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Research article

Mapping mathematics anxiety research: A bibliometric and science mapping study of Scopus indexed articles (2012–2025)

Lalin Abbacan-Tuguic*

College of Educaion, Kalinga State University, Purok 6, Bulanao Tabuk Kalinga, Cordillera Administrative Region, Philippines

* **Correspondence:** Email:latuguic@ksu.edu.ph.

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Abstract: In this study, I examined how mathematics anxiety research has evolved in scope, structure, and focus within the international literature from 2012 to 2025. Drawing on a corpus of 1,201 Scopus-indexed, peer reviewed journal articles, I combined performance indicators (publication and citation trends) with science mapping techniques, including co authorship analysis, co word analysis, bibliographic coupling, and thematic evolution mapping. The results showed a marked acceleration in publication output, especially after 2020, alongside a collaborative but geographically and institutionally concentrated authorship structure. Conceptually, the field remains anchored in affective motivational and cognitive constructs such as achievement, self-efficacy, motivation, working memory, and gender, while increasingly engaging statistics anxiety, intervention research, digital and online learning, and artificial intelligence in education. Collaboration and coupling networks reveal several well defined but only partially connected research streams, particularly between measurement and mechanism studies on the one hand and classroom or technology focused interventions on the other. Rather than indicating fragmentation, this pattern suggests a mature yet unevenly integrated field in which newer technology rich and post pandemic topics are layered onto long standing theoretical cores. The study is limited to Scopus indexed, English language journal articles, and to the inferential scope of bibliometric methods, so my findings should be interpreted as a structured representation of this segment of the literature rather than an exhaustive map. Within these boundaries, the analysis offers educators and researchers a data driven view of where mathematics anxiety research has consolidated, where it remains segmented, and where opportunities exist for stronger cross-national collaboration and closer linkage between mechanisms and interventions in digitally mediated learning environments.

Keywords: mathematics anxiety, bibliometric analysis, science mapping, digital learning, artificial intelligence in education

1. Introduction

Mathematics anxiety has become a major concern in contemporary education because it constrains learners' achievement, confidence, persistence, and participation in quantitatively demanding subjects and careers. Research across school and university settings shows that mathematics anxiety is associated with lower performance, weaker engagement, and a greater likelihood of avoiding mathematics-intensive pathways, including STEM trajectories [2,4,9]. This problem is not confined to a narrow subgroup of learners; rather, it appears across developmental stages and educational contexts, from early primary schooling to higher education, and is increasingly recognized as a barrier to educational equity and long-term workforce readiness in data-driven societies [15,26].

A growing body of scholarship further shows that mathematics anxiety is deeply intertwined with affective, cognitive, and motivational processes. Meta-analytic and longitudinal evidence indicates that anxiety in mathematics is closely related to lower motivation, weaker self-efficacy, poorer self-regulated learning, and diminished achievement, with these relations often operating reciprocally rather than in a simple one-way direction [1,7,16,33]. Studies have also emphasized the cognitive dimension of the problem, showing that mathematics anxiety is linked to attentional disruption, reduced cognitive reflection, executive-function constraints, and working-memory burdens during mathematical activity [10,13,19,31]. In this sense, mathematics anxiety should not be viewed merely as nervousness about tests or numbers, but as a multidimensional construct that shapes how learners interpret, approach, and persist in mathematical tasks.

The literature also makes clear that mathematics anxiety is socially and contextually produced. Family interactions, parental emotions, teacher sensitivity, classroom climate, stereotype threat, and broader gendered expectations all contribute to how learners experience mathematics and to whether anxiety is amplified or reduced over time [5,17,23,25]. Gender remains one of the most visible themes in this literature, although findings are nuanced: Some studies report higher anxiety among female learners, while others show that the relationship between gender, performance, stereotypes, and anxiety depends on developmental stage and context [15,25,31]. These patterns suggest that mathematics anxiety is embedded not only in individual cognition but also in the social ecology of learning.

Furthermore, the field has expanded beyond documenting negative associations toward identifying protective factors and intervention pathways. Research has shown that stronger self-efficacy, healthier self-concept, supportive teaching, and motivational scaffolds can buffer anxiety and improve engagement and performance [14,18,34]. Intervention studies likewise suggest that mathematics anxiety can be reduced through targeted supports such as mindfulness- and growth mindset-based programming, game-based learning, and adaptive digital tools, although effects vary by design and learner characteristics [6,8,22,30]. These developments indicate that the field is no longer limited to diagnosing the problem; it is increasingly concerned with what conditions, pedagogies, and technologies may help learners cope with or overcome it.

Transformations in educational technology further intensify the need to reconsider mathematics anxiety within new learning environments. Digital platforms, learning analytics dashboards, online

statistics courses, game-based systems, and artificial intelligence tools are reshaping how learners encounter mathematical tasks, feedback, and performance monitoring [3,12,28,29,32]. These environments may support learners by offering personalization, immediate feedback, and flexible pacing, yet they can also generate new forms of pressure, uncertainty, and self-comparison, especially in data-rich settings where performance is continuously visible [12,24,28]. In parallel, the post-pandemic period has heightened scholarly attention to students' emotional well-being, statistics anxiety, digital confidence, and the affective consequences of technology-mediated learning, making mathematics anxiety increasingly relevant within broader discussions of educational resilience and digital transition [20,24,27].

Despite this substantial growth, the literature remains fragmented in important ways. Much of the strongest evidence comes from meta-analyses, systematic reviews, and empirical studies on specific relationships such as anxiety and achievement, anxiety and motivation, statistics anxiety, or intervention effects [2,17,27]. These approaches are invaluable for clarifying effect sizes and mechanisms, but they are less suited to showing how the field as a whole has evolved structurally: Which countries, institutions, journals, and authors have shaped the knowledge base; how collaboration networks are organized; how conceptual emphases have shifted over time; and where emerging streams such as AI-assisted learning, digital intervention, or statistics anxiety are positioned relative to the broader literature. In other words, while the substantive evidence on mathematics anxiety has grown richer, a field-level map of its intellectual, social, and conceptual development remains comparatively underdeveloped.

This gap is especially important because mathematics anxiety research is now large, multidisciplinary, and increasingly heterogeneous. It spans educational psychology, mathematics education, developmental science, higher education, cognitive science, teacher education, and technology-enhanced learning. It also includes overlapping but not identical strands focused on mathematics anxiety, statistics anxiety, self-efficacy, interest, engagement, well-being, parental influences, and digital environments [9,11,21,27]. As a result, there is a pressing need for an integrative method capable of moving beyond isolated empirical findings to reveal the architecture of the field.

Bibliometric analysis offers such a method. By combining performance indicators with science-mapping techniques, bibliometric approaches can identify publication growth, citation concentration, authorship structures, collaboration networks, thematic clusters, and the evolution of research streams at a scale not attainable through conventional narrative synthesis. This makes bibliometric analysis particularly useful for understanding how mathematics anxiety research has consolidated, diversified, and responded to changing educational conditions over time. For a field that is simultaneously expanding in volume and branching into new technological and affective domains, a bibliometric perspective can provide evidence not only of what is being studied, but also of how knowledge is organized and where future inquiry is most likely to emerge.

Accordingly, in this study, I conduct a large-scale bibliometric and science-mapping analysis of mathematics anxiety research indexed in Scopus from 2012 to 2025. The study is designed to: Analyze the temporal evolution, growth trajectory, and authorship patterns of the field; identify the most productive and most influential countries, institutions, journals, and authors; map the conceptual structure of the literature through co-word and thematic analyses; examine collaboration networks among authors, institutions, and countries; and delineate major research streams and their thematic evolution through bibliographic coupling.

By addressing these objectives, the study provides a structured overview of where mathematics

anxiety research has expanded, where it remains concentrated, and how its conceptual center is interacting with emerging themes such as intervention, digital learning, statistics education, and artificial intelligence.

2. Methods and material

2.1. Study design

In line with my aims, my purpose was not to estimate effect sizes for specific relationships (such as the anxiety–achievement link), but to describe how the field has grown over time, how scholarly influence is distributed across countries, institutions, journals, and authors, and how major themes have emerged and evolved within this segment of the literature.

A bibliometric approach was appropriate for this purpose because it enables large-scale, quantitative mapping of publication trends, citation patterns, collaboration networks, and thematic trajectories that are difficult to capture through narrative or meta-analytic reviews alone. To address the reviewers' concerns about clarity and analytical integration, I combined two complementary components. First, performance analysis summarized productivity and impact using indicators such as annual output, citation counts, and the most productive and most cited units. Second, science-mapping techniques co-authorship, co-word analysis, bibliographic coupling, and thematic evolution were used to identify and relate clusters of researchers, institutions, and topics. Taken together, these elements provided a structured, but not exhaustive, account of how mathematics anxiety research has developed and reorganized within the Scopus-indexed literature over the study period.

2.2. Data source

All bibliographic data for this study were retrieved from Scopus. Scopus was chosen because it offers broad coverage of peer-reviewed literature in education, psychology, and social sciences, and provides relatively consistent metadata on authors, affiliations, citations, and keywords that are necessary for bibliometric analyses. In addition, its export functions are well suited to constructing large, structured datasets for performance indicators and science-mapping procedures. Furthermore, it is recognized that Scopus is only one major index; relevant work may be captured exclusively in other databases such as Web of Science or in regional indexing services. For this reason, my analysis should be interpreted as mapping the Scopus-indexed segment of mathematics anxiety research rather than as a comprehensive census of all global scholarships on the topic.

I focused on Scopus-indexed journal articles published in English between 2012 and 2025. This temporal and language scope reflected a deliberate emphasis on recent, peer-reviewed scholarships that were positioned at the center of international scientific communication and for which metadata were sufficiently standardized to support reliable bibliometric processing. However, this choice also meant that articles in non-indexed journals, other document types (books, dissertations, local reports), and publications in languages other than English were only indirectly reflected, if at all. These design decisions reduced duplication and metadata incompatibility but also narrowed coverage. Consequently, when interpreting the results, particularly claims about "global" patterns, it is important to keep in view that they apply to an influential, but bounded, subset of the mathematics anxiety literature.

2.3. Search strategy and study selection

To ensure a transparent and reproducible corpus, a structured search was conducted in Scopus using the TITLE-ABS-KEY field, targeting article titles, abstracts, and author-supplied keywords. The search strategy was designed to identify research that explicitly addressed mathematics-related anxiety and its determinants, outcomes, or interventions. The final query was:

> TITLE-ABS-KEY (("mathematics anxiety" OR "math anxiety" OR "numerical anxiety" OR "statistics anxiety") AND (cause OR factor OR predictor* OR determinant* OR antecedent* OR "cognitive factor*" OR "affective factor*" OR "socioeconomic factor*" OR effect* OR impact* OR outcome* OR consequence* OR "academic performance" OR achievement OR motivation OR "self-efficacy" OR intervention* OR strateg* OR program* OR treatment* OR therap* OR "cognitive behavioral therapy" OR CBT OR "mindfulness intervention*" OR "instructional intervention*" OR "pedagogical approach*" OR "teaching strategy*"))**

This query combined core expressions for mathematics-related anxiety with a broad set of terms for predictors, outcomes, and intervention types. It was chosen to capture the empirical and practice-oriented literature that forms the primary evidence base for contemporary work on mathematics anxiety, while acknowledging that some purely conceptual, historical, or theoretically framed contributions that used different terminology may not have been retrieved.

The initial search returned 1,856 records. A stepwise filtering and eligibility process was then applied. First, technical filters were used to restrict the dataset to journal articles, the years 2012–2025, and publications in English. Second, records were screened to remove duplicates and obviously irrelevant items (for example, cases where “anxiety” or “statistics” appeared in unrelated contexts). These decisions and counts were documented in a flow diagram modeled on PRISMA reporting logic to make the search and filtering process more transparent. However, because this study is a bibliometric analysis rather than a full systematic review of intervention effects, this use of PRISMA conventions was intended purely as a reporting aid and does not imply full adherence to all PRISMA methodological standards.

