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Internal Dimensions of Elementary Students' Mathematics Engagement: A Bibliometric Analysis (2019-2025)

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ABSTRACT
Internal dimensions including motivation, self-efficacy, emotion, interest, and metacognition are important psychological factors that shape elementary students' engagement in learning mathematics and enrich the theoretical understanding of engagement in basic mathematics contexts. This bibliometric study examines research trends on these internal dimensions from 2019 to 2025 using text mining and co-occurrence analysis to clarify and strengthen the theoretical framework of mathematics engagement at the elementary school level. The data consist of 995 peer reviewed articles retrieved from Google Scholar and analyzed using VOSviewer. The analysis identified 76 key terms that form five thematic clusters: (1) technology based internal factors, (2) self-efficacy and achievement, (3) teachers as facilitators of internal development, (4) developmental and relational factors, and (5) motivation as a core dimension. The term network shows a high level of interconnectedness (995 links, total link strength 1,999), with self-efficacy acting as a key factor that links motivation, emotion, and learning outcomes, rather than merely being the most frequently studied topic. Temporal analysis indicates a shift from studies of psychological factors in isolation (2019–2020) to more integrated models that examine multiple internal dimensions within technology enhanced learning environments (2023–2024); these findings refine and enrich engagement theory by positioning interactions among internal dimensions as the core of students' mathematics engagement in elementary school. Research gaps remain in understanding how internal dimensions develop across different grade levels and how teaching practices are connected to students' internal engagement. Practically, the findings provide a basis for elementary school teachers to design mathematics lessons that deliberately foster motivation, strengthen self-efficacy, and reduce mathematics anxiety through technology based activities that are appropriate to students' developmental stages, while also offering input for curriculum policymakers to integrate indicators of internal dimensions into curriculum and assessment design. Overall, this study offers a comprehensive mapping of the literature on internal dimensions, proposes theoretical refinement of the engagement construct in elementary mathematics, and suggests future research directions that are relevant for classroom practice and education policy.
***Keywords**: internal dimensions; student engagement; elementary mathematics; bibliometric analysis; VOSviewer*

ABSTRAK
Dimensi internal yang meliputi motivasi, efikasi diri, emosi, minat, dan metakognisi merupakan faktor psikologis penting yang memengaruhi keterlibatan belajar matematika siswa sekolah dasar

serta memperkaya pemahaman teoritis tentang engagement dalam konteks matematika dasar. Studi bibliometrik ini menelaah tren penelitian mengenai dimensi internal tersebut pada periode 2019–2025 dengan menggunakan text mining dan analisis ko-okurensi untuk memperjelas dan memperkuat kerangka teoritis keterlibatan belajar matematika di sekolah dasar. Data berupa 995 artikel terindeks yang telah ditinjau sejawat diperoleh dari Google Scholar dan dianalisis menggunakan VOSviewer. Hasil analisis mengidentifikasi 76 istilah kunci yang membentuk lima kluster tematik, yaitu: (1) faktor internal berbasis teknologi, (2) efikasi diri dan pencapaian, (3) guru sebagai fasilitator pengembangan internal, (4) faktor perkembangan dan relasional, serta (5) motivasi sebagai dimensi inti. Jaringan istilah menunjukkan tingkat keterhubungan yang tinggi (995 tautan, total kekuatan tautan 1.999), dengan efikasi diri berperan sebagai faktor kunci yang menghubungkan motivasi, emosi, dan hasil belajar, bukan sekadar topik yang paling sering diteliti. Analisis temporal menunjukkan pergeseran dari kajian faktor psikologis yang berdiri sendiri (2019–2020) ke model yang lebih terintegrasi yang menelaah berbagai dimensi internal dalam konteks pembelajaran berbasis teknologi (2023–2024); temuan ini memperhalus dan memperkaya teori engagement dengan menempatkan interaksi antar dimensi internal sebagai inti keterlibatan belajar matematika di sekolah dasar. Kesenjangan penelitian masih tampak pada aspek perkembangan dimensi internal di berbagai jenjang kelas dan pada mekanisme yang menghubungkan praktik mengajar guru dengan keterlibatan internal siswa. Secara praktis, hasil penelitian ini dapat menjadi dasar bagi guru sekolah dasar untuk merancang pembelajaran matematika yang secara sadar mendorong motivasi, memperkuat efikasi diri, dan mengurangi kecemasan matematika melalui kegiatan berbasis teknologi yang sesuai dengan tahap perkembangan siswa, sekaligus memberi masukan bagi perumus kebijakan kurikulum untuk mengintegrasikan indikator dimensi internal ke dalam rancangan kurikulum dan asesmen. Secara keseluruhan, studi ini menyajikan pemetaan komprehensif atas literatur mengenai dimensi internal, menawarkan penyempurnaan teoritis terhadap konsep engagement dalam matematika sekolah dasar, dan mengusulkan arah penelitian lanjutan yang relevan bagi praktik pembelajaran maupun kebijakan pendidikan.

