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RESEARCH ARTICLE

A Bibliometric Analysis of Research on Biology Teachers' Assessment Practices in Basic Education (2000–2025)

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Abstract

This study conducted a bibliometric analysis of research on biology teachers' assessment practices in basic education from 2000 to 2025. It aimed to examine publication trends, key sources, influential authors, and emerging themes in the field. Data were retrieved from the Scopus database and analyzed using Biblioshiny and Microsoft Excel. A total of 218 documents from 108 sources were included, showing a steady increase in research output with an annual growth rate of 8.39%. Findings revealed that journal articles were the dominant publication type, with strong collaboration among authors but limited international partnerships. Thematic analysis indicated a shift from traditional assessment methods toward formative, technology-integrated, and student-centered approaches. The study also identified gaps in regional representation and research focus. The findings provide valuable insights into the evolution of assessment practices in biology education and offer recommendations for educators, researchers, and policymakers to enhance teaching and assessment strategies.

Keywords: Teaching Biology, Bibliometric analysis, Biology Education, assessment practices, basic education, formative assessment, research trends, Scopus database.

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Introduction

Assessment plays a crucial role in shaping both teaching strategies and student outcomes in education, especially in science education. In biology, effective assessment methods are vital for measuring students' understanding of complex scientific concepts Chen et al, (2025). Despite the growing significance of assessment in biology education, there is limited research analyzing biology teachers' assessment practices in basic education Achor et al, (2025). This study aimed to address this gap by conducting a bibliometric analysis of research on biology teachers' assessment practices from 2000 to 2025.

Over the past two decades, transformations in education, driven by technological advancements and policy changes, have reshaped how biology teachers assess student performance Mena-Guacas et al, (2025). If this gap is not addressed, educators may continue to rely on outdated assessment methods that do not fully support students' learning needs, potentially limiting students' academic performance and long-term learning outcomes (Palmes, 2024). Research on biology teachers' assessment practices remains fragmented, and there is no comprehensive analysis of global trends Lubis et al, (2025).

Studies have explored various assessment methods, including formative and summative assessments, and the integration of technology (Choudhary & Bano, 2022). However, there is no comprehensive analysis synthesizing these practices on a global scale (Garcia, 2025). This study filled this gap by providing a bibliometric analysis that tracks the evolution of biology teachers' assessment practices over the last 25 years, focusing on trends, methodologies, and the influence of technology.

Bibliometric analysis, using academic database Scopus was the primary methodology (Maral, 2023). This study examined the frequency of publications, key themes, and technological advancements in biology assessment Fayzullina et al, (2023). It also explores the geographical distribution of research and identified regions contributing most to this field Ismail et al, (2025). One key objective is to explore the thematic evolution of biology assessment practices. By analyzing keywords and mapping trends, the study tracked the shift from traditional assessments to digital tools and interactive learning methods (Mariati, 2024). It
also explores the emerging role of artificial intelligence and machine learning in assessments and the growing importance of formative assessments (Zhai, 2024).

The study examined the international collaboration in biology assessment research. By analyzing co-authorship networks and citation patterns, it identified influential scholars, journals, and institutions contributing to this field (Shushanyan & Ohanyan, 2022). The study also highlighted gaps in the literature, such as underrepresented regions, and offer recommendations for future studies Santoso et al, (2025). The findings provide insights into how biology teachers assess students' learning and how these practices have evolved over time. By identifying gaps in the literature and tracking trends from 2000 to 2025, this study offered valuable insights for educators and researchers aiming to improve biology assessment practices. It also aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 4: Quality Education, SDG 12: Responsible Consumption and Production, and SDG 3: Good Health and Well-being (United Nations, 2025).

This bibliometric analysis offered a comprehensive overview of the trends, methodologies, and challenges in biology education. By addressing gaps and tracking the evolution of assessment practices, this study contributed to improving educational practices and provide a valuable resource for future research (Kadirhanoğulları & Köse, 2024b).

Methodology

This study employed a bibliometric research design, which was a quantitative method used to analyze academic literature. Bibliometric analysis allowed for the systematic examination of publication patterns, authorship, institutional affiliations, and thematic trends in research related to biology teachers' assessment practices in basic education. The study used descriptive and inferential methods to interpret the data collected from reputable databases

This study adopted an Input–Process–Output (IPO) framework to analyze research on assessment practices in basic education. The input consists of relevant publications retrieved from the Scopus database using carefully selected keywords. The process involved bibliometric analysis, including performance analysis and science mapping techniques such as keyword co-occurrence and thematic evolution. The final output of the study is a proposed assessment guide for biology teachers in basic education. This guide is informed by the findings of the bibliometric and thematic analyses, ensuring that it reflects current trends, research gaps, and best practices identified in the literature. See flow of the study on the next page.

The research was conducted in a digital environment using the online academic database Scopus. This platform provided access to peer-reviewed articles, conference papers, and other scholarly publications relevant to the topic. The analysis was performed using bibliometric tool Biblioshiny (R-based).