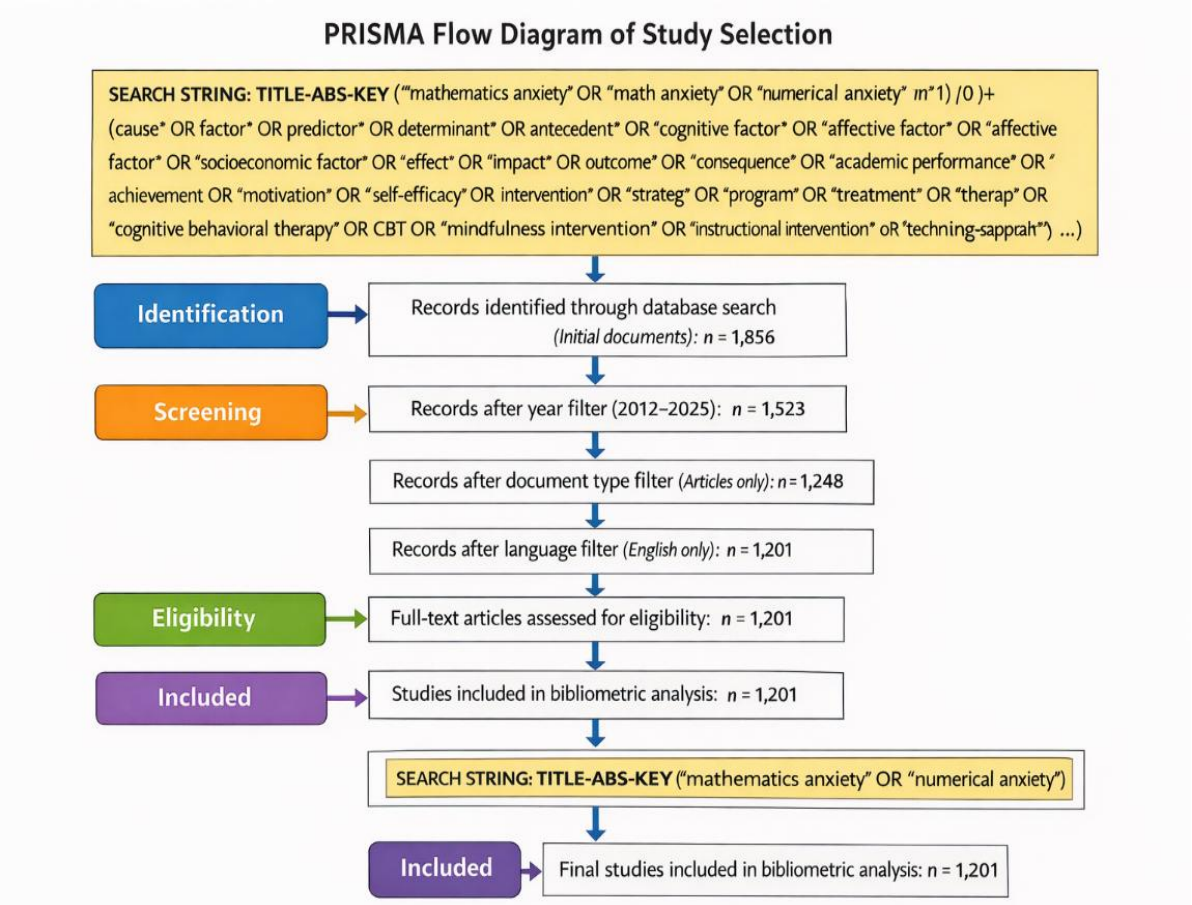

Figure 1. PRISMA flow diagram illustrating the systematic selection and screening process of studies included in the bibliometric analysis.

2.4. Data pre-processing and cleaning

Prior to analysis, data pre-processing was undertaken to improve the reliability of the bibliometric indicators and the interpretability of the resulting network structures. In bibliometric research, inconsistencies in metadata, such as variation in author names, institutional labels, or keyword usage, can artificially fragment networks and distort collaboration or thematic patterns. The cleaning procedures in this study therefore entailed four major areas, with the goal of reducing, but not eliminating, such distortions.

First, author name disambiguation was carried out to limit the splitting of the same author into multiple identities. Variants arising from differences in initials, hyphenation, and ordering were harmonized using a combination of automated rules (for example, matching surnames with identical affiliation patterns) and manual inspection for highly prolific or highly cited authors. Where available, unique identifiers such as ORCID IDs were used to support disambiguation. Nonetheless, some residual ambiguity was likely, especially for authors without unique identifiers or with very common surnames, and this should be kept in mind when interpreting author-level counts.

Second, keyword normalization was performed to unify synonymous or closely related terms. This process included reducing plural/singular variants ("intervention" vs. "interventions"), consolidating spelling differences (American vs. British spelling), and merging abbreviations with their full forms ("MA" and "math anxiety," "CBT" and "cognitive behavioral therapy") when the

context made them unambiguous. A thesaurus file was created and applied within the analysis software to promote consistent treatment of key concepts across documents; even so, the possibility remained that some fine-grained distinctions between closely related terms were smoothed in the process.

Third, institutional names were standardized to reduce fragmentation caused by alternative naming conventions such as abbreviated university names, department-level labels, and variant English renderings. Affiliations referring to the same parent institution were merged where metadata enabled it, and institutions were tagged by country to support country-level analyses. However, as noted by the reviewers, some duplications between department-level and university-level entries (for example, between a department and its parent university) could not be fully resolved. Institutional findings are therefore presented as indicative patterns of concentration and collaboration rather than definitive rankings.

Fourth, duplicate records arising from database exports were identified and removed, with only one instance of each article containing the most complete metadata retained. These procedures were designed to ensure that the co-authorship, co-word, and citation networks analyzed in the study reflected substantive scholarly relationships to the greatest extent possible, while acknowledging that some residual inconsistencies in the underlying metadata were unavoidable in large bibliometric datasets.

2.5. Data analysis

For the analytical framework, I integrated performance analysis with science-mapping techniques to address my objectives on the intellectual, social, and conceptual dimensions of mathematics anxiety research. Performance analysis was used to describe the temporal evolution and productivity of the field (Objectives 1 and 2) by examining indicators such as annual publication counts, total and average citations per year, and the most productive and most cited authors, institutions, countries, and sources. These indicators provided a descriptive overview of growth dynamics and concentration of influence within the Scopus-indexed literature, without attempting to evaluate the quality or causal implications of individual studies.

Complementing this, a set of science-mapping techniques was employed to reveal structural relationships within the corpus and to address objectives related to collaboration patterns, conceptual structure, and research streams (Objectives 3–5). Co-authorship analysis was conducted at three levels, author, institution, and country, to map collaboration networks and identify central and more peripheral actors in the research community. Co-word (keyword co-occurrence) analysis, based primarily on author keywords and supplemented where appropriate by indexed keywords, was applied to identify dominant and emerging thematic clusters, thereby clarifying the conceptual organization of the field. Bibliographic coupling was used to group documents that shared common references, revealing clusters of related studies and helping to delineate major research streams and their connections. Finally, thematic evolution analysis traced the development of key themes across successive time periods within the 2012–2025 window, indicating how the field has shifted from foundational concerns toward newer topics such as interventions, technology-mediated learning, and artificial intelligence, while retaining a stable core.

All analyses were conducted using established bibliometric software for statistical computation, thematic mapping, and network visualization. For each type of analysis, minimum threshold criteria

(for example, a minimum number of documents or citations per author, keyword, or source) were applied to reduce visual and statistical noise and to focus on structurally salient nodes. Normalization methods and clustering algorithms followed the default or recommended configurations of the software, unless otherwise specified, to support transparency and replicability while acknowledging that different parameter choices might yield somewhat different network configurations.

3. Results

3.1. Temporal evolution, growth, and authorship of mathematics anxiety research

Table 1. Main information.

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2012:2025
Sources (Journals, Books, etc)	510
Documents	1201
Annual Growth Rate %	17.05
Document Average Age	5.28
Average citations per doc	22.47
DOCUMENT CONTENTS	
Keywords Plus (ID)	1443
Author's Keywords (DE)	2445
AUTHORS	
Authors	3023
Authors of single-authored docs	92
AUTHORS COLLABORATION	
Single-authored docs	107
Co-Authors per Doc	3.71
International co-authorships %	22.31
DOCUMENT TYPES	
article	1201

Table 1 summarizes the main characteristics of the corpus, which comprised 1,201 Scopus-indexed, peer-reviewed journal articles on mathematics anxiety published between 2012 and 2025 in 510 sources. The annual growth rate of 17.05%, an average document age of 5.28 years, and a mean of 22.47 citations per article jointly indicate a field that is expanding in volume while attracting a non-trivial level of scholarly attention. Authorship patterns show that mathematics anxiety research is predominantly collaborative: 3,023 authors contributed to the corpus, only 107 documents were single-authored, the mean number of co-authors per article was 3.71, and international co-authorship accounted for 22.31% of publications. Taken together, these indicators suggest that, within the Scopus-indexed segment, mathematics anxiety has become a visible topic embedded in multi-author and, to a moderate degree, cross-national networks of knowledge production, rather than remaining confined to isolated, single-author contributions.

Table 2. Annual scientific production.

Year	Articles
2012	27
2013	39
2014	43
2015	53
2016	36
2017	59
2018	50
2019	80
2020	90
2021	117
2022	126
2023	121
2024	151
2025	209

Table 2 and Figure 2 present the annual scientific production. Publication output increased from 27 articles in 2012 to 53 in 2015, with a temporary dip to 36 in 2016, followed by a gradual rise to 59 in 2017 and 80 in 2019, and then a sharper increase from 90 publications in 2020 to 209 in 2025. This trajectory indicates that the field has not grown linearly; instead, the pattern can be segmented into three heuristic phases based on changes in slope and volume: an initial phase of incremental growth (2012–2016), a phase of steady consolidation (2017–2019), and a phase of accelerated expansion (2020–2025).

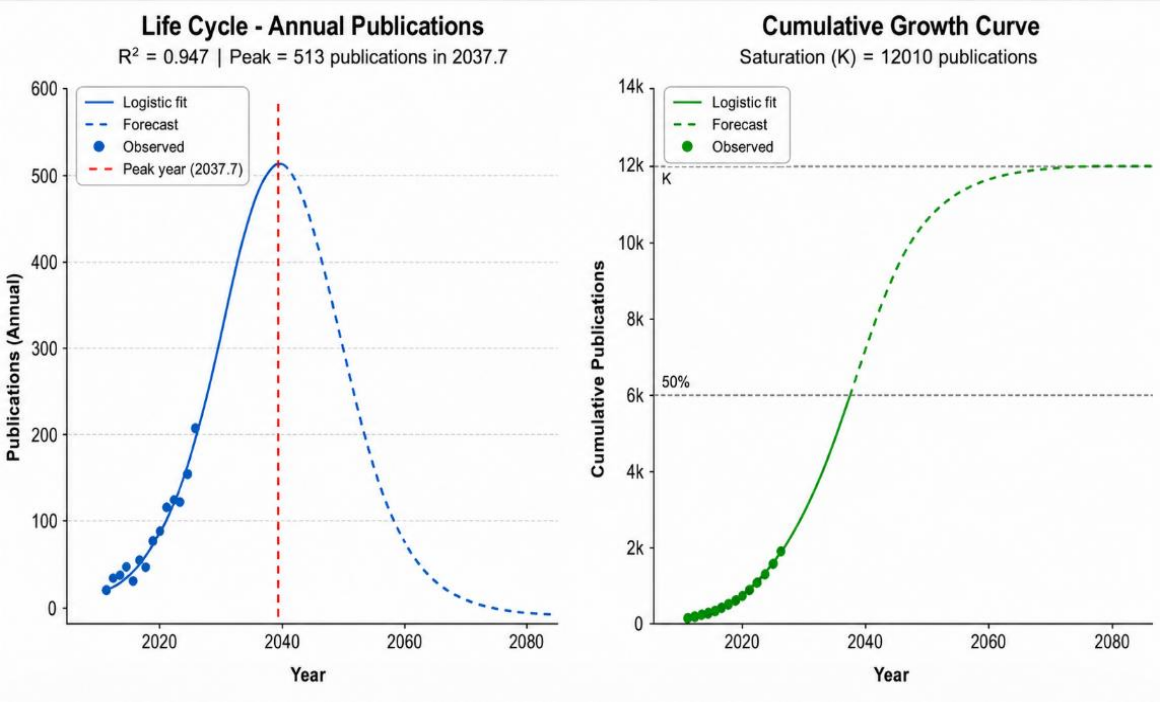

Figure 2. Life cycle-annual publication of mathematics anxiety research.