Kata Kunci: dimensi internal; keterlibatan siswa; matematika sekolah dasar; analisis bibliometrik; VOSviewer

INTRODUCTION

Student engagement plays a crucial role in improving students' academic achievement, especially in elementary school mathematics learning. Students who are actively involved in behavioral, emotional, and cognitive aspects tend to have better academic achievement and more developed critical thinking skills (Bagaskorowati et al., 2023). Mathematics as a core subject aims to develop logical, analytical, and systematic thinking, so high and sustainable engagement is essential for achieving learning goals. However, many elementary students remain passive in mathematics lessons, hold negative perceptions of the subject, and show low learning motivation, indicating that engagement in elementary mathematics is still an urgent problem that needs systematic attention.

Internal factors such as learning motivation, attention, interest in mathematics, and self-efficacy are key determinants of student engagement in mathematics learning. Xia et al. (2022) showed that motivation and engagement significantly influence mathematics achievement among elementary students in China, with intrinsic motivation as a strong predictor of engagement. Studies in Indonesian elementary contexts strengthen this evidence: Ituga & Alman (2023) found that self-efficacy, self-regulation, and self-confidence jointly influence fifth graders' problem solving abilities, while Wiryanto et al. (2024) reported that culturally responsive mathematics instruction can substantially increase students' interest and motivation. These findings confirm that self-efficacy and motivation are dominant constructs in the literature and often become the main focus when discussing internal dimensions of student engagement.

At the same time, several studies illustrate that internal dimensions in mathematics learning are not isolated variables but form interconnected psychological pathways. Peñuñuri et al. (2024) demonstrated that self-efficacy mediates the relationship between academic motivation and affective engagement in STEM contexts, while Geary et al. (2021) showed that in class attention, spatial ability, and mathematics anxiety together predict gains in mathematics achievement. Lo & Hew (2021) systematic review also emphasized that behavioral, emotional, and cognitive engagement need to be seen in an integrated way rather than as separate components. Subsequent empirical studies further report strong correlations between self-efficacy and problem solving ability (Firmansyah et al., 2024), and high predictive power of self-efficacy and motivation on mathematics achievement (Gultom & Sihombing, 2024. This body of work highlights the centrality of self-efficacy and motivation, but the discussion of other internal dimensions often appears fragmented and scattered across different studies.

From a system level perspective, the Program for International Student Assessment (PISA) 2022 results show that Indonesian students' mathematics scores are 366, about 13 points below the global average, indicating weaknesses in mastering concepts and applying mathematics in everyday contexts (Wijaya et al., 2024;Ituga & Alman, 2023) This condition reinforces the need for a more comprehensive understanding of how internal dimensions of engagement are studied in elementary mathematics, especially in the post pandemic period when many learning environments have shifted toward hybrid and technology supported modes. However, existing reviews and empirical studies tend to focus on specific variables (such as self-efficacy or motivation) or broader discussions of engagement, without systematically mapping how internal dimensions are conceptualized and linked in the elementary school context.

From a research status perspective, this study primarily supports and extends previous findings that highlight self-efficacy, motivation, and emotion as central determinants of student engagement, while also correcting the fragmented view by integrating these internal dimensions within technology enriched learning contexts at the elementary level (Wacner Simamora et al., 2025).

Previous literature reviews have discussed elementary mathematics learning and student engagement, but they rarely place internal dimensions as the main unit of analysis at the elementary level (Wahyudi et al., 2025), for example, reviewed engagement in mathematics learning without detailing internal dimensions as an integrated construct. Cipta et al. (2024) conducted a bibliometric analysis of research trends in elementary mathematics learning based on Scopus data, yet aspects such as motivation, attention, interest, and self-efficacy were not examined as a unified internal structure of engagement. This indicates a research gap: there is still a lack of bibliometric mapping that specifically focuses on internal dimensions of elementary students' mathematics engagement, especially for the post pandemic period when technology enhanced learning has become more prominent.

