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AUTOMATICITY AND ARITHMETIC FLUENCY IN PRIMARY-SCHOOL MATHEMATICS: A BIBLIOMETRIC MAPPING OF RESEARCH TRENDS

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ABSTRAK

Automaticitas dan kefasihan aritmetika merupakan komponen penting dalam pembelajaran matematika anak, tetapi penelitian masih menggunakan istilah yang saling tumpang tindih untuk menggambarkan kedua konstruk tersebut. Penelitian ini bertujuan memetakan struktur tematik dan pola temporal penelitian terindeks Scopus mengenai automaticitas, retrieval, kefasihan, dan aritmetika pada anak serta konteks sekolah dasar selama periode 2020–2026. Penelitian ini juga mengkaji representasi pemecahan masalah matematis dalam jaringan kata kunci yang dihasilkan. Analisis bibliometrik dilakukan menggunakan VOSviewer, sedangkan proses seleksi dokumen dilaporkan berdasarkan PRISMA 2020. Pencarian awal pada Scopus menghasilkan 433 dokumen. Setelah melalui penyaringan berdasarkan tahun publikasi, bidang subjek, jenis dokumen, bahasa, kata kunci, dan status akses terbuka, diperoleh 67 dokumen, dengan 64 dokumen yang tersedia dalam berkas ekspor RIS dianalisis lebih lanjut. Peta kata kunci terdiri atas 28 kata kunci yang terbagi dalam empat klaster. Kefasihan aritmetika berkaitan dengan memori kerja dan membaca, sedangkan pemecahan masalah berada dalam klaster terpisah bersama matematika, kepekaan bilangan, dan numerasi. Meskipun terdapat keterkaitan antara kefasihan aritmetika dan pemecahan masalah, pemecahan masalah masih kurang menonjol dan kedua konsep tersebut berada dalam klaster yang berbeda. Istilah metode pembelajaran tidak memenuhi ambang batas minimum kemunculan. Temuan ini menunjukkan peluang penelitian selanjutnya untuk mengkaji kefasihan aritmetika dan pemecahan masalah matematis dalam kerangka yang terintegrasi serta mengeksplorasi pendekatan pembelajaran yang mengakomodasi keduanya. Hasil ini menggambarkan pola dalam kumpulan dokumen yang dianalisis dan tidak menunjukkan efektivitas pembelajaran maupun hubungan sebab-akibat.

Kata kunci: automaticitas; analisis bibliometrik; kefasihan aritmetika; pengambilan fakta aritmetika; pengambilan otomatis; sekolah dasar; VOSviewer.

ABSTRACT

Arithmetic automaticity and fluency are important components of children's mathematics learning. However, research continues to use overlapping terminology to describe these two constructs. This study aims to map the thematic structure and temporal patterns of Scopus-indexed research on automaticity, retrieval, fluency, and arithmetic in children and elementary school contexts during the 2020–2026 period. It also examines the representation of mathematical problem-solving within the resulting keyword network. Bibliometric analysis was conducted using VOSviewer, while the document selection process was reported in accordance with PRISMA 2020. The initial Scopus search yielded 433 documents. Following screening based on publication year, subject area, document type, language, keywords, and open-access status, 67 documents were identified, of which 64 available in the RIS export file were included in further analysis. The keyword map consisted of 28 keywords grouped into

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four clusters. Arithmetic fluency was associated with working memory and reading, whereas problem-solving appeared in a separate cluster alongside mathematics, number sense, and numeracy. Although arithmetic fluency and problem-solving were interconnected, problem-solving remained less prominent, and the two concepts appeared in different clusters. Teaching method-related terms did not meet the minimum occurrence threshold. These findings highlight opportunities for future research to examine arithmetic fluency and mathematical problem-solving within an integrated framework and to explore instructional approaches that address both constructs. The results reflect patterns within the analyzed document corpus and do not demonstrate instructional effectiveness or causal relationships.

Keywords: arithmetic fluency; automatic retrieval; automaticity; bibliometric analysis; fact retrieval; primary school; VOSviewer

INTRODUCTION

Mathematical competence supports participation in education, work, and everyday life, while international assessments continue to document substantial differences in students' mathematics performance and learning opportunities (Mullis et al., 2020; OECD, 2023; World Bank et al., 2022). In primary education, the accurate and efficient use of basic arithmetic facts is one component of broader mathematical competence. Fluent retrieval may help students carry out routine calculations more efficiently, although fluency alone does not guarantee conceptual understanding or successful problem solving (McNeil et al., 2025; Sweller, 2020). Mathematical proficiency also involves practices such as problem solving and reasoning (Schoenfeld, 2020). The literature uses overlapping terms including automaticity, automatic retrieval, fact retrieval, fluency, arithmetic, calculation, mental arithmetic, and number facts so it is useful to map how these concepts are represented together in research.

Arithmetic fluency can involve accuracy, efficiency, and retrieval of basic number combinations, whereas automaticity often emphasizes performing a process rapidly and with reduced conscious effort. These constructs overlap but are not necessarily interchangeable across studies, so their definitions and measures need to be interpreted in context (McNeil et al., 2025). Research in elementary-school settings has examined ways to strengthen the fluent retrieval of arithmetic facts, including retrieval practice, and has shown that the instructional strategy and the timing of assessment matter when evaluating fluency outcomes (Ophuis-Cox et al., 2023). The present search therefore combines related terms rather than assuming that all studies use a single standardized label.

