part of the global scientific record (Birkle et al., 2020). This has direct implications for fields such as mathematics education and One Health, which often publish in interdisciplinary or regionally focused journals that may not be fully represented in mainstream databases.

The comparative analysis of Web of Science and Scopus by Mongeon and Paul Hus further reveals that bibliometric outcomes are contingent on database choice (Mongeon and Paul Hus, 2016). For example, a country or field that appears highly productive in one database may appear less so in another, not because of substantive differences in research activity but because of variations in coverage. This underscores the importance of methodological reflexivity in bibliometric interpretation.

At the level of indicators, the h index emerges as a powerful yet limited tool. Al demonstrated that the h index can capture both productivity and citation impact, making it attractive for evaluating national research performance (Al, 2008). However, Ellegaard and Wallin cautioned that such metrics can obscure important qualitative differences between fields and research traditions (Ellegaard and Wallin, 2015). In mathematics education, for instance, the citation culture may differ from that of experimental sciences, leading to lower citation counts despite significant pedagogical influence.

Science mapping techniques reveal that both mathematics education and One Health are characterized by complex thematic and collaborative structures. In mathematics education, the dual identity of the field produces clusters that align with both mathematical content areas and educational theories, reflecting the conceptual tension described by Aydin and Dorfler (Aydin, 1990; Dorfler, 2003). Drijvers and colleagues showed that specific constructs such as instrumental orchestration can form distinct research fronts within this broader landscape (Drijvers et al., 2020).

In One Health, bibliometric patterns reveal a rapidly expanding and highly interdisciplinary field. The bibliometric analysis by Miao and colleagues identified research priorities that span epidemiology, veterinary science, environmental studies, and policy analysis, reflecting the integrative ambition of the One Health paradigm (Miao et al., 2022). Humboldt Dachroeden and colleagues similarly demonstrated that One Health research is distributed across multiple sectors and disciplines, creating a dense network of cross citations and collaborations (Humboldt Dachroeden et al., 2020).

International collaboration emerges as a key driver of impact in both fields. Bordons and colleagues showed that countries with higher R and D intensity tend to achieve greater impact through international collaboration (Bordons et al., 2015). This pattern is evident in One Health, where global challenges such as COVID 19 have stimulated cross border research partnerships, as highlighted by Velavan and Christian (Velavan and Christian, 2020).

## 4. Discussion

The results of this bibliometric interpretation point to several deep theoretical and practical implications. First, they challenge the notion that bibliometric indicators are neutral measures of scientific quality. Instead, they reveal that metrics such as the h index are embedded in data infrastructures, disciplinary cultures, and policy regimes that shape their meaning and consequences. This insight aligns with the broader critique of bibliometrics articulated by Ellegaard and Wallin, who argued that the impact of scholarly production cannot be reduced to simple numbers (Ellegaard and Wallin, 2015).

Second, the analysis highlights the epistemological complexity of interdisciplinary fields. Mathematics education and One Health both resist simple classification, yet bibliometric systems often rely on rigid disciplinary boundaries. This tension can lead to the underrepresentation or misclassification of research that does not fit neatly into established categories, a problem that has been observed in the coverage practices of major databases (Birkle et al., 2020; Mongeon and Paul Hus, 2016).

Third, the findings underscore the importance of science mapping as a complement to traditional metrics. By revealing the thematic and collaborative structure of research fields, mapping techniques provide a richer and more nuanced understanding of scientific activity than citation counts alone (Borner et al., 2003; Cobo et al., 2011a; Cobo et al., 2011b).

At the same time, the analysis has limitations. Because it is based on a predefined set of references, it cannot capture the

full diversity of either mathematics education or One Health research. Moreover, the reliance on existing bibliometric studies means that any biases or gaps in those studies are necessarily reflected here. Future research could address these limitations by combining bibliometric analysis with qualitative methods such as expert interviews and ethnographic studies of research communities.

## 5. Conclusion

This article has demonstrated that bibliometric frameworks, when applied critically and contextually, offer powerful tools for understanding the structure and evolution of scientific knowledge. By integrating theoretical insights from bibliometrics with detailed analyses of mathematics education and One Health research, it has shown that metrics, maps, and databases are not merely technical instruments but active participants in the construction of scientific reality. In an era of global challenges and interdisciplinary collaboration, a reflexive and theoretically informed approach to bibliometrics is essential for ensuring that research evaluation supports, rather than constrains, the creative and integrative potential of science.

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