Based on this gap, the present study positions itself to provide both a structured mapping and a clearer academic contribution. The novelty of this research lies in its bibliometric analysis that specifically examines internal dimensions of elementary students' mathematics engagement using VOSviewer, with a focus on publications from 2019 to 2025 as a post pandemic oriented period. This study aims to: (1) map the development and trends of scientific

publications on internal dimensions of elementary students' mathematics engagement during 2019–2025; (2) identify dominant keywords, main thematic clusters, and conceptual relationship patterns among internal dimensions using bibliometric analysis; and (3) analyze the evolution of research focuses to identify topics that have been extensively studied as well as neglected areas that have potential for future development. Through this design, the study is expected to clarify the position of internal dimensions within the engagement literature in elementary mathematics and to offer theoretical and practical contributions for subsequent research and educational policy.

METHODS

Type and Design

This research uses bibliometric analysis with a quantitative descriptive approach to map patterns, publication trends, and research clusters related to the internal dimensions of elementary students' mathematics engagement from 2019 to 2025. The main tools used are the Publish or Perish application for citation data collection and VOSviewer for keyword network analysis and visualization, following common practices in recent bibliometric studies in education. In this study, thematic refinement was carried out at the keyword level rather than at the document level, so that the full set of retrieved articles remained included in the analysis while the focus of interpretation was narrowed through keyword selection.

Data and Data Sources

Data were obtained from Google Scholar using Publish or Perish version 8.19. Google Scholar was selected because it indexes a wide range of international and local journals in education and mathematics, including many outlets that are not fully covered by commercial databases, which is important for capturing studies on elementary mathematics engagement in diverse contexts. To address concerns about heterogeneity, a structured filtering procedure was applied to approximate a peer reviewed article corpus..

The search query focused on the internal dimensions of elementary students' mathematics engagement using the keywords "student engagement", "mathematics", "elementary school", and internal factors (motivation OR "self-efficacy" OR interest OR emotion), limited to publications from 2019 to 2025. The initial search produced 995 records. We then applied several verification steps: (1) only documents published in journals or conference proceedings with editorial review were retained, (2) non scholarly sources such as books, theses, reports, and preprints without clear peer-review status were excluded, and (3) duplicate records across different versions of the same article were removed; this procedure resulted in a final dataset of 995 peer-reviewed research articles indexed in Google Scholar..

To enhance reproducibility, the full search string, time window (January 1, 2019–December 31, 2025), and inclusion criteria are explicitly reported, and the data extraction was conducted in a single session using a fixed version of Publish or Perish (v8.19). Within this frame, the dataset demonstrated substantial academic impact, with 36,569 total citations, an H-index of 95, and a G-index of 152..

Data Collection Technique

The selection process followed a four step flow similar to PRISMA, namely identification, screening, eligibility, and inclusion. In the identification stage, the Google Scholar search produced 995 records. The screening stage was carried out by reviewing titles and abstracts to eliminate clearly irrelevant publications and non article document types, while documents that still fell within the broader theme of student engagement in mathematics were retained for further analysis. All articles that passed the eligibility stage were then used as the basis for the VOSviewer co-occurrence analysis. In line with the design of this study, refinement of thematic relevance was conducted at the keyword level through co-occurrence thresholds and clustering, rather than by excluding a large number of documents from the database.

Data Analysis

Text mining and co-occurrence analysis were conducted using VOSviewer version 1.6.20. Terms were extracted from the title and abstract fields using the binary counting method to ensure equal weight for each document, as commonly adopted in bibliometric mapping studies. A minimum occurrence threshold of 10 was set, resulting in 76 terms from a total of 4,217 terms that met this criterion. These terms were automatically grouped into five thematic clusters through VOSviewer's clustering algorithm, with the clustering resolution kept at the default value to balance thematic granularity and interpretability of the maps. The resulting network contained 995 co-occurrence links and a total link strength of 1,999, indicating dense conceptual relationships among the internal factors. In interpreting the maps, total link strength was used as a practical indicator of how central a term is within the co-occurrence network, that is, how strongly it is connected to other terms in the field. Cluster membership and link strength values were then combined to identify terms that play bridging roles across clusters (for example, self-efficacy and motivation) and to characterize each cluster's thematic focus. Three visualization types were generated to map research patterns: (1) Network visualization to identify thematic clusters, highly connected terms, and inter-term relationships, (2) Density visualization to map research intensity and identify areas with high research activity (hotspots), (3) Overlay visualization to analyze the temporal evolution of research themes based on the average publication year. In line with the descriptive aim of this study, we did not compute advanced network metrics such as centrality indices or modularity coefficients, so interpretations are restricted to descriptive patterns in the co-occurrence structures rather than formal network modelling.