Arithmetic performance is also associated with cognitive processes. A meta-analysis of primary-school children found a moderate overall association between working memory and arithmetic, with differences across working-memory domains, age groups, and arithmetic task types (Zhang et al., 2023). Other research has examined the roles of language, spatial skills, and other cognitive abilities in mathematics performance, suggesting that arithmetic learning occurs within a broader cognitive and educational system (Hawes & Ansari, 2020; Peng & Kievit, 2020; Peng et al., 2020). Bibliometric co-occurrence, however, shows only that terms appear together in the literature; it does not establish causation or show that fluency directly produces stronger problem-solving performance.

A bibliometric map can help describe the structure of a research field by identifying frequently occurring terms, links between terms, and themes that are more peripheral (van Eck & Waltman, 2010). Its usefulness depends on transparent search procedures and careful interpretation of the underlying records (Donthu et al., 2021; Passas, 2024). In keyword networks derived from Scopus, broad indexing terms such as human, child, male, female, and

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article may be prominent because of database indexing conventions, and their prominence should not automatically be read as a substantive research theme. The analysis therefore separates the visible structure of the map from claims about educational effectiveness.

Three research gaps motivate this study. The first is conceptual: the literature uses multiple overlapping labels for automaticity and arithmetic fluency, which can make studies difficult to compare (McNeil et al., 2025). The second concerns mechanisms: arithmetic performance is linked to cognitive factors such as working memory, and word-problem performance depends on text comprehension as well as arithmetic skills, yet these strands are often studied separately, so it is unclear how fluency connects to problem solving (Fuchs et al., 2020; Ji & Guo, 2023; Peng & Kievit, 2020; Pongsakdi et al., 2020; Zhang et al., 2023). The third is pedagogical: word-problem-solving instruction has been synthesized in several meta-analyses (Kong et al., 2021; Lein et al., 2020; Myers et al., 2022), and practice guidance recommends both building fluent retrieval of basic facts and teaching problem solving (Fuchs et al., 2021), but it is unclear how often instructional designs that combine the two are an explicit focus of the indexed literature. A methodological concern runs through all three: keyword maps can be distorted by generic database index terms, so researchers need to examine the content and context of terms rather than rely only on node size or link strength (Donthu et al., 2021; Passas, 2024). The current study addresses these gaps descriptively through bibliometric mapping; it does not claim to be a systematic review of intervention effectiveness.

Theory also suggests that fluent retrieval should be considered alongside, rather than as a replacement for, conceptual understanding. Cognitive load theory proposes that the demands imposed by complex tasks interact with the limited capacity of working memory; more efficient performance on component skills may help manage these demands, but this implication cannot be tested directly by keyword co-occurrence (Chen et al., 2023; Paas & van Merriënboer, 2020; Sweller, 2020, 2024). This background informs the interpretation of the mapped themes; it does not supply causal conclusions from the bibliometric data.

Accordingly, this study uses bibliometric mapping to describe the thematic structure, temporal patterns, and keyword connections in Scopus-indexed research on automaticity and arithmetic fluency in children and primary-school contexts. Particular attention is given to how mathematical problem solving appears in relation to arithmetic fluency in the resulting keyword network. Because the search strategy was designed around automaticity, fluency, arithmetic, and child or primary-school contexts rather than problem-solving terminology specifically, findings about problem solving are interpreted as patterns within this retrieved corpus, not as an exhaustive map of all research on the fluency–problem-solving relationship. The map represents indexed keyword co-occurrence rather than instructional impact or causal relationships.

The study addresses three research questions. RQ1: What thematic structure emerges from keyword co-occurrence in Scopus-indexed research on automaticity and arithmetic fluency in children and primary-school contexts, particularly in relation to mathematical problem solving? RQ2: How are the mapped themes and keywords distributed across average publication years 2020–2026? RQ3: What connections between arithmetic fluency and mathematical problem solving are visible in the keyword network, and which related concepts or instructional approaches appear underrepresented, suggesting directions for future research?

METHODS

This study used bibliometric analysis combined with a systematic selection procedure, with the selection flow reported following PRISMA 2020 (Page et al., 2021). Bibliometric

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analysis was chosen because it allows the structure, trends, and development of a field to be mapped quantitatively and replicably (Donthu et al., 2021; Passas, 2024). Mapping used VOSviewer, software for constructing and visualizing bibliometric networks (Arruda et al., 2022; Hamidah et al., 2020; van Eck & Waltman, 2010). The study proceeded in five stages: (1) defining the aims and scope, (2) data collection, (3) document selection, (4) analysis and visualization, and (5) interpretation of results.

Bibliographic data were retrieved from Scopus on 27 October 2026, so records for 2026 cover the year only up to that date. The search used:

((automaticity OR "automatic retrieval" OR "fact retrieval" OR fluency) AND
(arithmetic OR calculation OR "mental arithmetic" OR "number facts") AND
("primary school" OR "elementary school" OR child*))

The query combines four terms for automaticity and fluency, four arithmetic-related terms, and three population or context terms. The OR operators broaden each concept group, while AND requires records to connect the groups. Because child* is a truncation term, it retrieves variants such as child and children.