The initial phase (2012–2016) was characterized by relatively low but increasing annual output, with article counts doubling from 27 to 53 before the temporary decline in 2016. In bibliometric terms, such a pattern is consistent with a topic that is gaining recognition but still occupying a relatively specialized niche in the wider education and psychology literature. The second phase (2017–2019) showed stable yet higher publication counts (50–80 articles per year) and no major interruptions, suggesting that mathematics anxiety has achieved a more regular presence in journals, with sustained research activity but without the sharp inflection typical of emerging "hot topics." The third phase (2020–2025) displayed a marked change in slope: Annual output rose from 90 to 209 articles, representing nearly an eight-fold increase relative to 2012. This sustained acceleration, combined with the field's collaboration profile and citation visibility (Tables 1 and 5), points toward a transition from a modestly growing topic to one that is being investigated across a wider set of contexts, populations, and methodological approaches. It is important to emphasize that this segmentation into three phases is based on observable changes in publication counts and growth rates rather than on formal statistical breakpoints; the phases should therefore be viewed as analytical aids for interpreting the trajectory, not as rigid categorizations.

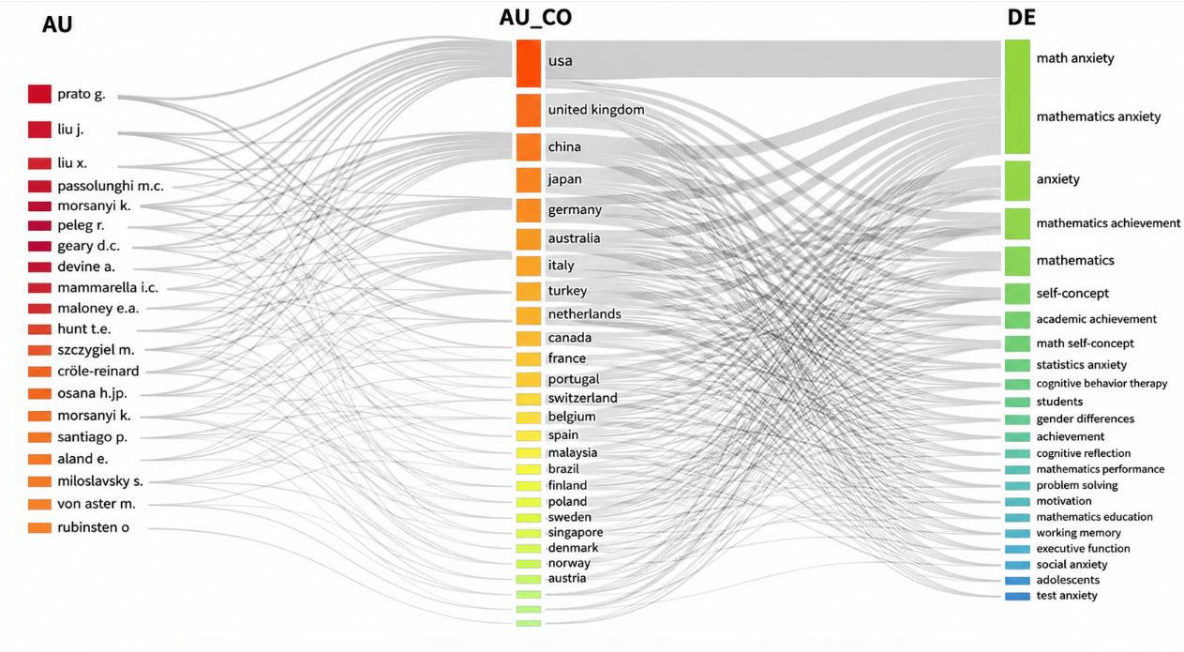

Figure 3. Three-field plot.

Figure 3 provides an additional perspective by linking productive sources, leading authors, and frequently used author keywords in a three-field plot. The densest connections converged around journals and authors associated with keywords such as mathematics anxiety, academic achievement, self-efficacy, motivation, and working memory. This suggests that the increase in publication volume has been accompanied by a relatively coherent set of recurring constructs, rather than by a proliferation of unrelated topics. When considered alongside the average citation indicators in Table 5, which show high mean citation counts for early years (85.33 citations per article for 2012 and 72.62 for 2013) and more moderate but still substantial levels for more recent years (24.66 for 2020 and 21.71 for 2021), this concentration of keywords implies that a cluster of foundational constructs has continued to

organize much of the literature over time. In other words, the bibliometric evidence points to a pattern in which growth and diversification occur around a set of psychologically oriented core themes, even though the exact balance of topics shifted across the study period.

Table 3. Total citations: Country.

Rank	Country	Documents	Total Citations
1	United States	367	11,687
2	United Kingdom	131	4,171
3	Canada	58	2,450
4	Italy	59	1,616
5	Germany	58	1,485
6	China	95	1,378
7	Australia	61	1,375
8	Spain	65	1,342
9	Netherlands	27	873
10	Turkey	53	721

Tables 3 and 4, together with Figure 4.a and 4.d reported in the subsequent subsection, illuminate how this growth was distributed across countries and institutions. The United States led by a wide margin in total citations (11,687) and publication count (367 documents), followed by the United Kingdom (4,171 citations, 131 documents) and Canada (2,450 citations, 58 documents), with Italy, Germany, China, Australia, Spain, the Netherlands, and Turkey also appearing among the top-cited countries. At the institutional level, organizations such as the Department of Psychology and the University of Chicago, Florida State University, Loughborough University's Centre for Mathematical Cognition, the University of Padova, Shandong Normal University, and several Spanish and Qatari institutions accounted for substantial citation totals.

Table 4. Total citations: Organization.

Rank	Organization	Documents	Total Citations
1	Department of Psychology, University of Chicago, USA	8	767
2	University of Chicago, USA	5	604
3	Department of Psychology, Florida State University, USA	5	263
4	Centre for Mathematical Cognition, Loughborough University, UK	10	139
5	Department of Developmental & Social Psychology, University of Padova, Italy	5	128
6	School of Psychology, Shandong Normal University, China	5	73
7	Institute of Neurosciences, University of Barcelona, Spain	7	62
8	Institute de Recerca Sant Joan de Déu, Spain	9	60
9	Institute of Neurosciences, University of Barcelona (variant)	7	59
10	Qatar University (Psychological Sciences Dept.)	6	45

This concentration of citations for countries and institutions, together with the authorship and collaboration indicators in Table 1, provides evidence that influential work on mathematics anxiety is

produced within a geographically and institutionally uneven landscape. In bibliometric terms, such a pattern is consistent with what previous field-level studies in education and psychology have described as a central core with peripheral participation: A limited number of research systems and centers generate highly cited, programmatic lines of work, while a broader array of countries and institutions contribute to volume and thematic expansion. Furthermore, the presence of multiple European, Asian, and Middle Eastern institutions among the most cited units indicates that, within this core, influence is not restricted to a single national setting. Given the persistence of department-level and university-level variants in Scopus affiliation metadata, however, the institutional rankings should be interpreted as indicative of concentration of influence rather than as definitive league tables, and some caution is warranted when comparing institutions with overlapping or fragmented labels.

Table 5. Average Citation (AC) per document.

Year	MeanTCperArt	N	MeanTCperYear	CitableYears
2012	85.33	27	5.69	15
2013	72.62	39	5.19	14
2014	53.28	43	4.10	13
2015	44.85	53	3.74	12
2016	38.25	36	3.48	11
2017	43.75	59	4.38	10
2018	44.72	50	4.97	9
2019	30.12	80	3.77	8
2020	24.66	90	3.52	7
2021	21.71	117	3.62	6

Table 5 adds an impact-over-time dimension by reporting average citations per document and per year for each publication year. Earlier years (2012–2015) showed high mean citation counts per article (44.85–85.33), reflecting the longer citation window available to those publications and the presence of several highly cited foundational studies. From 2016 onward, mean citations per article gradually declined in absolute terms, which was expected as newer articles had less time to accumulate citations, but mean citations per year remained relatively stable (around 3–5 citations per article per year). This combination of strong early impact and sustained annual citation rates for more recent output implies that, although citation distribution is skewed toward earlier, influential contributions, later work continues to be integrated into the literature rather than remaining marginal. In this sense, the citation profile is consistent with a field in which new studies build upon, refine, or extend earlier highly cited lines of research, even though the degree of reliance on specific seminal works may vary across sub-topics.

Taken together, the indicators in Tables 1–5 and Figures 2–3 therefore suggest the following evidence-based interpretation of the field's evolution: First, mathematics anxiety research experienced sustained and accelerating growth within the Scopus-indexed literature between 2012 and 2025, with collaboration networks and citation patterns indicating that this growth was occurring in an environment of multi-author, moderately internationalized scholarship. Second, the distribution of citations across countries and institutions points to a structurally uneven but expanding landscape, in

which a small number of research systems and centers play a particularly prominent role in shaping the knowledge base, while other regions contribute to diversification and extension. Third, despite thematic broadening and changes in publication volume, the concentration of author keywords around constructs such as achievement, self-efficacy, motivation, working memory, and gender, combined with stable annual citation rates and the continued visibility of earlier highly cited articles, implies that a set of affective-motivational and cognitive constructs has remained central to the way mathematics anxiety is studied over time. These inferences do not constitute definitive claims about "field maturation" or "stability" in a strict theoretical sense, but they provide bibliometric evidence that the field has moved beyond sporadic, isolated contributions toward a more sustained and organized pattern of research activity anchored in recurring conceptual foci.

3.2. Research performance: productive and influential units

Figures 4.a–4.d show how research output and influence were distributed across countries, sources, authors, and institutions. These indicators show that the expansion of mathematics anxiety research described in Section 3.1 has not been evenly distributed across the scholarly landscape. Instead, publication volume and citation visibility appear to be concentrated in a limited set of countries, journals, authors, and institutions, while broader international participation contributes to the field's expansion. This pattern is analytically important because it suggests that growth in the field is being driven not simply by increasing article counts, but by a recognizable set of research hubs and publication venues that help organize visibility, legitimacy, and agenda-setting within the literature.