RESULTS AND DISCUSSION

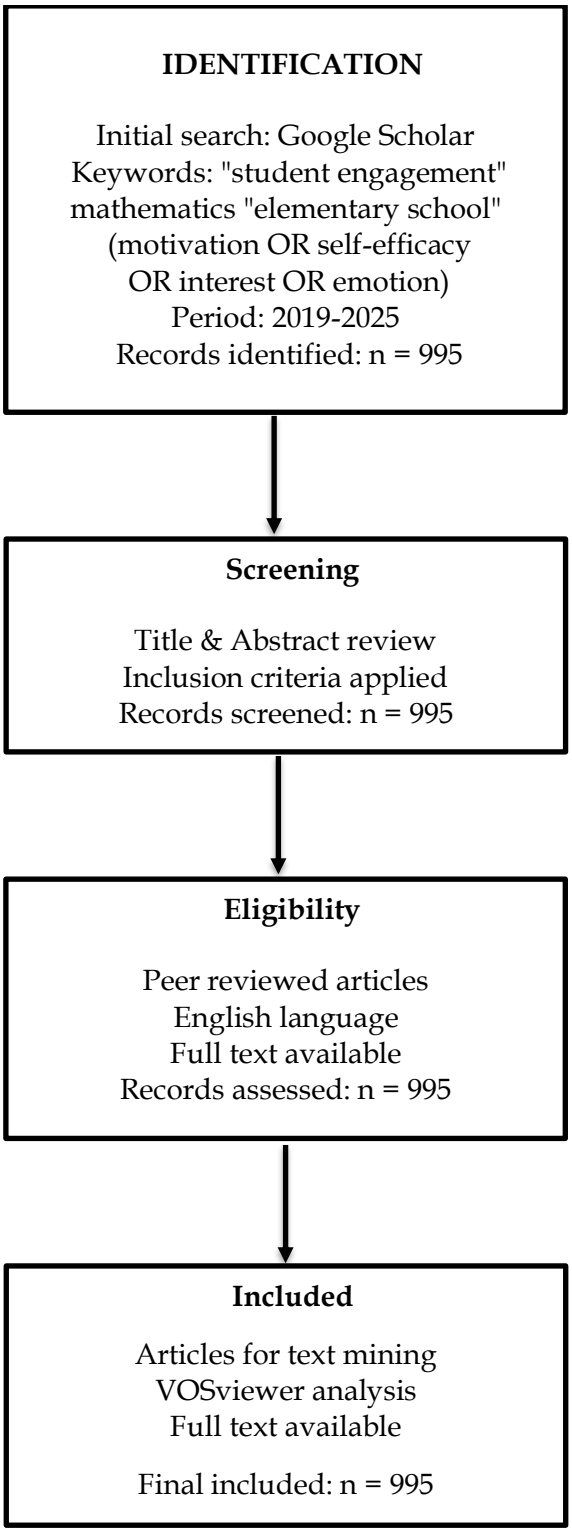

Figure 1. *PRISMA style flowchart depicting the systematic article selection process for bibliometric analysis.*

The search yielded 995 peer-reviewed articles from Google Scholar (2019–2025) focusing on internal dimensions of elementary students' mathematics engagement. The PRISMA style flowchart shows identical counts (n = 995) at the identification, screening, eligibility, and

inclusion stages because the main refinement in this bibliometric study was deliberately conducted at the keyword level rather than through extensive document exclusion. Initial title and abstract screening removed only a small number of clearly non scholarly items (such as preprints, books, and institutional reports) and duplicate records during the data-cleaning procedure described in the Methods section. Consequently, all 995 articles that met the basic inclusion criteria (peer-reviewed research published in journals or proceedings) were retained for VOSviewer text-mining analysis. Thematic focus was then narrowed through keyword based co-occurrence thresholds (minimum occurrence = 10) rather than through document level exclusion, ensuring that the full corpus was analyzed while interpretation concentrated on the most salient conceptual themes. Figure 1 also provides citation count information, which is fully reported in Table 1.

Table 1. *Citation Metrics: Bibliometric Data from PoP Search Results*

Search Parameter	Details
Database	Google Scholar
Search tool	Publish or Perish v8.19
Keywords	*"student engagement" mathematics "elementary school" (motivation OR "self-efficacy" OR interest OR emotion)*
Publication period	2019 – 2025
Document type	Peer-reviewed articles
Total articles retrieved	995
Total citations	36569
Cites/year	6094.83
Cites/paper	36.75
Cites/author	15896.20
Papers/author	456.15
Authors/paper	2.81
h-index	95
g-index	152
hI,norm	55
hI,annual	9.17
hA-index	50

Note: Search conducted in december 2025. Citation metrics calculated as of the search date.

Bibliometric analysis of 995 publications from Google Scholar (2019-2025) reveals high research activity on this topic. The H-index of 95 and G-index of 152 indicate significant impact on the global research community. The average citations per article and per year demonstrate sustained academic interest in internal dimensions of mathematics learning engagement at the elementary level.