Table 1. Summary of data source, search parameters, and analysis parameters

Component	Specification
Research design	Bibliometric analysis with a systematic selection procedure (PRISMA 2020)
Database	Scopus; search date 17 October 2026
Keyword string	((automaticity OR "automatic retrieval" OR "fact retrieval" OR fluency) AND (arithmetic OR calculation OR "mental arithmetic" OR "number facts") AND ("primary school" OR "elementary school" OR child*))
Publication period	2020–2026
Database filters	Publication year 2020, subject area, document type (article), language (English), keyword, all open access
Documents analyzed	64 records in the exported RIS file (67 records after all Scopus filters)
Software	VOSviewer 1.6.20
Analysis	Co-occurrence; unit of analysis: all keywords (author keywords and index keywords)
Minimum occurrence threshold	5; 28 keywords in 4 clusters
Visualization views	Network visualization, overlay visualization, and density visualization

Selection used sequential Scopus filters (Figure 1, Table 2). The initial search returned 433 records. Restricting publication year to 2020–2026 left 192 records; the subject-area filter left 131; the article document-type filter left 126; the English-language filter left 126; the keyword refinement left 110; and the all-open-access filter left 67. Of these 67 records, 64 were available in the exported RIS file (all journal articles in English), and these 64 records form the dataset analyzed. Percentages in Table 2 are calculated relative to the initial 433 records. Records were not screened manually by title and abstract.

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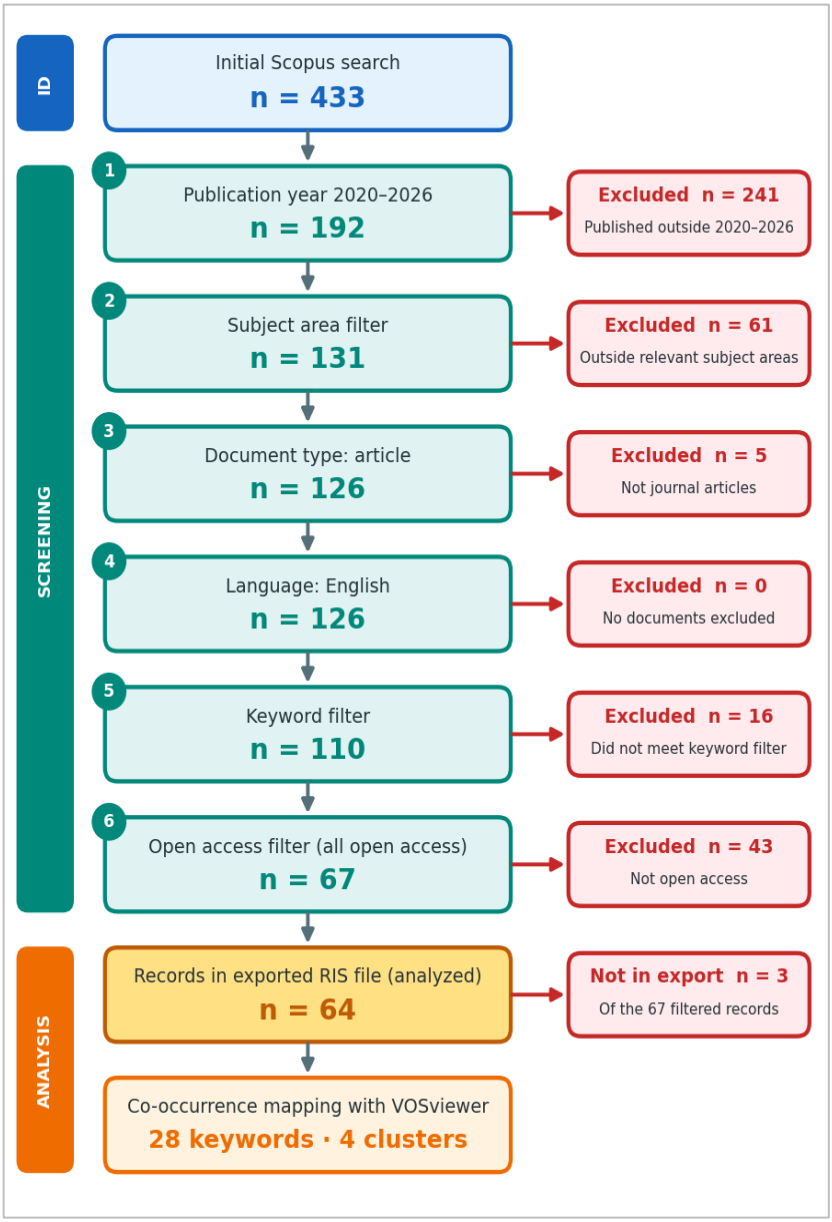


Figure 1. Document selection flow diagram based on PRISMA 2020 and the VOSviewer analysis workflow

Table 2. Document selection stages and number of documents excluded at each filter

Stage	Database filter	Documents remaining	Excluded	Remaining from initial
1	Initial Scopus search	433	–	100%
2	Publication year 2020–2026	192	241	44.3%
3	Subject area	131	61	30.3%
4	Document type: article	126	5	29.1%
5	Language: English	126	0	29.1%
6	Keyword	110	16	25.4%
7	All open access (Scopus filter)	67	43	15.5%
	Records in exported RIS file (analyzed)	64	3 not in export	14.8%