The study utilized several tools to support data processing and analysis. Biblioshiny was used for data cleaning and visualization to ensure accurate and well-organized bibliometric information. Microsoft Excel was employed to manage, tabulate, and analyze the data as well as the preparation of tables and figures that supported the interpretation of research patterns.
A bibliometric analysis was carried out beginning with the collection of publication data from Scopus, a comprehensive bibliographic database managed by Elsevier that provides global, interdisciplinary scientific information. The database search was conducted using advanced TITLE-ABS-KEY keywords.

(("biology teacher*" OR "science teacher*") AND ("assessment" OR "evaluation" OR "testing" OR "grading" OR "feedback") AND ("school" OR "basic education" OR "secondary education" OR "primary education"))) AND PUBYEAR > 1999 AND PUBYEAR < 2027 AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ARTS") OR LIMIT-TO (SUBJAREA , "PSYC") OR LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "MEDI") OR LIMIT-TO (SUBJAREA , "MULT")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ch")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (LANGUAGE , "English"))

The search results were then filtered based on specific criteria, including publication year (2000–2025), language (English), and relevance to the research topic. After filtering, the metadata of the selected documents—such as title, author(s), abstract, keywords, institution, country, and citation count—were exported in CSV format for further analysis.
After the data collection phase, several steps were undertaken to prepare the dataset for analysis. Each article was rechecked to ensure that it addressed assessment practices, evaluation, or testing conducted by biology teachers or science teachers teaching biology. The studies were required to be situated within basic education (i.e., elementary, junior high, or senior high school levels). Articles that focused exclusively on higher education, university-level biology courses, or non-teaching assessments (e.g., diagnostic tools for research purposes) were excluded.

Data Analysis. The data were analyzed using a combination of descriptive and network-based techniques, primarily through the use of Biblioshiny. Descriptive statistics, including frequency counts, percentages, and trend analysis, were applied to summarize publication patterns over time. Network analysis was conducted using Biblioshiny to examine co-authorship relationships and institutional collaborations, providing insights into research connectivity. Geographic analysis was performed to determine the distribution of publications by country, highlighting global research contributions. Source analysis was carried out to identify the most cited journals and institutions, offering an overview of influential sources within the field.

Results

The Distribution Pattern of Published Documents on Research on Biology Teachers' Assessment Practices in Basic Education.

Table 1, presents dataset covers 218 documents published from 2000 to 2025, sourced from 108 journals, books, and related outlets, indicating a broad dissemination of research. The field demonstrates a steady growth, with an annual growth rate of 8.39%, reflecting increasing scholarly interest over time. The average document age of 8.36 years suggests

that the literature is relatively recent, while the average of 17.65 citations per document indicates moderate to strong research impact. A total of 1,730 references highlights substantial engagement with prior studies. In terms of content, authors contributed more author keywords (564) than Keywords Plus (243), suggesting diverse and author-driven thematic emphases. The research community is highly collaborative, with 550 authors involved, an average of 2.87 co-authors per document, and only 42 single-authored documents. However, international collaboration remains limited (12.39%), indicating opportunities for greater global engagement. Regarding document types, journal articles dominate (195), while book chapters (11) and conference papers (12) play a minor role, emphasizing journals as the primary medium for knowledge dissemination in the field

Table 1. General information of published documents on research on biology teachers' assessment practices in basic Education

	Results
DATA SET PROPERTIES	
Timespan	2000:2025
Sources (Journals, Books, etc)	108
Documents	218
Annual Growth Rate %	8.39
Document Average Age	8.36
Average citations per doc	17.65
References	1730
DOCUMENT CONTENTS	
Keywords Plus (ID)	243
Author's Keywords (DE)	564
AUTHORS	
Authors	550
Authors of single-authored docs	32
AUTHORS COLLABORATION	
Single-authored docs	42
Co-Authors per Doc	2.87
International co-authorships %	12.39
DOCUMENT TYPES	
Article	195
Book chapter	11
Conference paper	12

Figure 1 shows that publication output was relatively low in the early 2000s, increased gradually over time, and peaked in 2020 with 24 articles, remaining strong through 2025. Earlier years exhibit much higher citation impact per article and per year, indicating that a smaller number of papers generated substantial influence, particularly in years such as 2000, 2008, 2012, and 2017. Recent years (2022–2025) show lower mean citations, which is largely attributable to shorter citable periods rather than weaker productivity. The trend suggests a transition from fewer but highly cited publications to a higher volume of more recent articles that have not yet had sufficient time to accumulate citations.