Table 2. *Annual development of publications on internal dimensions (2019–2025)*

Year	Number of publications	Percentage (%)
2019	117	12%
2020	112	11%
2021	105	10%
2022	128	13%
2023	150	15%
2024	195	20%
2025	188	19%
Total	**995**	**100%**

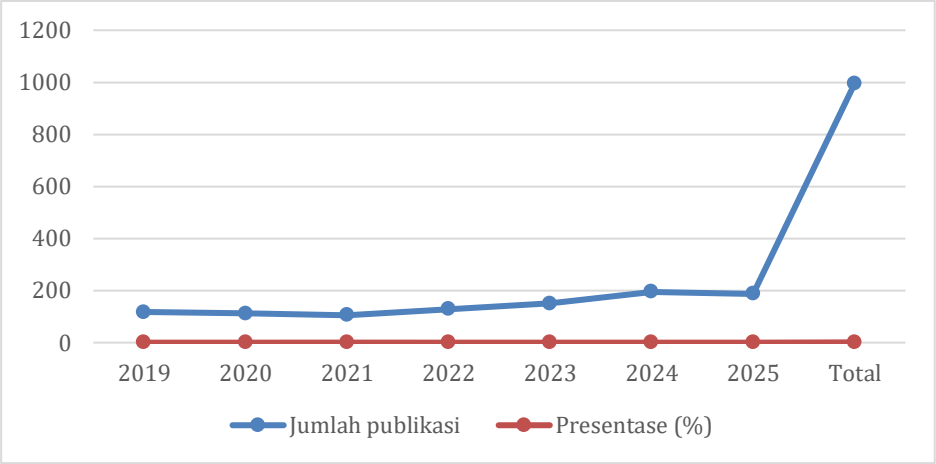

Figure 2. *Temporal Distribution of Publications on Internal Dimensions of Elementary Mathematics Engagement (2019–2025)*

Bar chart showing annual publication trends with notable increase from 117 articles (12%) in 2019 to peak of 195 articles (20%) in 2024, followed by slight decline to 188 articles (19%) in 2025. The growth pattern reflects heightened research interest in psychological factors of mathematics learning, particularly following the COVID-19 pandemic period (2020-2022). Data source: Google Scholar (n = 995 articles).

Text mining analysis of 995 articles published between 2019 and 2025 identified 76 key terms representing internal dimensions of elementary students' mathematics learning engagement. These terms formed 5 interconnected thematic clusters with 995 co-occurrence links and total link strength of 1,999, indicating dense conceptual relationships among psychological, cognitive, and emotional factors influencing student engagement.

Network Visualization: Five Thematic Clusters

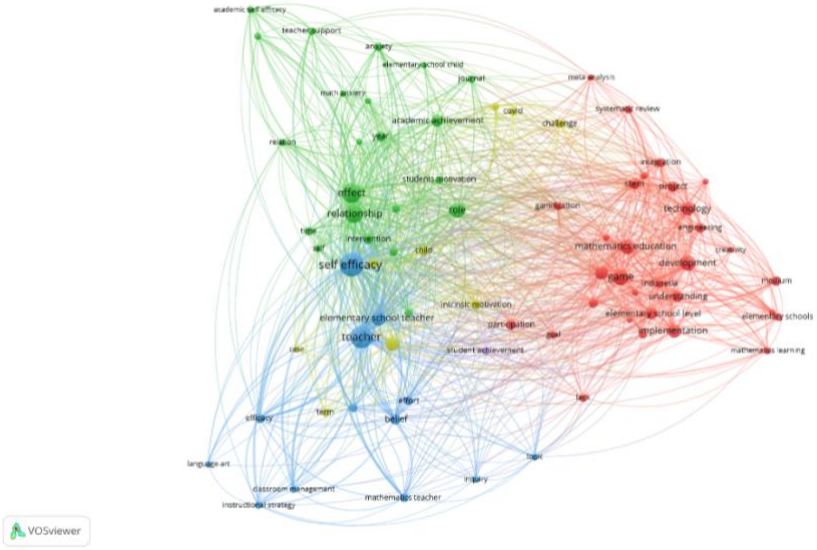

Figure 3. *Network Visualization of Co-occurrence Relationships Among 76 Key Terms in Internal Dimensions Research (2019-2025).*

Term co-occurrence analysis of 995 articles using VOSviewer produced a network of 76 terms organized into five thematic clusters: Cluster 1 (red, 18 terms) represents technology-mediated internal factors; Cluster 2 (green, 16 terms) centers on self-efficacy and achievement with strong links to mathematics anxiety; Cluster 3 (blue, 15 terms) captures teacher-related factors that facilitate internal development; Cluster 4 (yellow, 14 terms) focuses on developmental and relational factors; and Cluster 5 (purple, 13 terms) highlights motivation as a core internal dimension. Node size reflects term frequency (minimum 10 occurrences) and line thickness indicates co-occurrence strength, with 995 links and a total link strength of 1,999 showing dense conceptual interconnections among psychological, cognitive, and emotional factors.