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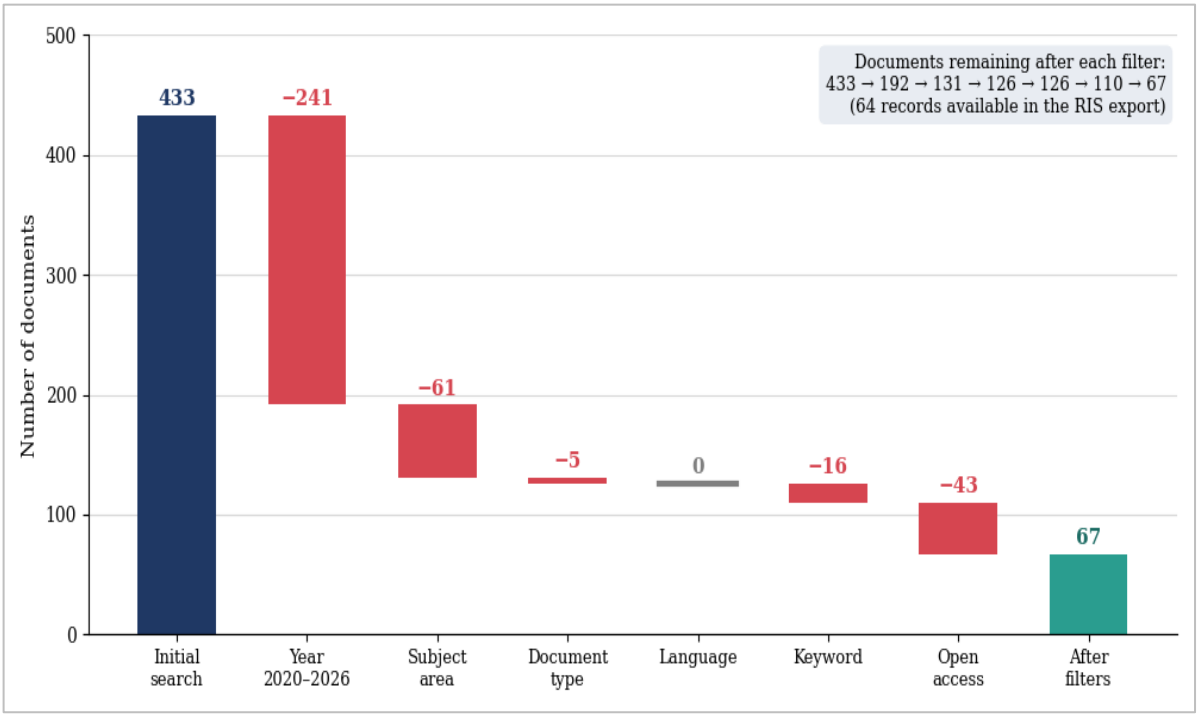


Figure 2. Waterfall diagram of the number of documents excluded at each selection stage (source: Table 2)

Metadata for the 64 exported records were inspected, including authors, titles, publication years, abstracts, keywords, and DOI fields. Keywords were not harmonized through a thesaurus, so closely related forms and database index terms may appear as separate nodes.

Science mapping was performed with VOSviewer 1.6.20 using co-occurrence analysis. The unit of analysis was all keywords (author keywords and index keywords), with a minimum occurrence threshold of 5; 28 keywords met this threshold and entered the map. The threshold was set with the relatively small number of documents in mind, so that the map would remain readable and informative. Cluster formation and layout used VOSviewer's default settings, which group keywords by the strength of their associations.

Results were visualized in three views: (1) a network visualization to identify thematic clusters and the proximity among concepts, with node size indicating frequency of occurrence and line thickness indicating link strength; (2) an overlay visualization to observe shifts in research focus based on the average publication year of keywords; and (3) a density visualization to show dense topic areas and areas that remain sparse. Clusters were named according to their dominant keywords, and small, low-density nodes were treated as tentative indications of under-represented topics rather than confirmed research gaps.

Several limitations should be noted. First, the data came from a single database, so documents not indexed in Scopus are not covered. Second, the open-access and English-language restrictions may introduce selection bias because closed-access studies and studies in other languages are not represented. Third, selection relied on database filters rather than manual screening of titles and abstracts, so some records may be only loosely related to the topic. Fourth, the minimum occurrence threshold removes low-frequency terms, so absence from the map does not mean absence from the literature. Fifth, bibliometric analysis describes patterns of keyword occurrence, not the quality or strength of evidence of individual studies.

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RESULTS AND DISCUSSION

Results

Keyword cluster structure

The co-occurrence map contained 28 keywords in four clusters (Figure 4, Table 3). The two largest clusters, red (12 keywords) and green (11), were followed by a four-keyword blue cluster and a single-keyword purple cluster. Of the 28 keywords, nine were generic database index terms (*human*, *humans*, *male*, *female*, *child*, *school child*, *article*, *controlled study*, and *human experiment*) and 19 were substantive concepts (Figure 3), a composition that bears on how the density results in Section 3.4 should be read.