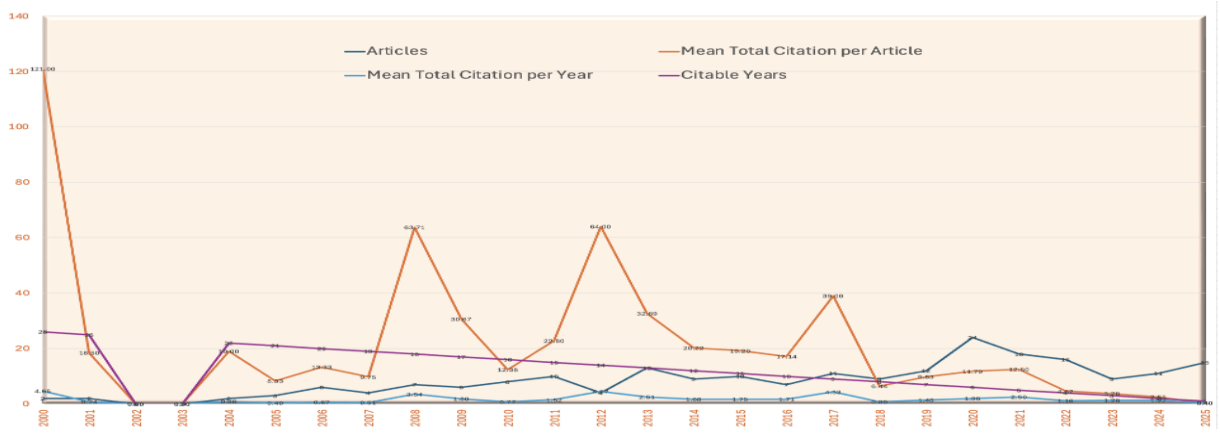


Figure 1. Annual distribution pattern of production and citation of published documents

The Main Sources of Documents of Journal, Countries, Institutions and Authors in the field

Figure 2 shows the publications are concentrated in a small group of core journals, led by the Journal of Science Teacher Education (15 articles), indicating its central role in the field. This is followed by the Journal of Research in Science Teaching and Research in Science Education (9 articles each), and the International Journal of Science Education (8 articles), all of which are well-established outlets in science education research. Most other sources contributed 3–6 articles, showing a long-tail distribution where research is dispersed across many journals with smaller outputs. Overall, the pattern suggests that while the field is anchored in leading science education journals, it also benefits from diverse regional and interdisciplinary publication venues

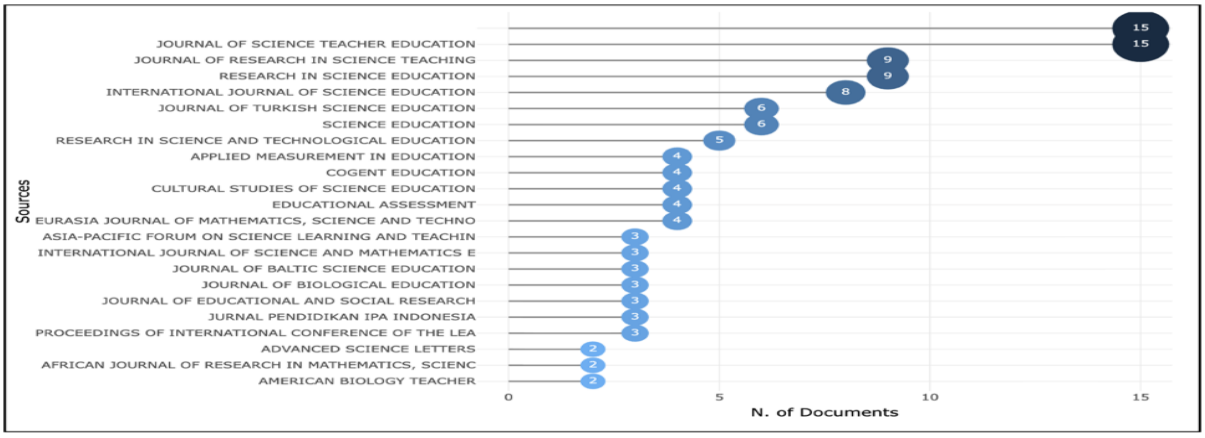


Figure 2. Main Sources of Documents

Figure 3 maps the sources of documents of countries on research on biology teachers' assessment practices in basic education across the world, with color intensity indicating the volume of production output. Country with darker shade color indicates higher contribution while the lighter shade means lower contributions. The data show a strong dominance of the United States, with a continuous and substantial increase in publications from 2000 to 2025, reaching 201 articles, making it the leading contributor in the field. China follows with steady growth, particularly after 2014, culminating in 30 articles by 2025. Australia also demonstrates consistent output, rising to 20 articles, indicating sustained research engagement. The United Kingdom and Turkey show moderate but gradual increases, with Turkey's output accelerating after 2017. Malaysia and the Philippines emerge later in the timeline, with noticeable growth only after 2015, reflecting recent but increasing participation in the field. The pattern highlights concentration of research in developed research systems, alongside a gradual expansion of contributions from emerging countries.