Cluster 1 (Red): Technology Mediated Internal Factors

Cluster 1 includes terms such as mathematics education, technology, engineering, STEM, development, creativity, and elementary schools. This configuration shows that recent studies increasingly examine how digital and hybrid learning environments relate to students' motivation, interest, and cognitive engagement. Marpaung et al. (2024), ound that Canva-based interactive media improved sixth-graders' critical thinking in solving word problems, indicating that technology can scaffold higher-order thinking rather than merely present content. (Azzahra Nurlatifah & Purniati, 2025a). reported that Android-based applications and digital games enhanced both motivation and mathematics learning outcomes among elementary students. Together with the concentration of technology-related terms in the more recent years of the overlay visualization, these findings suggest a post-pandemic shift toward viewing technology as a learning ecology that shapes internal dimensions of engagement.

Cluster 2 (Green): Self-Efficacy and Achievement

luster 2 centers on self-efficacy, with closely linked terms such as academic self-efficacy, academic achievement, anxiety, teacher support, and academic engagement. This pattern confirms that self-efficacy is the dominant internal dimension in the mapped literature, often

examined alongside mathematics anxiety and achievement. Ituga & Alman (2023) found that self-efficacy, together with self-regulation and self-confidence, significantly predicts problem-solving ability among fifth grade students, showing that internal dimensions tend to operate synergistically rather than in isolation. Zakariya (2022) systematic review identified mastery experiences and positive feedback as key mechanisms for enhancing mathematics self-efficacy, while Basileo et al. (2024) reported that perceived teacher support of basic psychological needs significantly predicts self-efficacy among 2,359 middle school students. Recent analysis by Rahmawati & Nopriana, (2024) indicates that problem solving ability and persistence in facing challenges are the strongest self-efficacy indicators, although teacher dependence remains a pedagogical concern. The dominance of self-efficacy in the network may reflect both substantive theoretical interest and database characteristics, as Google Scholar indexes many psychology and motivation oriented journals that more frequently publish self-efficacy studies than work on less operationalized constructs such as productive disposition or metacognitive beliefs. In addition, some studies report null findings where self-efficacy and motivation do not significantly predict achievement ($p>0.05$), suggesting that contextual and methodological factors including measurement timing and sample characteristics critically mediate these relationships (Wahyuningtyas et al., 2018).

Cluster 3 (Blue): Teacher as Facilitator of Internal Development

Cluster 3 brings together terms such as *t*eacher, elementary school teacher, belief, classroom management, instructional strategy, and inquiry. These terms show that many studies conceptualize teachers as key external agents who shape students' internal dimensions through their classroom practices. Mega & Madani (2023) documented that authentic assessment practices in elementary mathematics not only measure learning but also enhance motivation and critical thinking through continuous feedback and opportunities for reflection. Indrawati et al. (2024) found that differentiated mathematics instruction can strengthen students' self-efficacy and learning motives when supported by adequate teacher preparation and institutional support. In the network, teacher-related terms connect mainly to motivation and self-efficacy, indicating that teacher influence is widely acknowledged but often discussed at a broad conceptual level, with fewer bibliometric signals for specific mechanisms such as feedback types or discourse strategies.

Cluster 4 (Yellow): Developmental and Relational Internal Factors

Cluster 4 emphasizes developmental and relational aspects, with terms such as child, relationship, intervention, case, role, and participation. The co-occurrence of "child" and "relationship" suggests attention to how social emotional relationships with teachers and peers shape internal states such as motivation and interest. Intervention-related terms indicate experimental efforts to influence internal factors through approaches aligned with developmental psychology. Suminar et al. (2024) showed that spatial reasoning based Problem Based Learning improves fifth graders' geometry problem solving by matching task demands to students' cognitive development stage, while Mega et al. (2024) reported varying levels of higher order thinking skills in geometry, underscoring the need for differentiated support. Nevertheless, the relatively low density of developmental terms and the absence of strong grade specific clusters suggest that longitudinal and grade differentiated perspectives remain limited in the current corpus.