Table 3. Keyword clusters from the co-occurrence analysis

Cluster	Color	Count	Keywords	Apparent theme
1	● Red	12	Mathematics, problem solving, number sense, numeracy, education, child development, learning, mathematical concepts, mathematical phenomena, physiology, humans, male	Mathematical concepts, learning, and problem solving
2	● Green	11	Arithmetic, child, cognition, math anxiety, primary school, school child, controlled study, human experiment, article, human, female	Primary-school arithmetic: cognition, anxiety, and experimental design
3	● Blue	4	Arithmetic fluency, reading fluency, reading, working memory	Fluency and its supporting cognitive processes
4	● Purple	1	Skill	Skill (single node at the edge of the map)

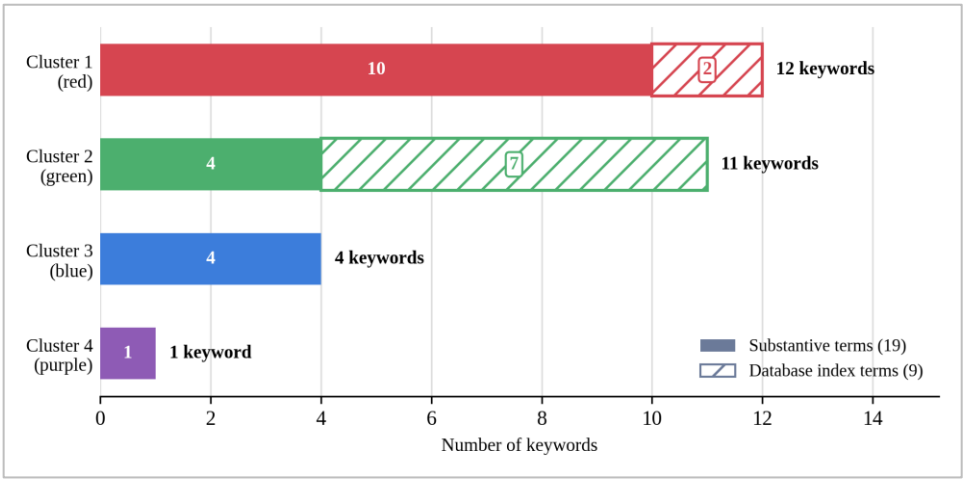


Figure 3. Keyword composition in each cluster: substantive terms and database index terms (source: Table 3; index terms follow those identified in Subsection 3.5)

Network visualization

The blue cluster is centered on *arithmetic fluency*, which lies close to *reading fluency*, *reading*, and *working memory*. In this dataset, arithmetic fluency is studied largely together with cognitive processes and literacy. The red cluster is centered on *mathematics* and contains *problem solving*, *number sense*, *numeracy*, *education*, and *learning*, so problem solving groups with conceptual and educational themes rather than with arithmetic fluency. The green cluster brings together *arithmetic*, *child*, *primary school*, *cognition*, and *math anxiety*, along with

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research-design terms such as *controlled study* and *human experiment*. The purple cluster contains only *skill*, with thin links.

Arithmetic fluency has links to many nodes, including *problem solving*, so a connection between the two does exist. However, the *problem solving* node is small and its links are relatively thin compared with the nodes around it, indicating that problem solving is less prominent in the fluency literature captured here.

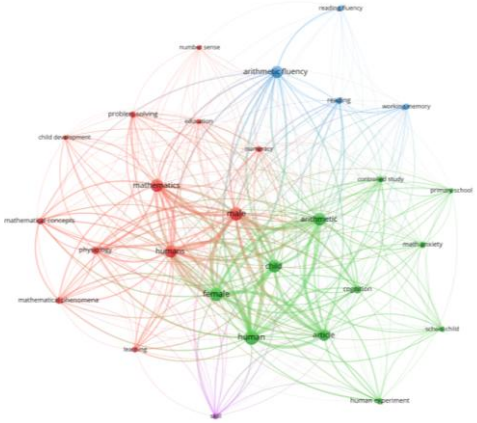


Figure 4. Network visualization of keyword co-occurrence (source: VOSviewer analysis results)

Overlay visualization

Node colors in Figure 5 indicate the average publication year of the documents containing each keyword, ranging from about 2023 to 2025. The most recent keywords (yellow) are *mathematical concepts*, *mathematical phenomena*, *education*, and *child development*, with *physiology* and *cognition* approaching the same color. Teal-green keywords, averaging around 2024, include *arithmetic fluency*, *problem solving*, *working memory*, *arithmetic*, and *child*. *Mathematics*, *math anxiety*, *controlled study*, and *primary school* are slightly more recent than that group. The oldest keywords (purple-blue, around 2023) are *reading fluency*, *number sense*, *numeracy*, *school child*, *human experiment*, and *skill*. Because these are averages per keyword, they indicate relative recency rather than the year a topic emerged. The ordering of keyword groups by average publication year is summarized in Figure 6.