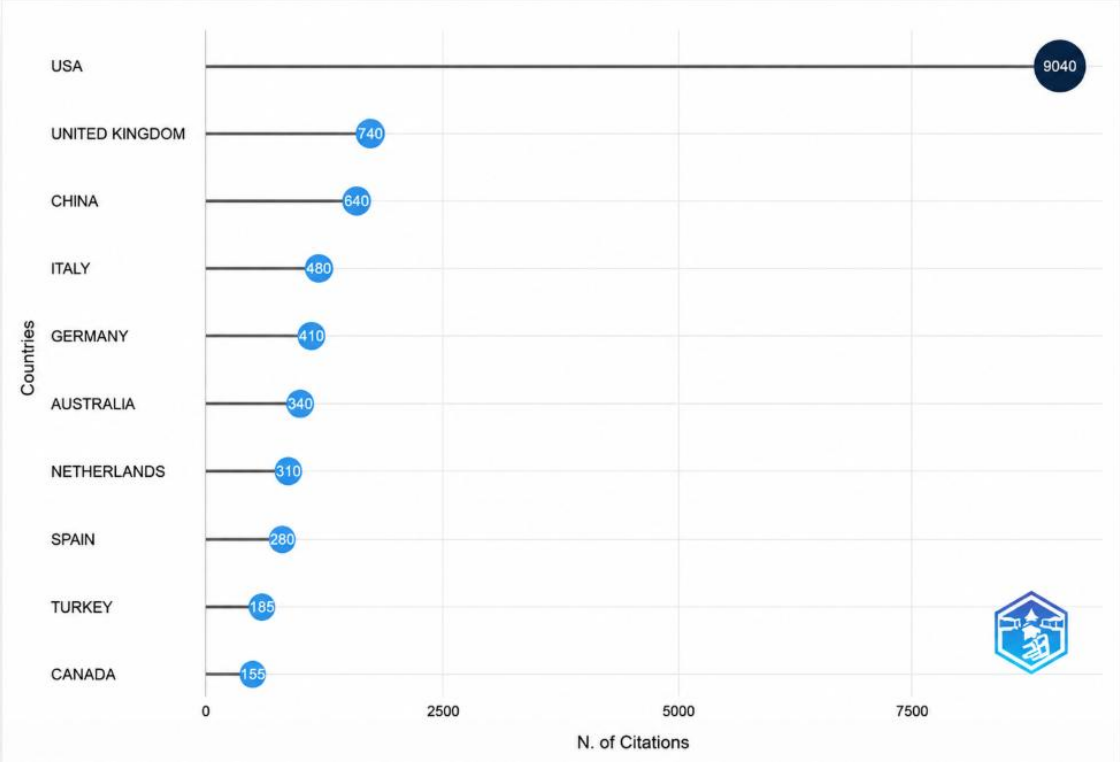

Figure 4.a. Top 10 most influential countries.

Figure 4.a shows that the United States occupied the highest position in citation influence,

followed by the United Kingdom. China, Italy, Germany, Australia, the Netherlands, Spain, Turkey, and Canada form the remainder of the top group. In combination with Table 3, the figure indicates that the geography of citation impact was uneven, with a steep decline from the leading country to the rest of the top ten.

The country profile also shows that influence was not restricted to a single region. Countries from North America, Europe, Asia, and the Middle East are represented among the leading contributors. Furthermore, the concentration of citations in a small number of countries, together with the international co-authorship rate reported in Table 1, indicates that broad participation across countries is not matched by an even distribution of highly cited output.

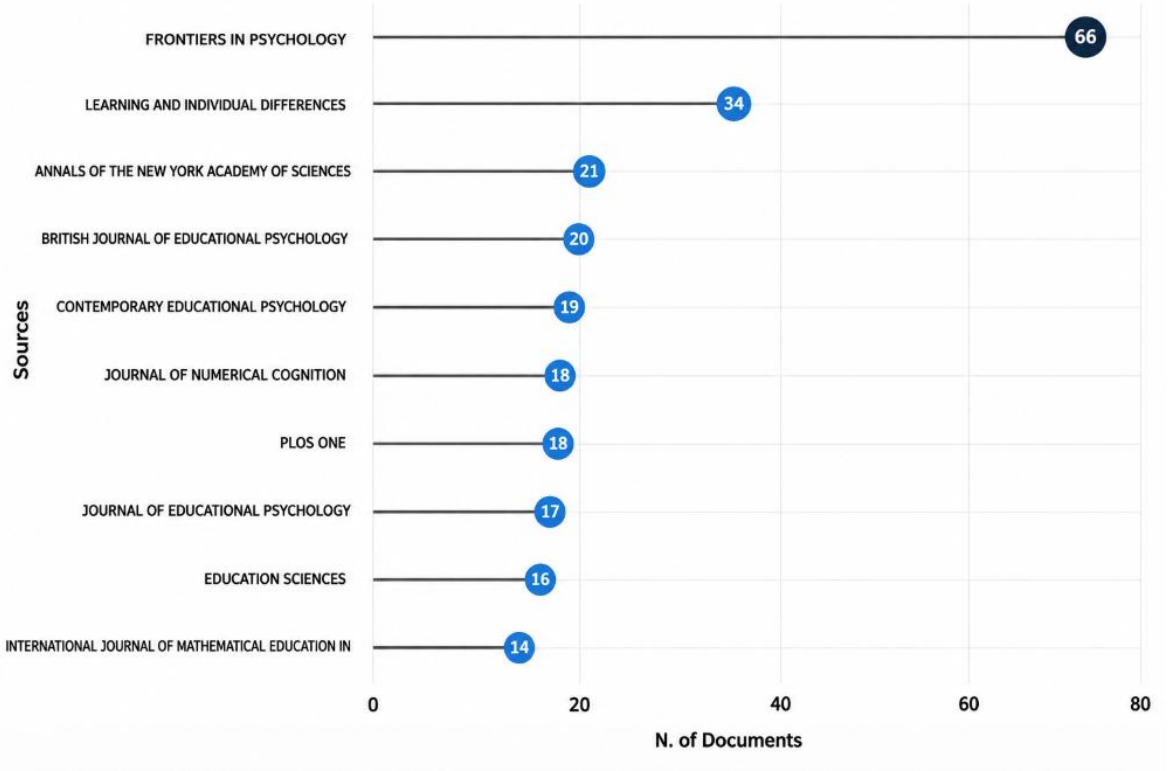

Figure 4.b. Top 10 most influential sources.

Figure 4.b highlights the journals that function as the main publication outlets for mathematics anxiety research. Frontiers in Psychology led by a wide margin, followed by Learning and Individual Differences, Annals of the New York Academy of Sciences, British Journal of Educational Psychology, Contemporary Educational Psychology, Journal of Numerical Cognition, PLOS ONE, Journal of Educational Psychology, Education Sciences, and the International Journal of Mathematical Education in Science and Technology. The composition of this source profile was analytically revealing because it placed the literature at the intersection of psychology, education, cognitive science, and, to a lesser extent, mathematics education. Rather than indicating dispersion across unrelated outlets, the source distribution suggests that mathematics anxiety research circulates through a relatively coherent set of journals that share interest in learning processes, individual differences, achievement emotions, and educational practice. This pattern is consistent with the keyword structure reported in Section 3.1, where recurring terms such as achievement, self-efficacy, motivation, and working memory indicate a persistent affective-motivational and cognitive

orientation in the field.

Furthermore, the distribution of leading journals also suggests that the field is organized around adjacent but not identical scholarly communities. Journals such as Frontiers in Psychology, Learning and Individual Differences, and Contemporary Educational Psychology are more strongly aligned with psychological and cognitive perspectives, whereas the International Journal of Mathematical Education in Science and Technology connects the topic more directly to mathematics education. This does not justify a strong claim that the field is divided into fully separate communities on the basis of source distribution alone. However, it does indicate that mathematics anxiety research is being mediated through partially overlapping publication venues with somewhat different epistemic emphases. From a bibliometric perspective, this source structure is consistent with a field whose intellectual traffic crosses disciplinary boundaries but may still be shaped by different publication logics, audiences, and preferred explanatory frameworks.

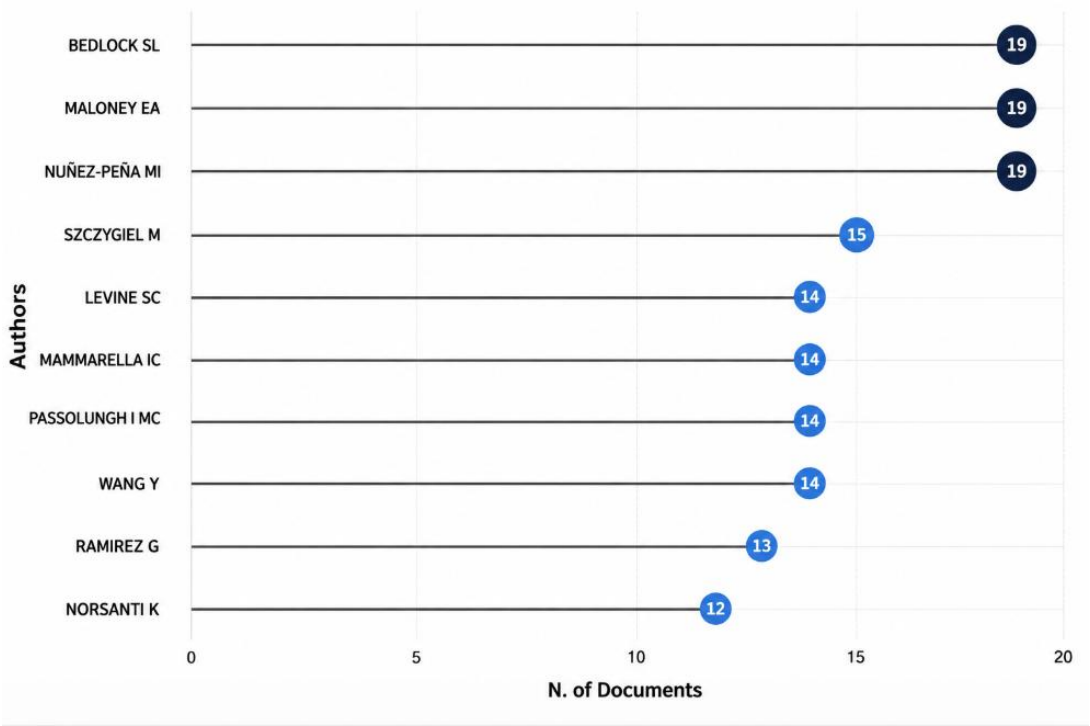

Figure 4.c. Top 10 most influential authors.

Figure 4.c presents the most prolific authors in the field. Beilock S.L., Maloney E.A., and Núñez-Peña M. shared the highest number of documents, followed by Szczygieł M., Levine S.C., Mammarella I.C., Passolunghi M.C., Wang Y., Ramirez G., and Morsanyi K. The author distribution shows that a relatively small set of recurring contributors accounted for a visible share of output within the corpus. When read alongside Figure 3 and the authorship indicators in Table 1, this pattern indicates that publication activity is not evenly dispersed across authors but clustered around recurrent contributors. At the descriptive level, the author profile points to concentration in output among identifiable contributors without implying causal explanations for the persistence of particular themes.

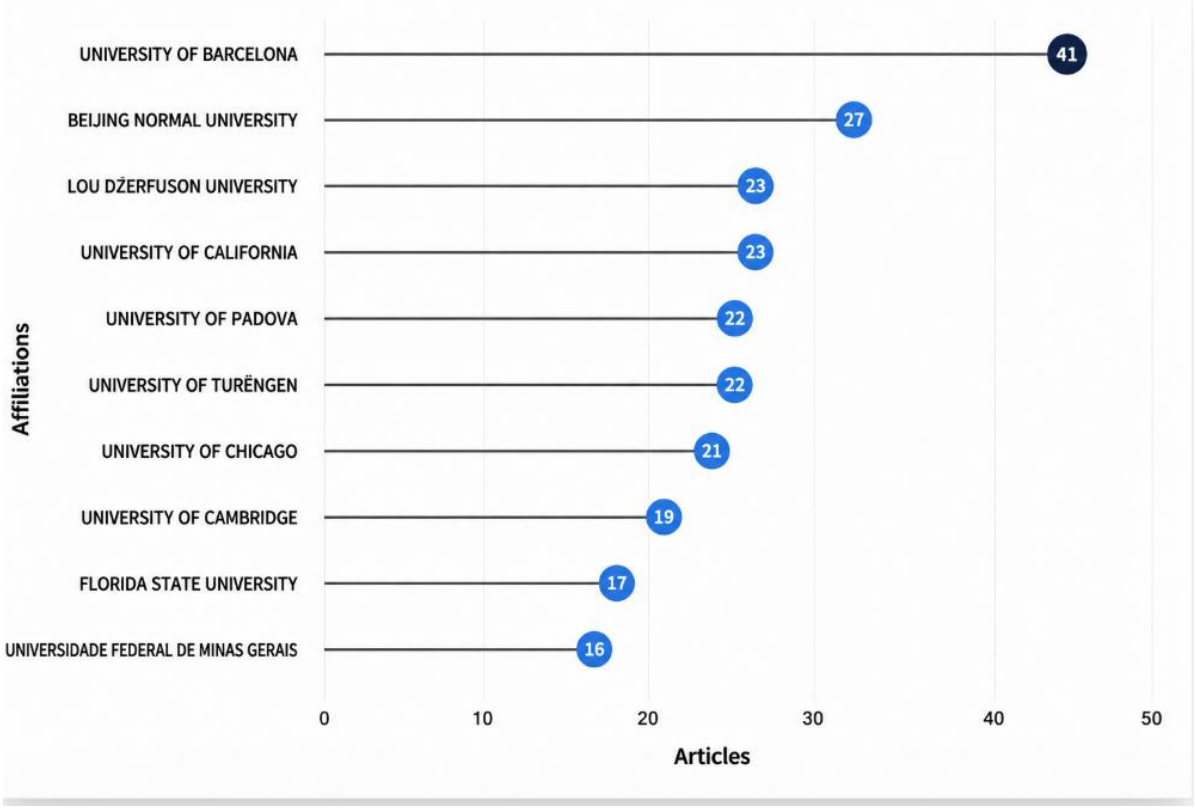

Figure 4.d. Top 10 most influential institutions.