Cluster 5 (Purple): Motivation as Core Internal Dimension

Cluster 5 contains terms such as students motivation, academic motivation, academic engagement, student achievement, role, and effect, underscoring motivation as a core internal driver in elementary mathematics engagement. Many studies in this cluster examine how motivation relates to persistence, participation, and achievement, often in combination with other internal factors. Hasanah & Pasaribu (2020) reported that Realistic Mathematics Education increased both self-efficacy and motivation, while Khairizka & Wandini (2024) found that open ended, realistic tasks significantly enhanced fifth graders' creative mathematical thinking, suggesting links between motivation, interest, and creative dispositions. However, the co-occurrence patterns indicate that motivation is frequently treated in broad terms, with relatively few distinctions between intrinsic and extrinsic motivation or between mastery and performance oriented goals, leaving room for more nuanced motivational analyses in future research.

Density Visualization: Research Intensity Hotspots

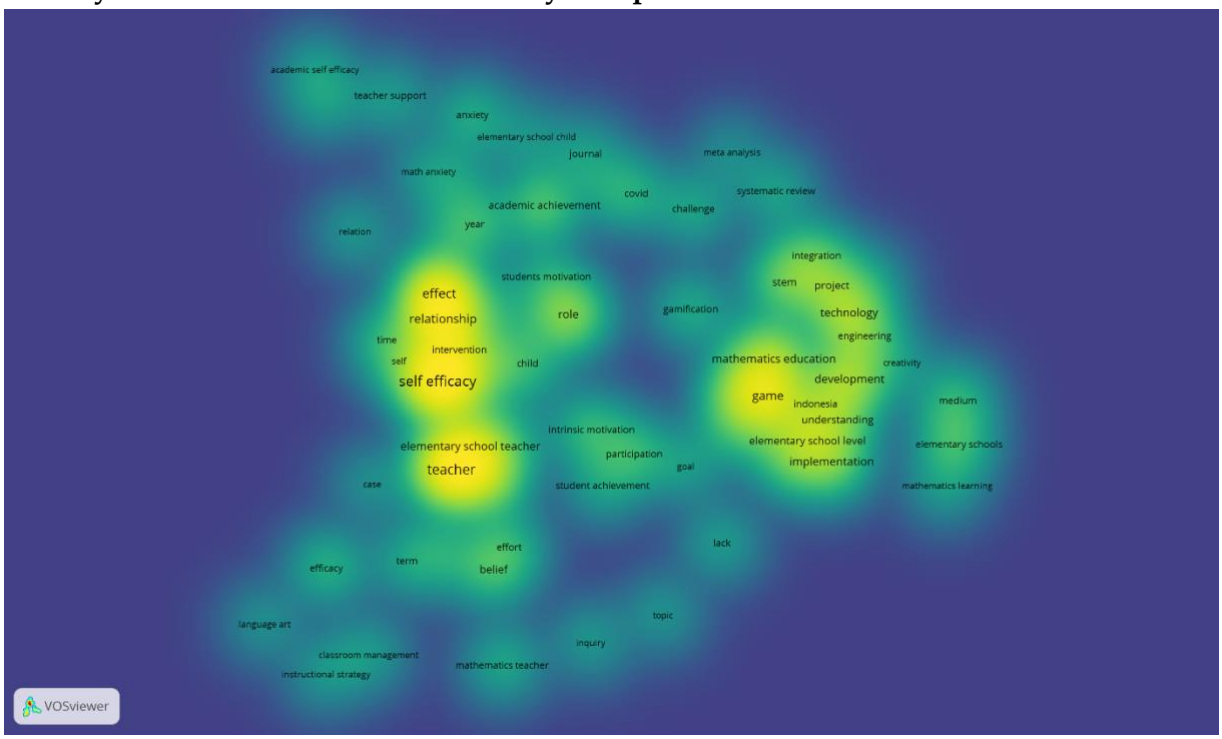

Figure 4. *Research Intensity Heatmap of Internal Dimensions Topics*

Density visualization derived from term co-occurrence network, where color intensity represents research concentration. Yellow to red zones indicate high density "hotspots" of intensive research activity, while blue zones represent emerging or underexplored areas. The densest hotspot centers on self-efficacy (Cluster 2) and its relationships with academic achievement, anxiety, and teacher support, indicating this remains the most heavily researched internal dimension. Secondary hotspots emerge around technology mediated terms (Cluster 1), reflecting post pandemic growth in STEM and engineering education research. Lower density regions in Cluster 4 (child, relationship, intervention) suggest developmental aspects remain relatively underexplored, presenting opportunities for future research. Visualization parameters: minimum term occurrence = 10; attraction = 2; repulsion = 1.

Density analysis reveals research intensity distribution across the term network. Yellow areas represent high density hotspots indicating concentrated research activity, while blue areas represent emerging or underexplored topics.