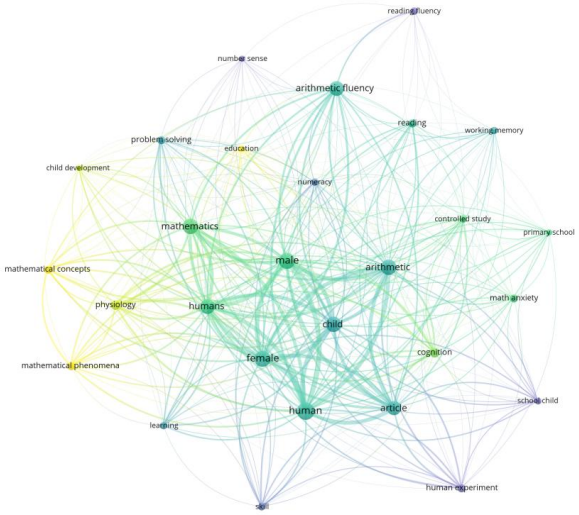


Figure 5. Overlay visualization by average publication year of keywords (source: VOSviewer analysis results)

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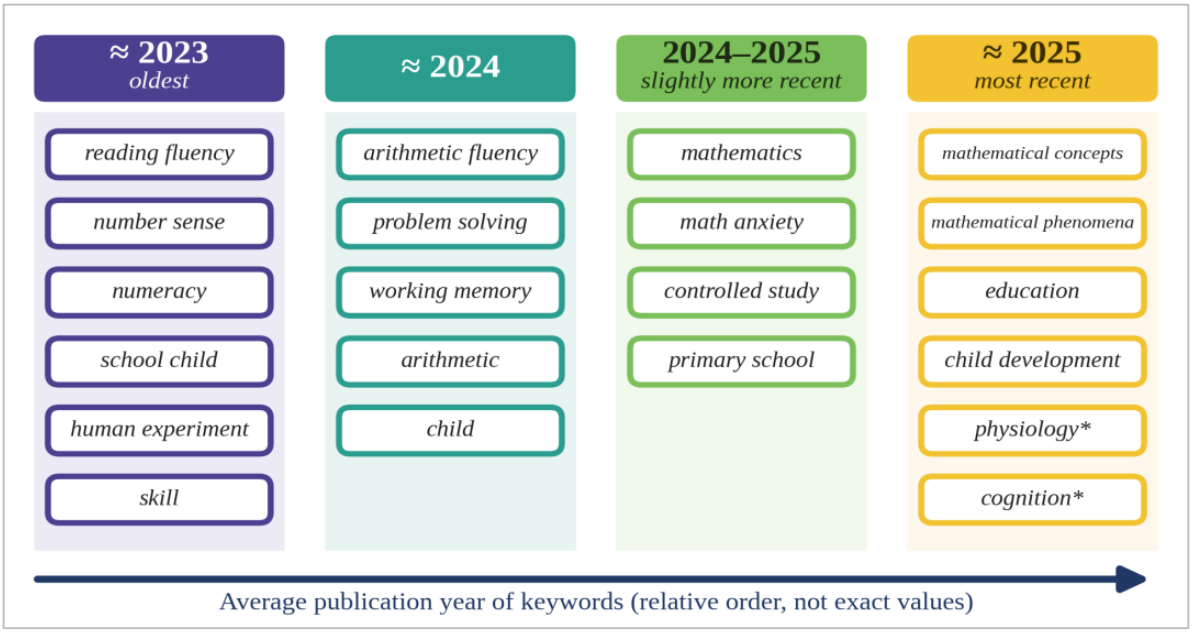


Figure 6. Keyword groups by average publication year on the overlay map (source: Figure 5; * approaching the color of the most recent group; keywords not described in the text are not shown)

Density visualization

The densest area (yellow) in Figure 7 is occupied by *arithmetic fluency*, *mathematics*, and *arithmetic*, together with general index terms such as *human*, *humans*, *male*, *female*, *child*, and *article*. The medium-density area (green) contains *problem solving*, *working memory*, *math anxiety*, *number sense*, *numeracy*, *learning*, and *cognition*. The sparsest area (blue-purple) lies at the edge of the map and includes *skill* and *reading fluency*. Density reflects the frequency of a keyword and of its neighbors, so the high-density area is partly produced by the generic index terms. A summary of density levels and their interpretation is presented in Table 4.