Figure 4.d presents the institutions with the highest publication output, including the University of Barcelona, Beijing Normal University, Loughborough University, the University of California, the University of Padova, the University of Tuebingen, the University of Chicago, the University of Cambridge, Florida State University, and Universidade Federal de Minas Gerais. Read together with Table 4, these data indicate that publication activity and citation visibility are concentrated in a limited set of universities and specialized research settings.

The institutional profile also shows cross-regional representation, with institutions from Europe, Asia, North America, and Latin America included among the leading producers. However, because some institution names remain split across department- and university-level variants, these rankings should be interpreted as indicative of concentration patterns rather than as exact institutional hierarchies.

3.3. Conceptual structure: co-word and themes

The conceptual organization of mathematics anxiety research was examined through co-word evidence from the TreeMap (Figure 5.a) and the temporal keyword profile in the Trend Topics analysis (Figure 5.b). Taken together, these visualizations do more than identify frequently used terms; they indicate how the field organizes its central problems, which constructs remain recurrent across time, and where thematic expansion is occurring. In bibliometric terms, co-word structure is informative because repeated co-occurrence of keywords reflects not only topical popularity but also the extent to which concepts are being mobilized together within the same knowledge space. The results therefore enable a cautious interpretation of conceptual continuity and thematic

diversification within the Scopus-indexed literature on mathematics anxiety.

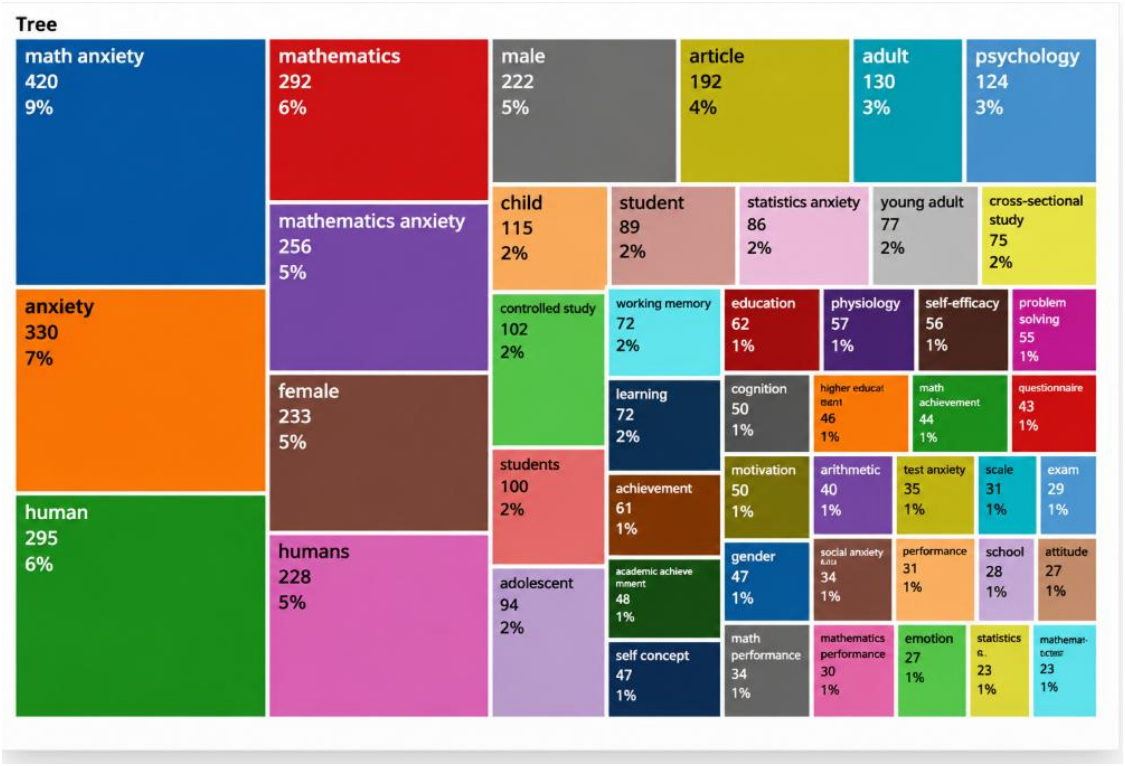

Figure 5.a. TreeMap.

Figure 5.a shows that mathematics anxiety was the dominant organizing term in the corpus, but it did not appear in isolation. It was most strongly associated with keywords such as academic achievement, self-efficacy, motivation, working memory, gender, attitudes, test anxiety, and statistics anxiety. This pattern suggests that the literature is structured less around a single undifferentiated topic than around a recurring constellation of affective-motivational, cognitive, and contextual constructs. The prominence of achievement, self-efficacy, and motivation indicates that mathematics anxiety is frequently investigated in relation to learner beliefs, performance outcomes, and engagement processes, while the presence of working memory and test anxiety points to a persistent cognitive-processing and academic-emotions strand. Likewise, gender, attitudes, and statistics anxiety indicate that the field repeatedly returns to questions of group differences, adjacent forms of academic anxiety, and domain-related emotional responses.

The TreeMap provides evidence of conceptual concentration around a limited set of recurring constructs rather than evidence of conceptual uniformity. The field is not reducible to one explanatory model, yet the repeated visibility of the same keyword groupings suggests that a substantial proportion of the literature continues to frame mathematics anxiety through recognizable affective, motivational, and cognitive lenses. In this sense, it is reasonable to infer the presence of a relatively stable conceptual center, provided that the term is used cautiously. The bibliometric evidence supports the claim that certain constructs recur persistently and occupy central positions in the keyword structure; it does not imply that the field is theoretically settled or that all studies share the same assumptions. A more precise interpretation is that the literature shows patterned continuity around a recurring set of variables that have remained central to how mathematics anxiety is

operationalized and discussed.

This pattern is also consistent with the performance evidence reported in Sections 3.1 and 3.2. The concentration of prolific authors, the prominence of journals at the intersection of educational psychology and mathematics education, and the sustained citation visibility of earlier publications together suggest that conceptual persistence is not accidental. Rather, it likely reflects the cumulative influence of programmatic lines of research that repeatedly examine mathematics anxiety through constructs such as achievement, self-beliefs, executive functioning, and social or gendered differences. When the co-word structure is read alongside those performance indicators, the field appears to have expanded by adding new themes to an established conceptual architecture rather than by replacing that architecture entirely.

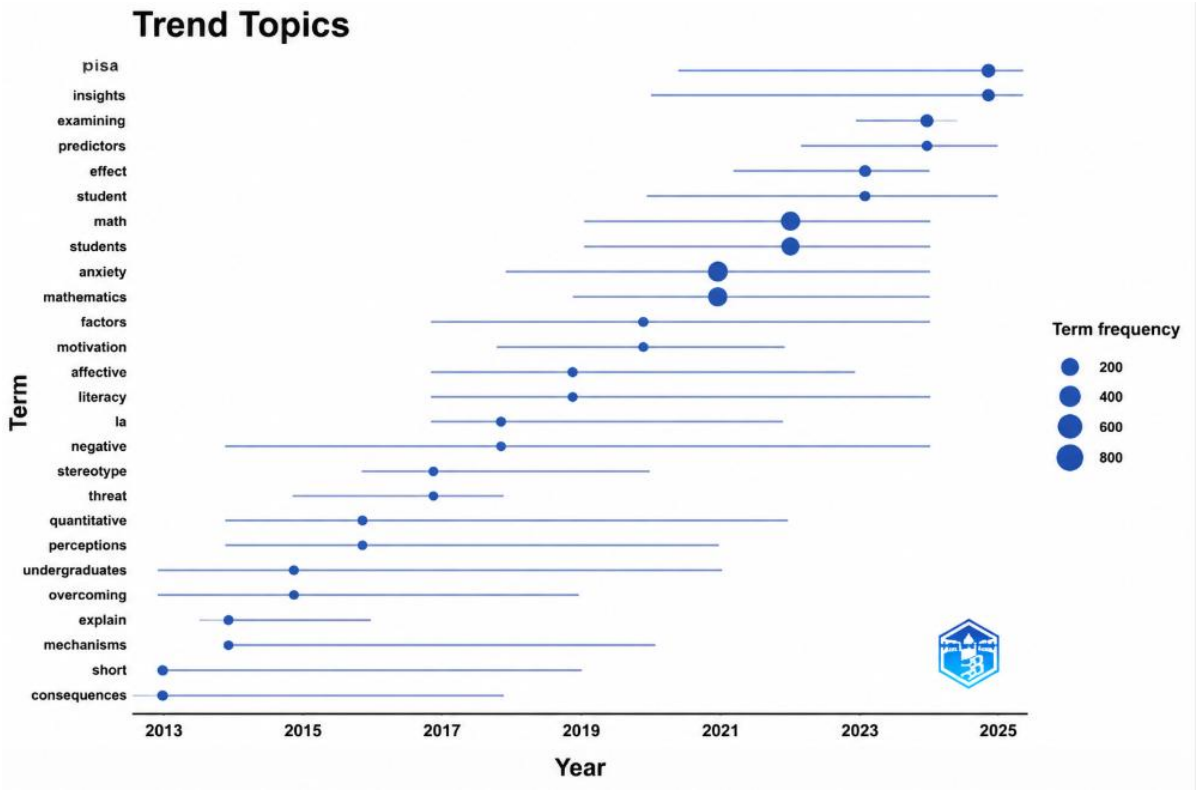

Figure 5.b. Trend topics.

Figure 5.b adds a temporal dimension by showing which keywords were more visible in different parts of the study period. Earlier portions of the period showed stronger visibility for terms associated with measurement and foundational relationships, including scale, validation, achievement, performance, and gender. Later portions of the period showed increased visibility for terms such as intervention, online learning, digital learning, COVID-19, and artificial intelligence.

This pattern indicates that the keyword profile broadens over time. Importantly, newer terms appear alongside recurring constructs such as mathematics anxiety, achievement, and self-efficacy, rather than replacing them completely. At the Results level, the trend-topics visualization therefore shows continuity in core keywords together with the appearance of additional topical terms in more recent years.

3.4. Collaboration networks

The social organization of mathematics anxiety research was examined through co-authorship networks at the levels of authors, institutions, and countries (Figures 6.a–6.c). These visualizations add a relational dimension to the performance indicators reported in Sections 3.1 and 3.2, showing not only who publishes and is cited, but also how researchers and organizations connect to one another. In bibliometric terms, co-authorship patterns are informative because they reveal the extent to which knowledge production is coordinated within collaborative clusters, how densely these clusters are connected, and where bridges between parts of the field may exist.