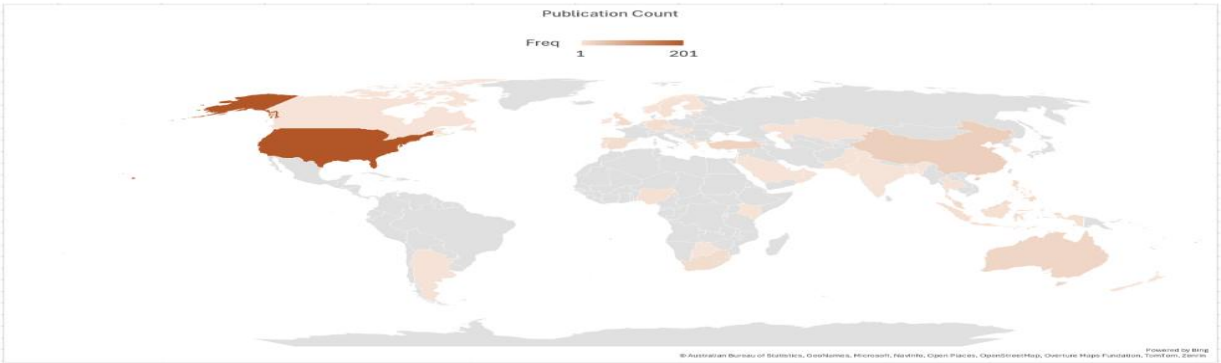


Figure 3. Main Sources of Countries

Figure 4 indicates that Stanford Graduate School of Education is the leading contributor, showing early involvement and steady growth, reaching 10 articles by 2025. University of Colorado Boulder also demonstrates strong and continuous growth, emerging as a major contributor with the highest output (12 articles) by 2025. Several institutions, including University of Hawai‘i at Mānoa, Michigan State University, and University of California, show stable but moderate productivity, reflecting sustained research engagement rather than rapid expansion. Institutions such as National Taiwan Normal University, University of Notre Dame, and Universiti Pendidikan Sultan Idris exhibit later entry with noticeable growth after 2015, indicating increasing participation from Asian and international institutions. The pattern highlights a concentration of research output among well-established U.S. universities, alongside a gradual diversification of contributing institutions in recent years.

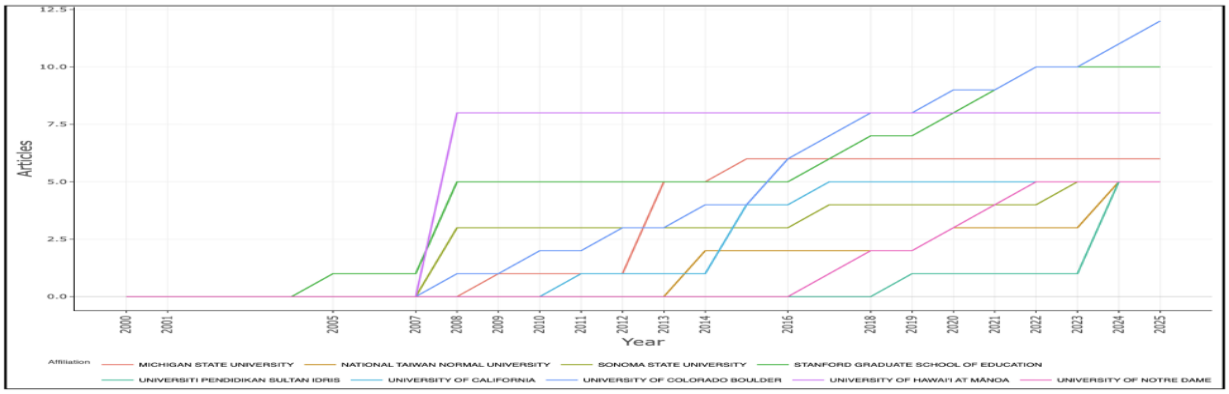


Figure 4. Main Sources of Institutions

Figure 5 presents the publication timelines, productivity, and citation impact of key authors in the field. Each horizontal line represents the active years of an author, while the size of the circles corresponds to the number of articles published and the shading reflects the average citations per year. The results show that authors such as Furtak E.M., Dawson V., and Erduran S. demonstrate long-term research engagement, with publication records spanning more than a decade. This indicates sustained contributions and continued relevance in the field. Authors like Govender S., Kok L., and Mncube D.W. exhibit more recent activity, particularly from 2018 to 2025, suggesting emerging or currently active contributors. Notably, some of these authors display relatively larger nodes, indicating strong citation impact despite shorter publication periods. Several authors, including Jita L.C., Ramnarain U., and Abdullah H.N., show moderate but consistent productivity, contributing across multiple years with varying citation influence. Meanwhile, others such as Ayala C.C. and Brandon P.R. appear to have limited but impactful contributions, as indicated by fewer yet relatively larger nodes.