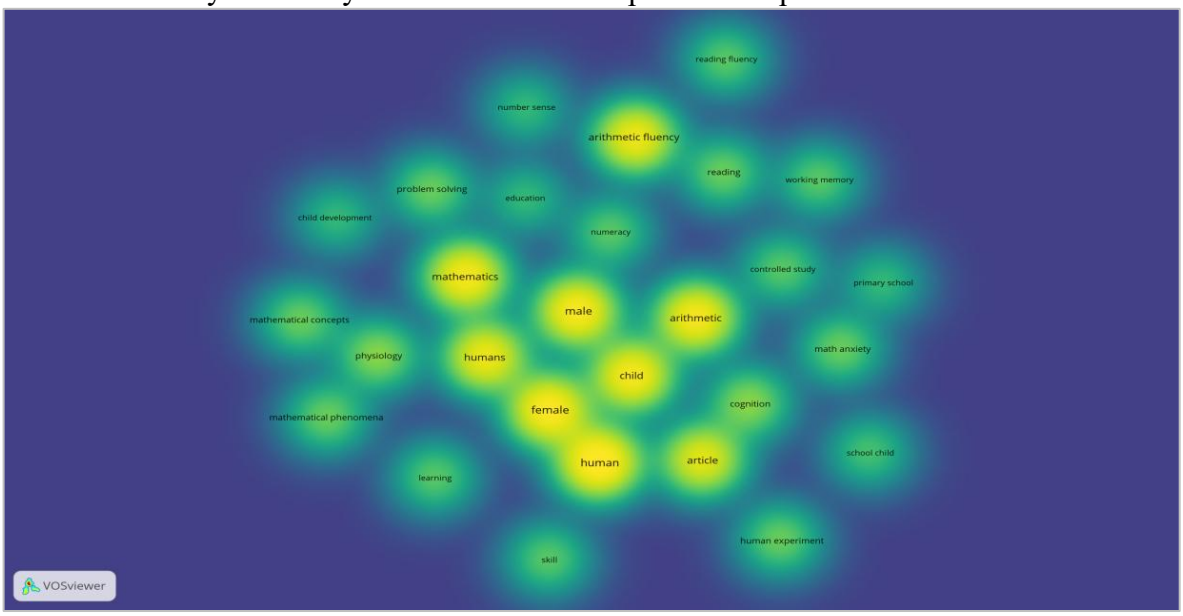


Figure 7. Density visualization of keywords (source: VOSviewer analysis results)

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Table 4. Keyword density levels on the map and their interpretation

Density	Color on map	Keywords	Interpretation
High	● Yellow	arithmetic fluency, mathematics, arithmetic; index terms: human, humans, male, female, child, article	Core of the literature; some nodes are database index terms
Medium	● Green	problem solving, working memory, math anxiety, number sense, numeracy, learning, cognition	Studied, but not yet central
Low	● Blue–purple (map edge)	skill, reading fluency	Sparse area; potential research gap

Discussion

Arithmetic fluency is prominent but tied to cognitive processes and literacy. *Arithmetic fluency* is the only fluency term that forms a large, dense node; *reading fluency* appears only as a small peripheral node. *Computational fluency* and *math fact fluency* do not appear as nodes, possibly because they fall below the minimum occurrence threshold. This is consistent with, though it does not prove, the conceptual gap identified in the introduction: one label dominates while others rarely appear as keywords. The proximity of arithmetic fluency to *working memory* and *reading* is consistent with literature linking automaticity to working-memory load (Ding et al., 2024; Qi et al., 2023; Yu et al., 2025), with the reciprocal relationship between language and mathematics (Peng et al., 2020), and with research on students who have mathematics difficulty with and without comorbid reading difficulty (Powell et al., 2020b).

Problem solving is not yet integrated with fluency. The placement of *problem solving* in the red cluster, apart from the blue fluency cluster, suggests that the two topics are still studied along partly separate tracks. A connecting line exists, but it is thin and the node is small. Word problems have long been a focus of mathematics education research (Verschaffel et al., 2020), and the pattern here is consistent with findings that word-problem performance depends on arithmetic skills as well as text comprehension (Pongsakdi et al., 2020) and that working memory is associated with problem solving (Fuchs et al., 2020; Ji & Guo, 2023). Word-problem interventions have also examined components beyond computation, such as pre-algebraic reasoning (Powell et al., 2020a). However, the map does not show how fluency has been studied as a pathway to problem solving, which corresponds to the mechanism gap identified in the introduction.

Affective factors are present but not central. *Math anxiety* appears in the green cluster together with *primary school*, at medium density. Its presence is consistent with evidence that math anxiety is negatively related to achievement (Barroso et al., 2021) and with the broader attention to emotions and motivation in mathematics education (Schukajlow et al., 2023). Its non-central position may indicate that anxiety is more often studied as a separate variable than together with fluency and problem solving in a single model. Metacognitive monitoring is another process that has been examined in relation to arithmetic (Bellon et al., 2020) and could likewise serve as a linking factor.

A tentative shift toward concepts and child development. On the overlay map, the most recent keywords are *mathematical concepts*, *mathematical phenomena*, *education*, and *child development*, whereas *reading fluency* and *number sense* are older. This may indicate that

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attention is moving from fluency and basic abilities toward conceptual understanding and the educational context, a direction consistent with the view that fluency and understanding are complementary (McNeil et al., 2025) and with the recommendation to combine fluency practice with explicit problem-solving instruction (Fuchs et al., 2021). The reading is tentative, however: *mathematical concepts* and *mathematical phenomena* resemble database index terms rather than author-defined constructs, so their recency may reflect indexing practice as much as research focus. The keyword *physiology*, which also has a recent color, signals a physiological perspective. Similar approaches, such as EEG recordings to study students' information-processing speed, have been used in Indonesia (Darmawan, 2012; Darmawan et al., 2017), although this does not mean that the documents on the map used that method.

Instructional-method keywords are absent. The map contains no nodes such as *teaching*, *instruction*, *intervention*, *contextual*, or *automaticity*. Research-design terms such as *controlled study* and *human experiment* are present, but they are not accompanied by instructional-method terms. This suggests that instructional designs combining fluency building with problem solving in primary-school classrooms are still rarely an explicit focus, in line with the pedagogical gap identified earlier. The reading is conditional: terms that do not appear on the map are not necessarily absent from the literature, because their frequency may fall below the minimum threshold. The study that measured counting automaticity through integrated instruction (Tartillah et al., 2026) illustrates this point, since the term *automaticity* does not appear as a node on this map.