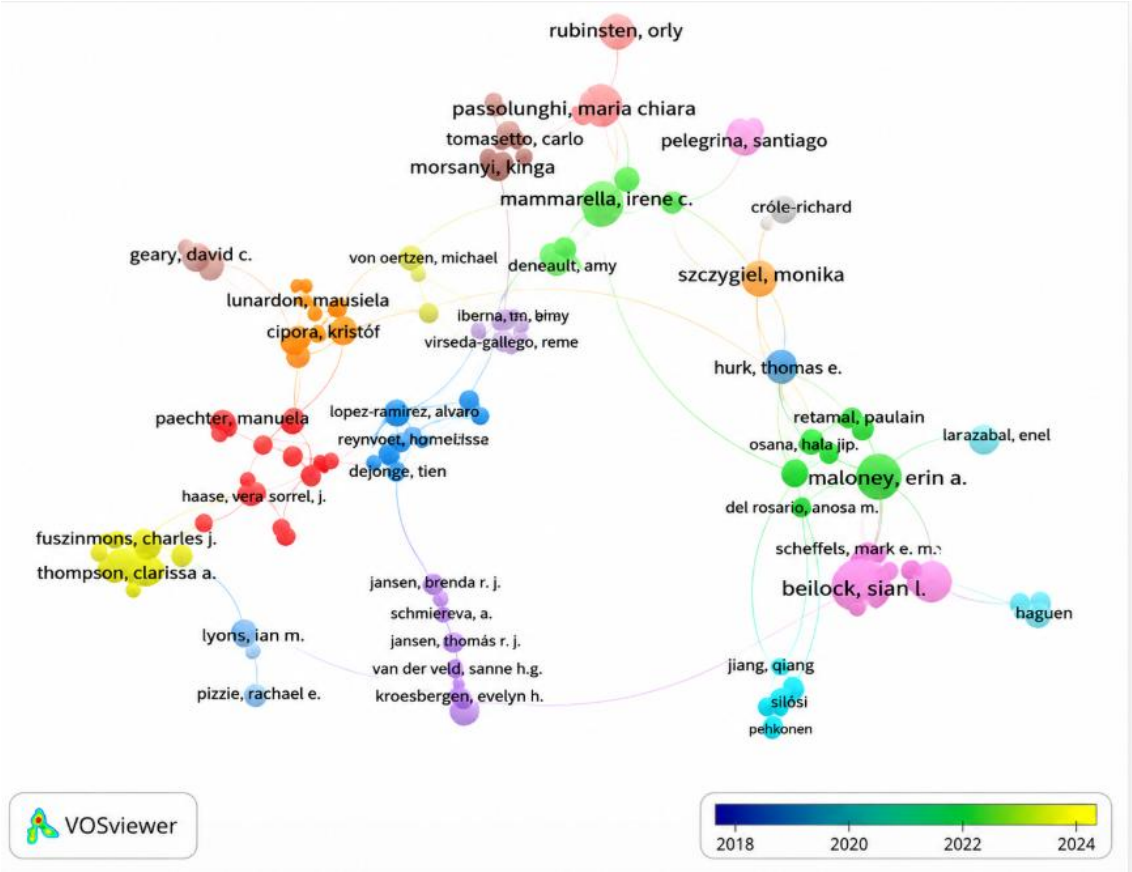

Figure 6.a. Co -Authorship-Author: Network visualization.

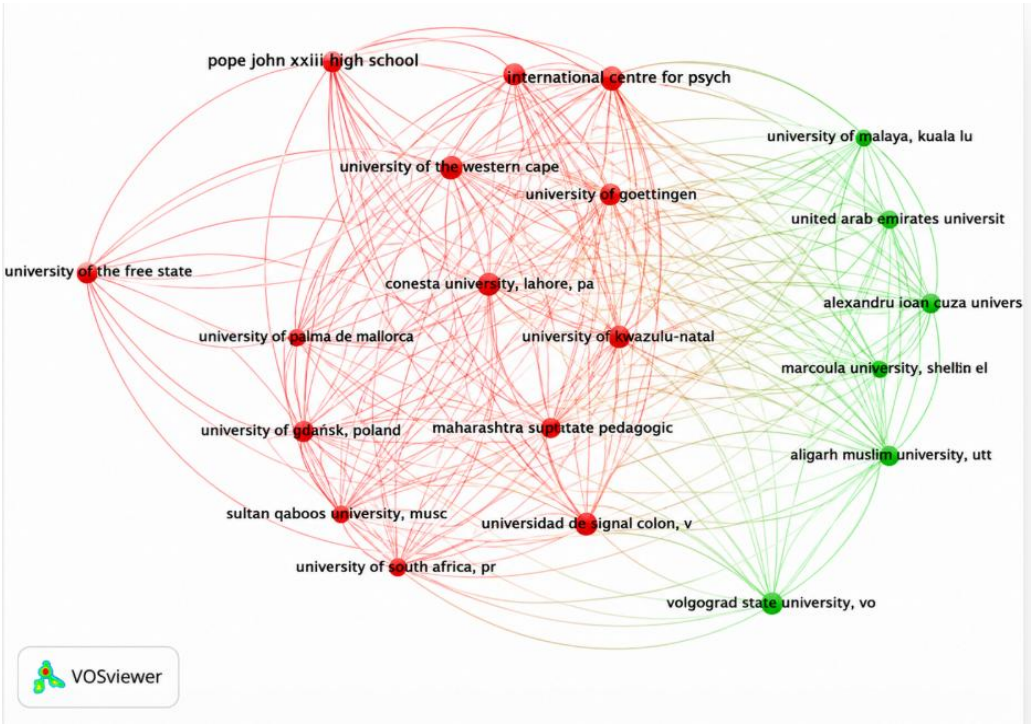

Figure 6.b. Co -Authorship- Institution: Network visualization.

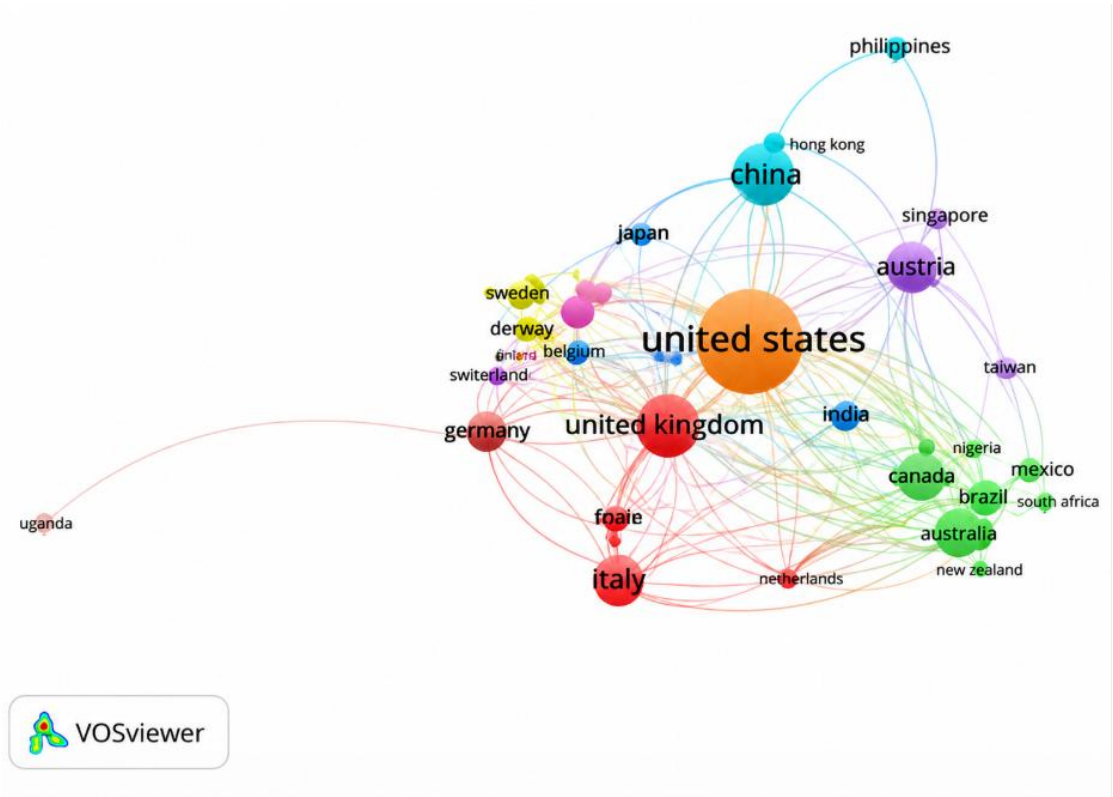

Figure 6.c. Co -Authorship- Country: Network visualization.

Figure 6.a displays the author-level co-authorship network. The visualization reveals several identifiable clusters of authors, each anchored by one or more highly prolific or frequently

collaborating researchers. Within these clusters, ties are relatively dense, indicating that many mathematics anxiety studies are produced by recurring teams or research groups rather than by isolated collaborations. When this pattern is read alongside the concentration of productive authors in Figure 4.c and the high average co-authors per document in Table 1, it suggests that mathematics anxiety research has developed coherent local collaboration structures in which certain authors repeatedly work together across studies.

However, the author network also showed that inter-cluster connections were less dense than intra-cluster ties. Some clusters shared only a small number of bridging authors, and others appeared loosely connected to the rest of the network. On its own, this does not demonstrate the existence of fully separate or "semi-independent" research communities, but it does provide evidence that collaboration is unevenly distributed: Strong ties exist within recurrent teams and groups, while cross-group collaboration is more limited. This pattern is consistent with a field in which programmatic lines of inquiry develop within specific research groups often anchored around institutions or key scholars without extensive co-authorship overlap across all clusters. The author-level structure therefore points toward a socially clustered but not fully integrated collaboration landscape.

Figure 6.b shows co-authorship at the institutional level. The network revealed that universities such as the University of Barcelona, Beijing Normal University, Loughborough University, the University of Chicago, the University of Padova, and several others acted as central nodes in their respective collaboration clusters. Within each cluster, institutions tended to collaborate repeatedly with a defined set of partners, forming regionally or thematically oriented subnetworks. When combined with the institutional productivity and citation patterns in Figures 4.d and Table 4, this configuration suggests that mathematics anxiety research is supported by a limited number of institutional hubs that maintain strong internal and regional collaboration ties.

Moreover, inter-cluster connections between institutions were present but not pervasive. Some institutions served as bridges between clusters, but many collaboration ties appeared to be concentrated within national or regional boundaries. This was consistent with the moderate level of international co-authorship (22.31%) reported in Table 1 and with the country-level concentration of influence in Figure 4.a. The institutional network therefore provides further evidence that mathematics anxiety research is internationally distributed but regionally organized: Collaboration is not confined to single institutions, yet it tends to occur more intensively within particular institutional constellations than across the global field. Rather than asserting the presence of fully "semi-independent" institutional communities, a more cautious interpretation is that the field contains multiple collaboration clusters whose connections to each other are uneven, with some hubs playing bridging roles and others remaining more locally oriented.

Figure 6.c shows co-authorship at the country level. Countries such as the United States, the United Kingdom, China, Italy, Germany, Spain, Australia, Turkey, and Canada occupied prominent positions in the network, reflecting their high productivity and citation impact. The visualization indicates that co-authorship links among these countries are more frequent than among lower-output countries, suggesting that international collaboration tends to be concentrated among systems that already contribute substantially to publication volume and influence. This pattern is in line with the earlier finding that citation impact is heavily skewed toward a small set of countries; here, the social dimension complements the performance evidence by showing that these countries also share more

collaborative ties with each other.

Furthermore, the country-level network did not show a fully connected global structure. Some countries appeared only loosely linked or were connected primarily to one or two partners. This suggests that, while mathematics anxiety research has become an internationally visible topic, the depth and breadth of cross-national collaboration remain uneven. In bibliometric terms, this configuration implies that international co-authorship in mathematics anxiety is selective and clustered: Strong ties exist among certain high-output countries, but the overall network contains areas where transnational collaboration is limited. This pattern aligns with broader observations in education and psychology bibliometrics, where topics often globalize in terms of participation faster than they globalize in terms of dense, multi-directional collaboration.