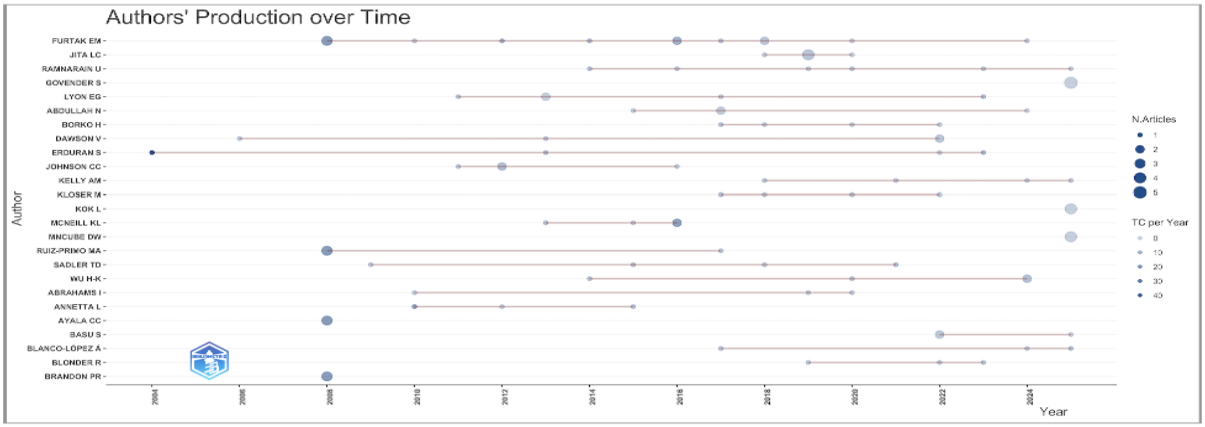


Figure 5. Authors by number of production research on biology teachers' assessment practices in basic education

Figure 6 presents the thematic analysis indicates that current research on biology teachers' assessment practices is increasingly anchored in formative and classroom assessment, which function as central and well-developed themes in the field. These studies emphasize how assessment is used to support learning within biology classrooms, particularly through alignment with science education, pedagogical content knowledge, and professional development highlighting teachers' continuous capacity-building as a key research focus. Research also underscores the growing importance of students and biology teachers' reflecting a shift toward learner-centered and teacher-responsive assessment approaches. Foundational themes such as teacher knowledge and middle school assessment continue to support the field, providing essential frameworks for understanding how assessment practices are enacted. Areas such as scientific literacy, practical work, ecology, and broader biology education appear as emerging or less emphasized themes, suggesting opportunities for further investigation. The presence of science teacher achievement as a niche theme indicates a specialized but underexplored line of inquiry. The map reflects a research trend moving toward formative, practice-oriented assessment in biology teaching, while pointing to new directions for expanding assessment research across diverse biology contexts.

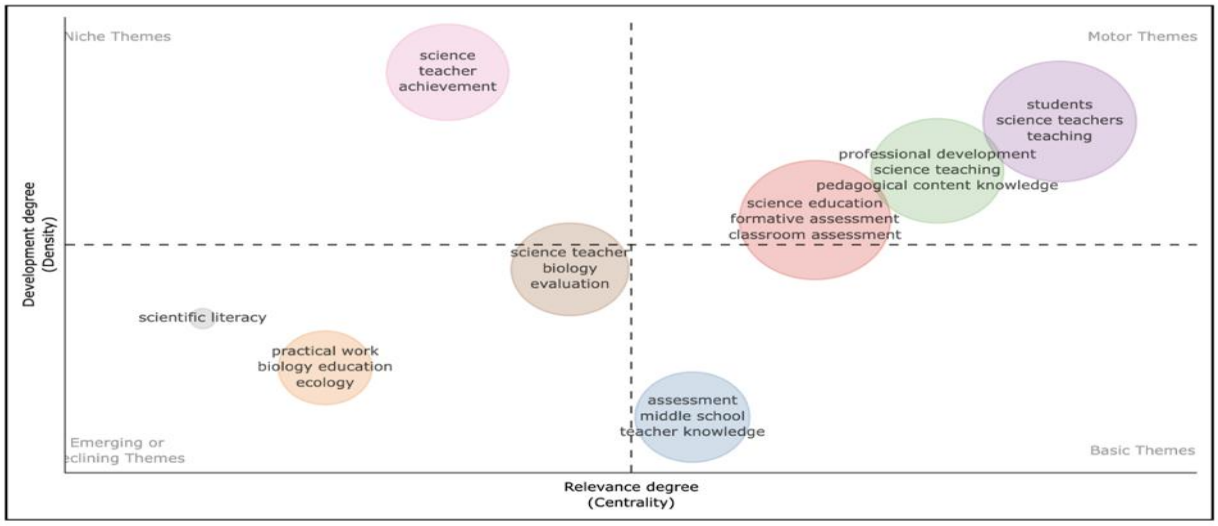


Figure 6. Thematic Map

Figure 7 shows that emerging research on biology teachers' assessment practices is strongly centered on formative assessment within science education, as indicated by its highest betweenness and PageRank values, highlighting its role as a key connecting and influential concept in the network. Closely linked themes such as feedback, classroom assessment, science classroom practices, and biology education suggest a growing focus on assessment as an ongoing, instructional process rather than a purely evaluative one. The prominence of students, teaching, and teaching and learning further reflects an increased emphasis on learner-centered and evidence-based assessment approaches. The presence of professional development, professional learning, and professional aspects indicates an emerging research trend that examines how teachers' assessment literacy and continuous training influence effective assessment practices in biology classrooms. Newer but notable concepts such as learning progressions, evaluation methodologies, and learning systems point to a shift toward more systematic, data-informed, and progression-based assessment strategies across primary, middle, and secondary biology education.