Implications. Overall, the map points to three research opportunities. First, fluency and problem solving could be tested in a single model rather than separately. Second, cognitive and affective factors could be included as linking mechanisms. Third, integrated instructional methods that build automaticity without sacrificing conceptual understanding could be examined in regular classrooms. One candidate is GASING (Gampang, Asyik, dan Menyenangkan) combined with contextual teaching and learning (CTL), which was associated with improved counting automaticity among fourth-grade students in one study (Tartillah et al., 2026) and has been applied to improve fifth-grade mathematics learning outcomes (Saifudin et al., 2026), but has not yet been tested against problem solving. The relationships among the gaps, evidence on the map, and research opportunities are summarized in Table 5, while Figure 8 depicts the two research tracks and the integrated instructional methods that do not yet appear on the map.

Table 5. Synthesis of research gaps, evidence on the map, and research opportunities

Gap	Evidence on the map	Research opportunity
Conceptual	Only arithmetic fluency appears as a large, dense node; computational fluency and math fact fluency do not appear as nodes (probably below the minimum threshold)	Map and compare the three fluency terms together in relation to problem solving
Mechanism	Problem solving (red cluster) is separate from the fluency cluster (blue) with a thin line; math anxiety is not at the center of the map	Test fluency and problem solving in a single model, with cognitive and affective factors as linking mechanisms
Pedagogical	No teaching, instruction, intervention, contextual, or automaticity nodes	Examine integrated instructional methods in regular classrooms; candidate: GASING combined with CTL (not yet tested against problem solving)

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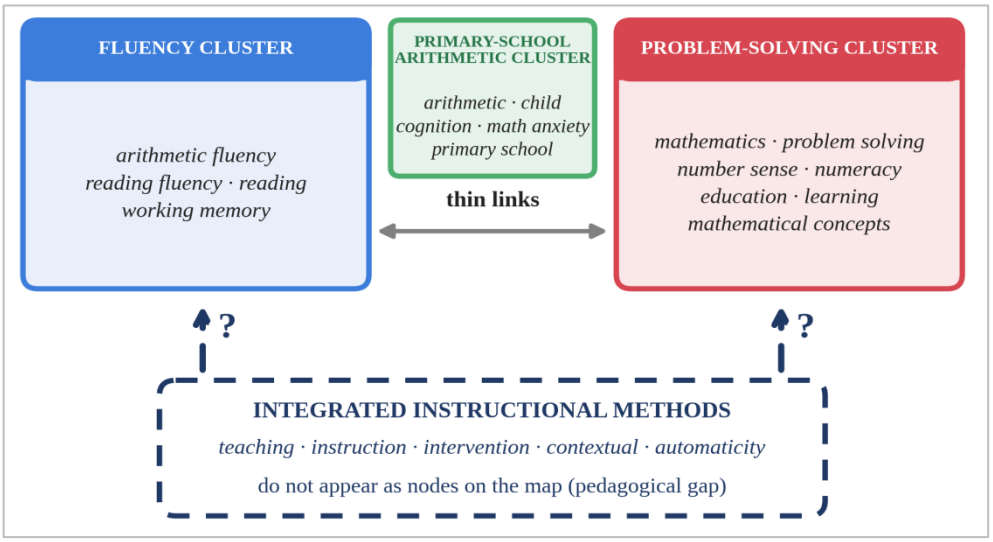


Figure 8. Schematic of findings: the fluency cluster and the problem-solving cluster are studied along separate tracks, while integrated instructional methods do not yet appear on the map (conceptual schematic based on Figure 4)

Interpretation limitations. Nine of the 28 keywords (*human*, *humans*, *male*, *female*, *child*, *article*, *controlled study*, *human experiment*, and *school child*) are database index terms rather than substantive concepts, so their size and density do not indicate research focus (Donthu et al., 2021). In addition, the average publication years on the overlay map range only from 2023 to 2025 because they are averages per keyword; they do not show the distribution of all documents published in 2020–2026, and 2026 covers only part of the year. The map also depicts patterns of keyword co-occurrence, not the content or strength of evidence of individual documents.

CONCLUSIONS

This study mapped Scopus-indexed research on automaticity and arithmetic fluency in children and primary-school contexts using 64 exported records from 2020–2026. In answer to RQ1, the keyword network of 28 terms formed four clusters: arithmetic fluency grouped with working memory and reading; problem solving grouped with mathematics, number sense, and numeracy; and a large cluster combined arithmetic, cognition, math anxiety, and primary school with generic index terms. Generic index terms such as human, child, male, female, and article were highly visible and should not be interpreted as substantive research themes. In answer to RQ2, keywords associated with concepts, education, and child development had the most recent average publication years, whereas reading fluency and number sense were older, although this signal is tentative. In answer to RQ3, instructional-method terms and automaticity itself did not appear as nodes, and problem solving was only weakly linked to arithmetic fluency, suggesting that integrated designs combining fluency building and problem solving deserve further attention.

Future research should examine how arithmetic fluency and automatic retrieval support children's mathematics learning while distinguishing basic retrieval speed from conceptual understanding and problem-solving performance. Experimental and quasi-experimental classroom studies could test integrated instructional methods directly, which bibliometric mapping cannot do. Researchers should also extend the search across databases, harmonize

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keywords with a thesaurus, relax the open-access and language restrictions, and document the export and screening process transparently so that the mapping can be replicated.

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