Taken together, the three co-authorship networks suggest that the social structure of mathematics anxiety research is characterized by collaborative clustering at multiple levels. Recurring author teams, institutional hubs, and high-output countries form the backbone of knowledge production, with dense ties within these clusters and more selective links across them. The evidence does not justify strong claims that the field is fragmented into fully separate research communities. Instead, it supports a more nuanced interpretation: Mathematics anxiety research appears to be clustered and partially interconnected, with collaboration patterns that facilitate cumulative work within groups and hubs, but that leave some potential for stronger cross-cluster integration.

3.5. Research streams and thematic evolution

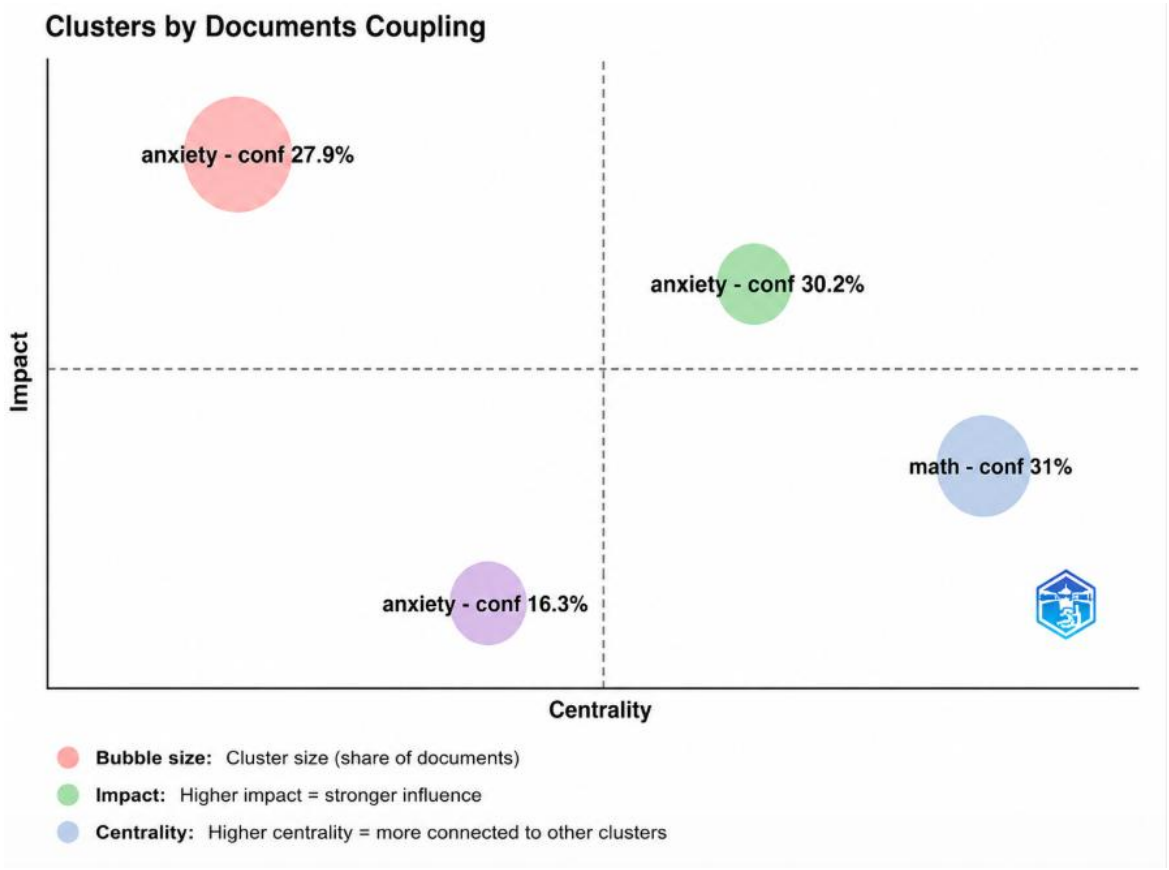

Figure 7. Coupling map.

The bibliographic coupling map (Figure 7) groups documents that share references, revealing how mathematics anxiety research has crystallized into distinct, yet related, streams. One prominent cluster centers on measurement and psychometrics, including scale development, validation, and cross-cultural adaptation. A second large cluster focuses on mechanisms and correlates, linking mathematics anxiety with achievement, self-efficacy, motivation, working memory, and related cognitive–affective processes. A third set of coupled documents concentrates on classroom and instructional context, such as teaching practices, classroom climate, and teacher beliefs. More recent clusters highlight intervention and technology-mediated learning, including game-based approaches, online statistics courses, dashboards, and AI-assisted tools.

What is analytically noteworthy is not merely the existence of these clusters, but their pattern of connectivity. Measurement and mechanism articles are tightly coupled with each other and with classroom-context studies, indicating substantial cross-referencing among work that defines the construct and investigates its relations in traditional settings. In contrast, intervention and technology-related documents tend to be more strongly coupled within their own group than with the measurement and mechanism clusters. This suggests that while applied and digital work draws on some core references, it also builds partially separate citation bases, consistent with uneven integration across streams rather than complete separation or full convergence.

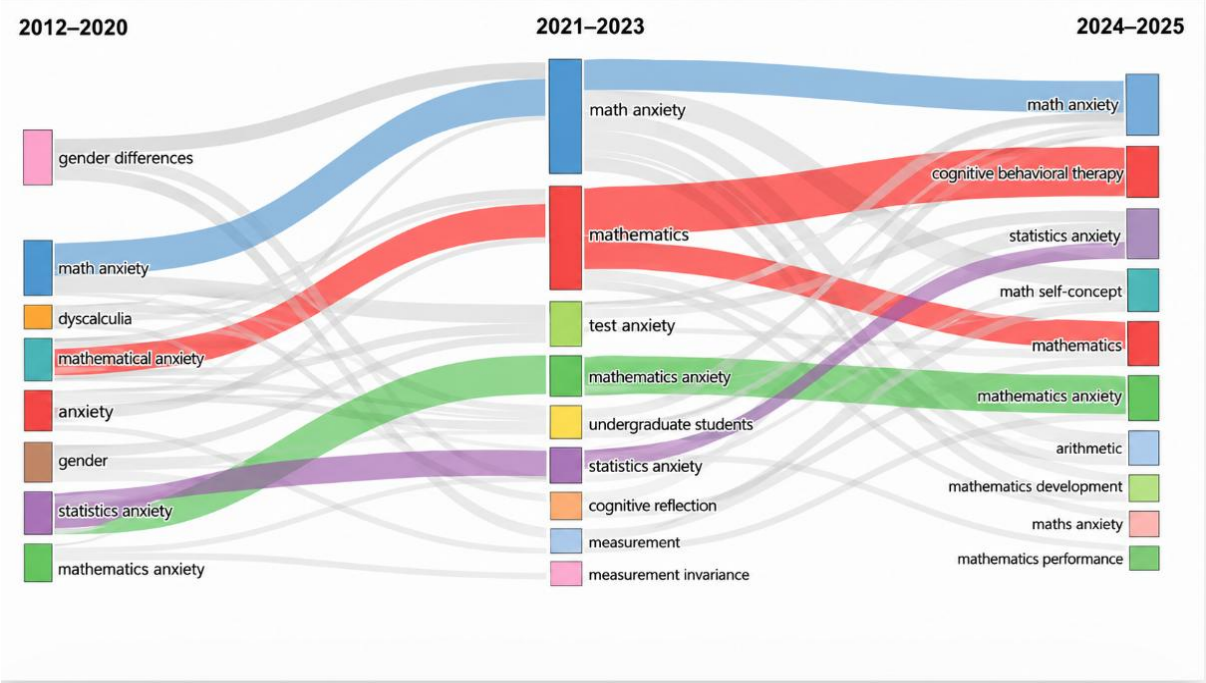

Figure 8. Thematic evolution analysis.

The thematic evolution analysis (Figure 8) streams unfold over time across three analytically defined periods: 2012–2020, 2021–2023, and 2024–2025. The first interval aggregated the longer initial phase of incremental and steady growth identified in the annual production data, providing sufficient volume to detect stable early themes (mathematics anxiety, gender, statistics anxiety, dyscalculia, and general anxiety). The second, shorter interval (2021–2023) corresponded to the onset of accelerated expansion, enabling emerging topics to be distinguished from the earlier baseline. The final interval (2024–2025) isolated the most recent years, where publication counts

were highest and new terms such as cognitive behavioral therapy, math self-concept, mathematics development, arithmetic, and mathematics performance became more visible.

Across these periods, early streams were dominated by measurement and basic mechanisms, while later periods increasingly featured intervention-focused and technology-related themes (cognitive-behavioural therapy, statistics anxiety in digital contexts, and performance in mathematics and statistics). Crucially, newer themes emerged alongside, rather than replacing, foundational constructs such as mathematics anxiety and mathematics, which persisted across all three intervals. In combination with the coupling results, this temporal pattern supports a cautious interpretation: Mathematics anxiety research has developed recognizable, partly interconnected streams in which core psychometric and mechanism work provide a shared reference frame, while intervention and technology strands have, to date, linked back to that core selectively rather than uniformly.

4. Discussion

This bibliometric and science-mapping study provides a structured view of how mathematics anxiety research has evolved in the Scopus-indexed literature between 2012 and 2025, emphasizing the field's growth dynamics, intellectual organization, conceptual trajectories, and collaboration structures rather than re-evaluating substantive theories or classroom practices. Within the corpus defined by the Scopus database, the TITLE-ABS-KEY search strategy, and the inclusion of English-language journal articles published from 2012 to 2025, the reported results show a rapidly expanding but unevenly organized field: Publication output accelerates markedly after 2020, citation impact is concentrated in a limited set of countries, institutions, authors, and journals, conceptual structure displays continuity and thematic broadening, and collaboration and coupling networks reveal recognizable but only partially interconnected research streams [1,2,7,9,10,16,19,27,31]. Taken together, these findings indicate that, within this Scopus-indexed segment of the literature, mathematics anxiety research has moved beyond isolated contributions toward a more coherent yet still unevenly integrated research landscape, where established affective-motivational and cognitive constructs anchor the field while newer intervention- and technology-oriented topics are layered onto that core.

4.1. Evolution and concentration of the research landscape

The temporal analysis shows a three-phase trajectory: An initial period of incremental growth, a phase of steady consolidation, and a post-2020 phase of accelerated expansion, with annual output reaching 209 articles in 2025 and an overall growth rate of 17.05%. Within the constraints of the Scopus database and the study's search and inclusion criteria, this pattern suggests that mathematics anxiety has transitioned from a specialized topic toward a more widely recognized area of inquiry within education and psychology, although this transition should be interpreted cautiously as a bibliometric trend rather than definitive evidence of field maturation. The accelerated growth after 2020 likely reflects several converging drivers visible in the results: Intensified concern with learners' emotional well-being in post-pandemic contexts, expanded attention to statistics anxiety and digital learning environments, and the proliferation of technology-mediated research settings where anxiety about quantitative tasks becomes more salient [3,12,20,24,27–29]. Comparable bibliometric studies in education have shown similar acceleration when fields respond to policy change, digital

transition, or new interdisciplinary demand, with research fronts growing around established conceptual foundations rather than replacing them outright.

Citation and productivity indicators further show that this expansion is geographically and institutionally concentrated. The United States, the United Kingdom, and Canada lead in influence, with several European and Asian countries also appearing among the most visible contributors, while institutions such as the University of Chicago, Loughborough University, Beijing Normal University, the University of Padova, and the University of Barcelona function as recurring hubs of knowledge production. Given that these patterns are derived from Scopus-indexed, English-language articles retrieved through the study's search query, they should be viewed as evidence of uneven influence and diffusion within this indexed segment rather than as a complete picture of global activity. This pattern points to a structurally uneven landscape in which a relatively small number of research systems and centers generate highly cited, programmatic lines of work, while broader participation contributes to thematic diversification and contextual extension. Similar central-peripheral configurations have been observed in bibliometric mapping across education, where concentration of influence can support cumulative development of tools, concepts, and methods, but may also limit the range of contexts represented in the most visible literature. In this case, the concentration of citations should therefore be interpreted less as a judgment about scholarly value than as evidence of uneven knowledge diffusion within the Scopus-indexed segment of the field.