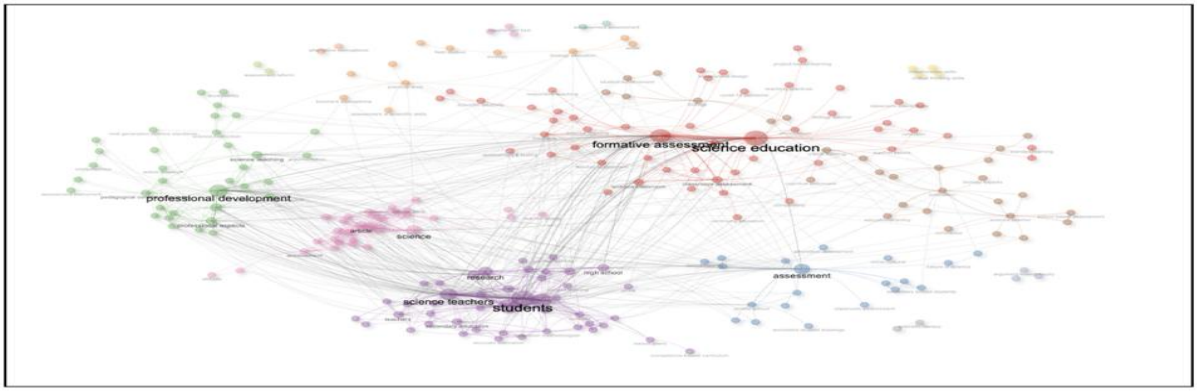


Figure 7.

Visualization of keywords based on occurrence time with emphasis on the centrality and frequency of formative assessment and science education

Figure 8 shows a sharp global increase in research on biology teachers' assessment practices in basic education, especially after 2010, with one country dominating and reaching nearly 200 articles by 2025. Most other countries remain below 50 articles, indicating uneven research development. This trend implies a growing emphasis on evidence-based assessment to improve biology teaching, influencing curriculum reforms and teacher training. However, the disparity suggests a need for international collaboration and capacity-building to ensure widespread adoption of innovative assessment practices.

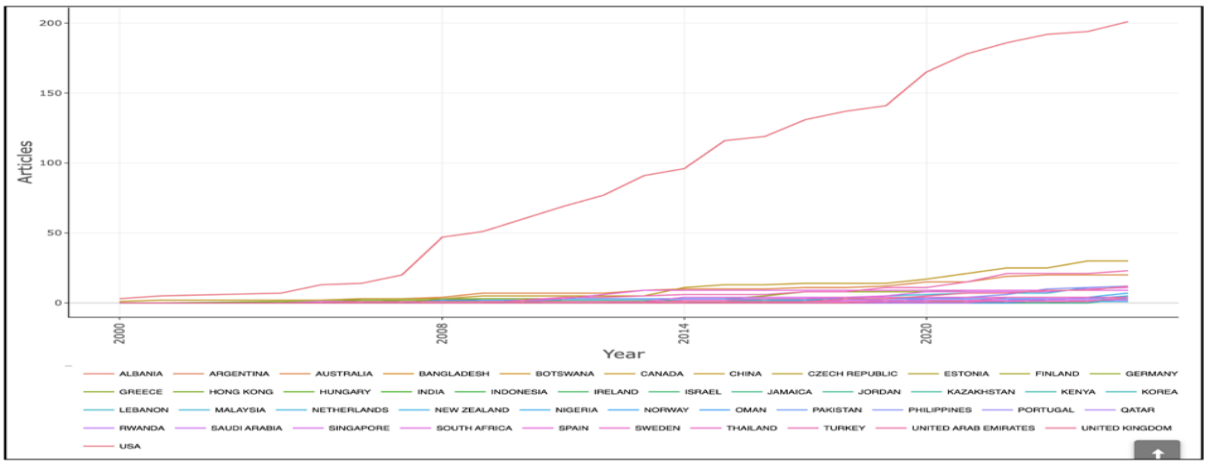


Figure 8. Leading Countries conducting research biology teachers' assessment practices in basic education

Figure 9 shows prominent central cluster is led by Furtak, Erin Marie, indicating her role as a key hub with strong collaborative ties to multiple researchers, particularly bridging to another well-connected group. Other clusters are relatively smaller and more isolated, suggesting localized or limited collaboration among specific research teams. The weak connections between clusters indicate that the field is fragmented, with few authors acting as connectors across research groups. The network highlights centralized influence by a small number of leading scholars and limited cross-group collaboration within the field