4.2. Conceptual continuity and thematic diversification

The co-word and trend-topic analyses indicate that mathematics anxiety research remains organized around a recurring set of constructs, especially achievement, self-efficacy, motivation, working memory, gender, attitudes, test anxiety, and statistics anxiety. Within the keyword universe defined by the Scopus records and the study's search strategy, the persistence of these terms across the study period suggests a stable conceptual center in a descriptive bibliometric sense: A substantial proportion of the literature continues to frame mathematics anxiety through affective-motivational, cognitive, and contextual variables rather than through wholly unrelated perspectives [1,7,10,13,16,19,31]. This interpretation is consistent with bibliometric studies in mathematics education, creativity, and pedagogical content knowledge, where recurring keyword clusters often indicate continuity in how a field defines its central problems even as publication volume expands and new topical layers emerge. The bibliometric evidence therefore supports continuity, but not conceptual closure: The field retains recurrent focal constructs while remaining open to extension and recontextualization.

Furthermore, the trend-topic profile and bibliographic coupling map show that intervention-oriented and technology-related themes have become increasingly visible. Keywords such as intervention, online learning, digital learning, COVID-19, and artificial intelligence indicate that the field has progressively responded to shifting educational conditions and new forms of pedagogical mediation [3,12,24,28,29,32]. However, these newer themes emerge alongside, not instead of, the long-standing core of achievement-, efficacy-, motivation-, and cognition-related constructs. This pattern is more consistent with layered thematic expansion than with abrupt conceptual change, and similar trajectories have been reported in recent bibliometric studies of data science in education and STEAM education, where new digital or interdisciplinary fronts are added to research architectures without immediately reorganizing the field's conceptual center. In this case,

the conceptual structure suggests that, within the Scopus-indexed corpus analyzed here, mathematics anxiety research is broadening its empirical settings and applications while continuing to depend on a relatively stable set of explanatory vocabularies.

4.3. Collaboration dynamics and social organization

The co-authorship networks at author, institution, and country levels indicate a socially clustered but only partially interconnected field. Author-level maps show dense local clusters around recurring contributors, while institutional and country-level visualizations reveal a limited number of strong hubs surrounded by more weakly connected participants. This pattern suggests that mathematics anxiety research, as represented in Scopus-indexed English-language journal articles, is socially organized through stable collaboration environments rather than through a single, fully integrated international network. The moderate level of international co-authorship reported in the results reinforces this interpretation: Collaboration is present and meaningful, but international participation has advanced further than full cross-national integration.

This social structure is important because collaboration patterns shape how knowledge circulates, which methods become standardized, and which themes receive sustained attention. Highly connected hubs often support cumulative work by enabling repeated studies, shared instruments, and continuity of research programs, especially in fields that rely on recurring constructs such as self-efficacy, working memory, or academic achievement [10,16,31]. Furthermore, clustered collaboration may also reinforce path dependence, whereby influential teams and institutions disproportionately shape what counts as central or legitimate in the field. Comparable bibliometric analyses in education have shown that such clustered, yet partially connected networks often accompany the emergence of identifiable scholarly communities without necessarily yielding fully integrated global collaboration systems. My results, interpreted within the scope of the Scopus-indexed segment, are consistent with that broader pattern and suggest that cross-cluster collaboration remains an important avenue for future development.

4.4. Research streams, uneven integration, and field development

The bibliographic coupling map and thematic evolution analysis provide the clearest evidence about how mathematics anxiety research has differentiated into streams and how those streams relate over time. The coupling structure points to at least four recognizable strands: Measurement and psychometrics; mechanisms and correlates such as achievement, self-efficacy, motivation, and working memory; classroom and instructional context; and more recent intervention- and technology-oriented studies. Because the coupling and evolution analyses are based on references and themes within the Scopus-indexed, 2012–2025 English-language corpus, the identified streams should be understood as intellectual structures in this selected segment rather than as exhaustive classifications of all global work on mathematics anxiety. This configuration suggests that the field has developed through successive layers of inquiry rather than through a single homogeneous agenda. In the thematic evolution analysis, earlier periods are dominated by measurement and baseline relationship themes, while later periods bring increasing visibility to intervention, statistics anxiety, digital learning, and AI-related topics [3,12,27,28,32].

What is analytically significant is not simply the presence of these clusters, but their pattern of

connectivity. Measurement and mechanism studies appear more tightly interconnected and more consistently linked to classroom-context work than intervention and technology-related clusters, which appear to draw on some shared references but also maintain partially distinct citation bases. This does not justify a claim of fragmentation in any absolute sense; rather, it suggests uneven integration across streams, where some parts of the literature are more strongly consolidated around shared references than others. Similar forms of layered or selective integration have been reported in bibliometric analyses of educational fields undergoing rapid diversification, especially when new technological or applied fronts emerge faster than they are incorporated into theoretical frameworks. In this study, the coupling and evolution evidence therefore suggests that mathematics anxiety research has a recognizable intellectual center, but that the linkage between core measurement/mechanism work and newer intervention or technology strands remains incomplete within the Scopus-indexed, English-language journal segment.

This interpretation helps explain why broad claims about integration or maturity should be qualified. The results do not show a field that is conceptually disordered, but neither do they show one in which all major streams are deeply unified. Instead, the evidence is more consistent with cumulative expansion accompanied by selective synthesis. Earlier highly cited work provides a shared reference frame, recurring keywords indicate continuity in focal constructs, and collaboration hubs stabilize the social structure; yet, emerging areas such as digital learning, AI-assisted support, and intervention design appear to connect to the core unevenly [3,6,8,12,22,28]. From a field-development perspective, this suggests that future advances may depend less on continued growth in publication volume and more on whether these streams become more explicitly connected through shared concepts, methods, and reference structures.

4.5. Implications for future research and field organization

The principal contribution of this study lies in clarifying what the bibliometric evidence reveals about the organization and evolution of mathematics anxiety research within a clearly defined corpus of Scopus-indexed English-language journal articles published between 2012 and 2025. The results suggest a field that is large, rapidly growing, and conceptually continuous, yet socially and intellectually uneven in its distribution of influence and degree of integration. This has several implications. First, future research would benefit from more deliberate linkage between emerging topics such as AI-assisted learning, online environments, or intervention design and the long-standing constructs that continue to organize the field, including achievement, self-efficacy, motivation, and working memory [10,12,16,28,31]. Stronger conceptual bridging of this kind may help newer streams connect more fully with the established literature rather than developing as partially parallel trajectories.

Second, the concentration of influence in a limited set of countries, institutions, and journals implies that broadening the geographical and institutional basis of highly visible research remains an important challenge. A more diverse set of influential contributors could expand the range of educational systems, learner populations, and cultural conditions represented in the literature, thereby improving the field's interpretive breadth and reducing over-reliance on a relatively narrow set of research environments. Third, the coexistence of stable conceptual structures with emerging technological and intervention-oriented themes suggests that future bibliometric studies should examine bridging publications, authors, and institutions more directly, for example through

co-citation or historiographic analysis, to determine whether the current pattern of selective integration is narrowing or widening over time.

These implications should nonetheless be interpreted within the methodological boundaries of the study. The analysis is limited to Scopus-indexed English-language journal articles retrieved through a specific TITLE-ABS-KEY search strategy and to the inferential scope of bibliometric methods; it does not capture the full range of non-indexed, non-journal, or non-English scholarship, nor does it assess the empirical quality of individual studies or the effectiveness of specific interventions [2,27]. Within those limits, however, the study contributes a field-level account of where mathematics anxiety research has consolidated, where it remains unevenly connected, and where future development is most likely to depend on stronger conceptual, social, and cross-contextual integration.

5. Conclusions

This bibliometric and science-mapping study offers an evidence-based account of how mathematics anxiety research has developed within the Scopus-indexed, English-language journal literature from 2012 to 2025. It shows that the field has experienced sustained and accelerating publication growth, organized around a limited number of highly influential countries, institutions, journals, and authors, and embedded in moderately internationalized but socially clustered collaboration networks. Conceptually, co-word and trend-topic analyses indicate a recurring center of affective-motivational, cognitive, and contextual constructs such as achievement, self-efficacy, motivation, working memory, gender, and related academic emotions alongside newer themes on interventions, statistics anxiety, and technology-mediated learning. Bibliographic coupling and thematic evolution further reveal identifiable streams in measurement, mechanisms, classroom context, and increasingly digital and AI-supported environments. These streams share a common reference base but are connected unevenly, suggesting cumulative expansion accompanied by selective synthesis rather than complete integration.

The distinctive contribution of this study lies in providing the large-scale, multi-method bibliometric map of mathematics anxiety research that integrates performance indicators, co-authorship structures, conceptual mapping, bibliographic coupling, and thematic evolution within a single analytical framework. Moreover, while reviews and bibliometric analyses have focused primarily on specific relationships (such as anxiety and achievement, motivation, or statistics anxiety) or on particular segments of the literature, this study systematically traces how the field's social organization, conceptual center, and emerging streams relate to one another over time. In doing so, it moves beyond topic-specific syntheses to clarify the architecture of mathematics anxiety research as a whole, including where influence is concentrated, how collaboration clusters are configured, and how intervention- and technology-oriented lines of work are positioned relative to measurement and mechanism studies.

This broader, field-level perspective is particularly relevant for future research. First, by documenting a stable conceptual core alongside layered thematic expansion, I identify concrete opportunities for stronger integration between long-standing constructs (achievement, self-efficacy, motivation, working memory) and newer topics such as AI-assisted support, online and digital learning, and intervention design. Second, by showing that citation influence is concentrated in a limited set of countries, institutions, and journals, this study highlights the need to broaden the geographical and institutional bases of highly visible research so that interpretations of mathematics

anxiety better reflect educational systems and learner populations. Third, by revealing uneven connectivity among research streams, it underscores the value of future work that deliberately builds bridging publications, authors, and institutions through, for example, co-citation and historiographic analyses, or through collaborative projects that link measurement and mechanism studies with classroom and technology-mediated interventions.

Within the methodological boundaries of the study, including Scopus-indexed English-language journal articles from 2012 to 2025 and the inferential limits of bibliometric techniques, the findings should be interpreted as mapping an influential but bounded segment of the literature, rather than as an exhaustive census of all global work on mathematics anxiety. Nonetheless, by making visible the field's growth trajectory, social and geographical concentration, conceptual continuity and diversification, and uneven integration of its major streams, the study provides a structured baseline against which future bibliometric and substantive investigations can be compared. This baseline can guide subsequent systematic reviews, empirical studies, and policy-relevant syntheses that seek not only to refine understanding of mathematics anxiety in specific contexts, but also to strengthen the coherence, inclusiveness, and cross-contextual relevance of the field as it continues to evolve.

Use of Generative-AI tools declaration

The author declares the use of Artificial Intelligence (AI) tools in the preparation of this article.
AI tools used: SciSpace, Perplexity, and Grammarly.
How the AI tools were used: SciSpace was used to support literature exploration and organization of the substantive mathematics-anxiety and bibliometric literature; Perplexity was used to help structure and refine the presentation of arguments; Grammarly was used for grammar and language editing.
Where in the article this support is reflected: Primarily in the Literature Review, and in the organization and phrasing of the Methods and Discussion sections. After using these tools, the author carefully reviewed and edited all content and takes full responsibility for the final manuscript.

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Conflict of interest

The author declares that there are no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Ethics declaration

The author declared that no ethics approval is required for the study. This article reports a Scopus-based bibliometric study using published documents as its corpus. No human participants, human tissue, animal experiments, or confidential personal data were involved, so institutional ethics review was not required.

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Author's biography

Lalin Abbacan-Tuguic is a faculty member at the College of Education, Kalinga State University, Philippines. Her research focuses on mathematics education, learners' affective and motivational processes, and the application of bibliometric and science-mapping methods to understand the evolution of educational research fields. She has experience in quantitative and mixed-methods designs and is particularly interested in how digital and AI-mediated learning environments interact with mathematics anxiety and student engagement.