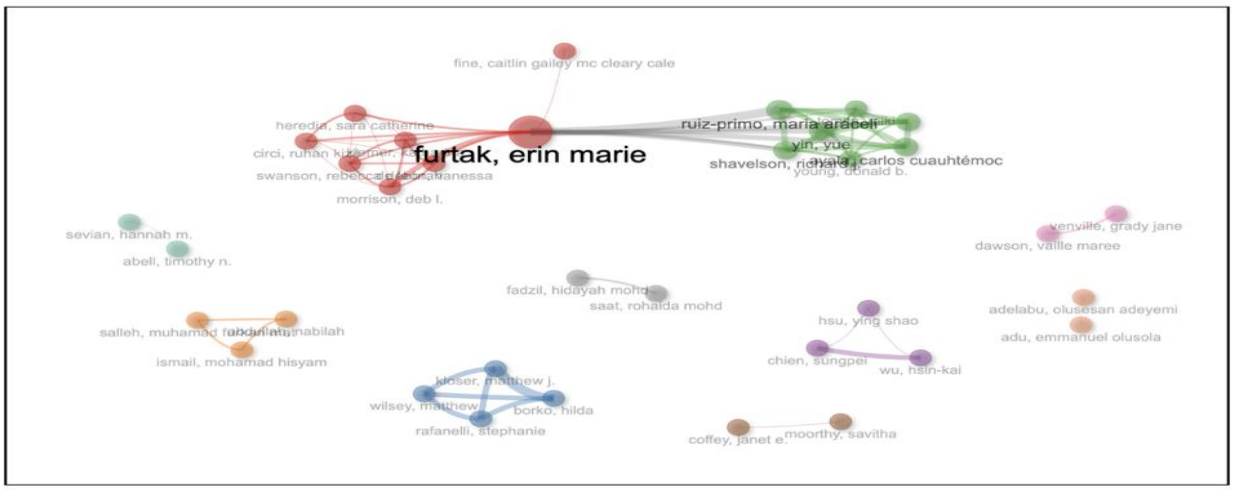


Figure 9. Collaboration Network

Figure 10 shows the collaboration patterns suggest that research on biology teachers' assessment practices in basic education is beginning to reach beyond national boundaries, though international cooperation is still relatively limited. The United States emerges as a key connecting country, partnering with several nations such as Germany and China, which highlights its role in influencing and supporting research development in the field. At the same time, collaborations among countries in Asia, Europe, Africa, and the Middle East show that interest in assessment practices is becoming more globally shared. However, because most partnerships occur only once, the findings imply that researchers often work within local or national contexts. As the field continues to evolve, strengthening sustained international collaborations could enrich research by incorporating diverse classroom realities, promoting shared learning, and improving assessment practices for biology teaching across different basic education systems.

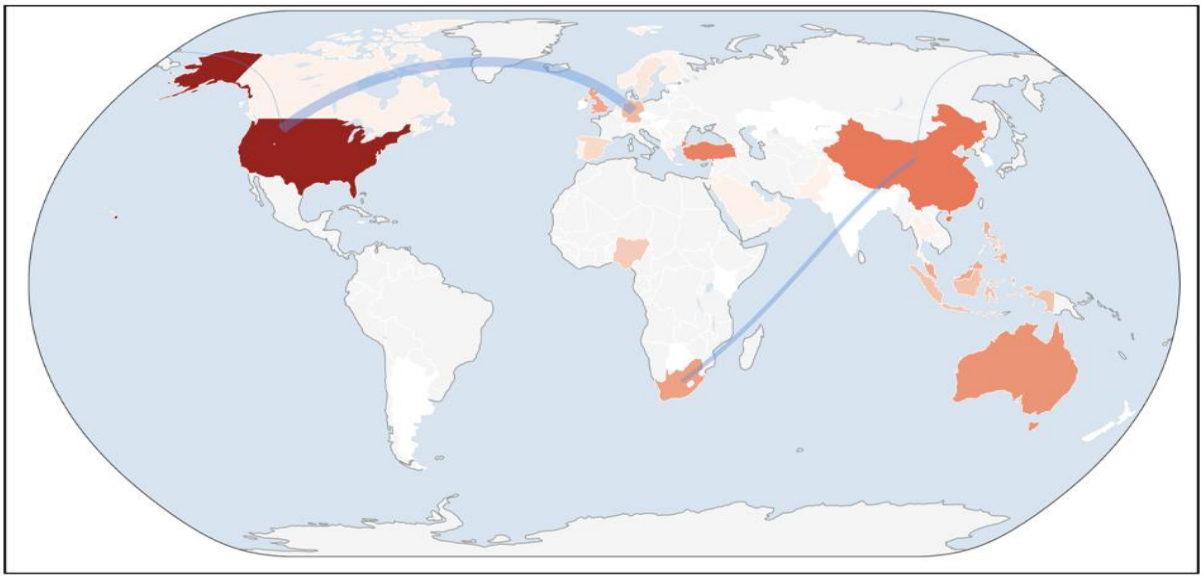


Figure 10. Countries Collaboration

The evolving body of research on biology teachers' assessment practices in basic education carries several important implications for the teaching of biology. The strong shift from traditional summative assessments toward formative and classroom-based assessment implies that biology teaching is becoming more learner-centered. Teachers are now encouraged to continuously monitor students' understanding, provide timely feedback, and adjust instruction accordingly. This development enhances students' conceptual understanding of complex biological topics and supports the development of higher-order thinking skills rather than mere memorization.

The increasing integration of technology and digital assessment tools suggests that biology teaching must adapt to more innovative and flexible learning environments. Tools such as virtual laboratories, online quizzes, and AI-assisted assessments enable more interactive and personalized learning experiences. As a result, biology teachers are expected to develop digital competence and effectively incorporate these technologies to improve both assessment and instruction.

The prominence of project-based and performance-based assessments highlights a shift toward authentic learning. This implies that biology teaching should emphasize real-world applications, inquiry-based learning, and problem-solving. Such approaches help students connect biological concepts to real-life situations, thereby improving engagement and scientific literacy.

The growing focus on professional development and assessment literacy indicates that effective biology teaching depends not only on content knowledge but also on teachers' ability to design and implement appropriate assessment strategies. Continuous training and capacity-building programs are therefore essential to equip teachers with the skills needed to apply modern, evidence-based assessment practices.

The identified global disparities in research and practice imply that biology teaching improvements are uneven across regions. While developed countries are advancing in innovative assessment practices, many developing regions still rely on traditional methods due to limited resources. This highlights the need for increased support, collaboration, and investment in educational infrastructure to ensure equitable and effective biology teaching worldwide.

The overall evolution of research suggests that assessment is no longer a separate component of teaching but an integral part of the learning process. For biology educators, this means that assessment should be used not only to evaluate learning outcomes but also to actively support and enhance student learning throughout the instructional process.

Discussion

The bibliometric profile portrays a research area that has expanded steadily but remains concentrated in particular countries, institutions, journals, and author networks. The annual growth rate of 8.39% and the presence of 218 documents across 108 sources indicate sustained scholarly interest. The concentration of output in a small group of journals and institutions suggests that established science education research communities have played a substantial role in shaping the field.

The prominence of formative assessment, classroom assessment, and feedback is a major thematic finding. It is consistent with the broader educational view that assessment can guide learning when evidence is interpreted and acted upon. In biology, this is especially relevant because conceptual understanding, practical skills, scientific reasoning, and application may not be adequately represented by a single test format. The appearance of professional development as a central theme further suggests that teachers' capacity to use assessment evidence is an important condition for meaningful implementation.

The results also reveal a gap between the global reach of the topic and the distribution of research contributions. The United States dominated the country analysis, while the participation of several developing and Southeast Asian contexts appeared later or remained comparatively modest. This pattern does not necessarily mean that assessment practices are absent in these settings; rather, it may indicate differences in research output, indexing, publication access, or visibility. More locally grounded studies are needed to represent the realities of basic education classrooms across diverse systems.

Collaboration patterns reinforce this concern. Although the average number of co-authors per document was 2.87, international co-authorship was 12.39%. This suggests that collaboration often occurs within national or institutional boundaries. Cross-country partnerships could support comparative work on teacher assessment literacy, formative feedback, technology access, and the relationship between assessment policy and classroom practice.

The findings should be interpreted within the methodological boundaries of the study. Scopus coverage, English-language restriction, search terminology, and metadata quality shaped the dataset. In addition, bibliometric maps reveal patterns of

scholarly communication but cannot establish the effectiveness of a particular assessment method. Future studies could combine bibliometric mapping with systematic reviews, classroom observations, teacher interviews, or intervention research to connect publication trends with actual practice.
A further implication concerns data transparency. For reproducibility, future reporting should specify the exact search date, initial retrieval count, screening flow, duplicate-removal process, and treatment of multi-country affiliations. These details will help readers evaluate and replicate the analysis.

Conclusion

Based on the findings, it was concluded that research on biology teachers' assessment practices in basic education has expanded steadily over the past two decades, with increased scholarly attention in recent years. The observed publication trends reflect the rising importance of assessment as a key component of effective biology instruction. The dominance of specific journals, countries, institutions, and authors suggests that the field is shaped by a relatively concentrated group of contributors. While this has contributed to the consolidation of key theoretical and methodological perspectives, it also points to the need for broader participation from diverse educational contexts, particularly from developing countries and basic education settings. The prominence of formative and classroom-based assessment themes indicates a clear shift in research focus toward assessment practices that support student learning and engagement. These trends underscore the growing recognition of assessment as an integral pedagogical tool in biology education rather than merely a means of measuring achievement.

Recommendations

Considering the findings and conclusions of the study, the following recommendations were advanced:

For future researchers: Further studies should explore biology teachers' assessment practices in underrepresented regions and educational contexts to address existing gaps identified in the geographic and institutional analyses.

For teacher education and professional development: Programs should place greater emphasis on developing biology teachers' assessment literacy, particularly in formative assessment and feedback strategies aligned with current research trends.

For curriculum developers and policymakers: Assessment policies and curriculum frameworks should be informed by emerging research that supports assessment for learning and classroom-based assessment practices in biology education.

For future bibliometric research: Subsequent bibliometric studies may incorporate additional databases, longer time frames, or comparative analyses across science disciplines to provide a more comprehensive understanding of assessment research developments.

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