The densest hotspot centers on self-efficacy and its connections to academic achievement, anxiety, and teacher support (Cluster 2), indicating this remains the most heavily researched internal dimension. A secondary hotspot emerges around technology mediated terms (Cluster 1), reflecting rapid growth in STEM and engineering education research post pandemic (2020-2025).

Lower density areas include terms in Cluster 4 (child, relationship, intervention), suggesting that developmental and relational aspects of internal factors remain relatively underexplored despite their theoretical importance. This gap presents opportunities for future research examining how elementary students' internal dimensions evolve across developmental stages and social contexts.

Temporal Evolution Through Overlay Visualization

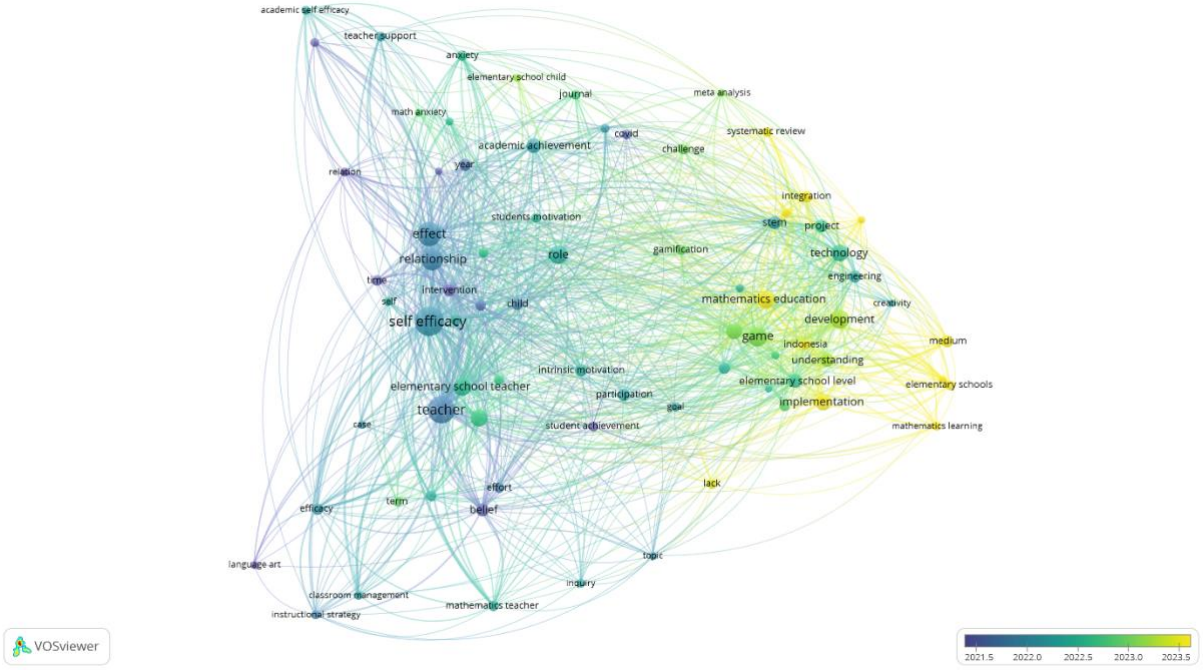

Figure 5. *Temporal Evolution of Research Themes in Internal Dimensions (2019-2025)*

Overlay visualization using average publication year as a color gradient maps the temporal development of research focus. Blue nodes (2019–2020) represent early phase foundational constructs (self-efficacy, teacher beliefs, classroom management); green nodes (2020–2022) indicate a transitional period with increased attention to emotional dimensions (anxiety, affect) and relational factors; yellow nodes (2023–2024) mark recent research prominently featuring technology mediated terms (technology, engineering, STEM, creativity) and more holistic engagement constructs. This temporal pattern indicates a gradual shift from studies examining isolated psychological factors toward designs that consider multiple internal dimensions within technology enhanced learning environments. The concentration of yellow nodes in Clusters 1 and 5 suggests a recent convergence of interest around intersections

between motivation and technology-supported mathematics learning. Color scale: dark blue (2019) → yellow (2024).

Overlay visualization using average publication year as the color scale reveals temporal shifts in research focus across three distinct phases:

Phase 1 (2019–2020, blue nodes): Foundational psychological constructs dominated early research, including self-efficacy, teacher beliefs, and classroom management. This phase reflects more traditional approaches emphasizing cognitive and motivational psychology theories, with studies largely focusing on relationships between individual internal factors (e.g., self-efficacy) and achievement outcomes.

Phase 2 (2020–2022, green nodes): A transitional period marked by increased attention to emotional dimensions (anxiety, affect) and relational factors (relationship, participation). This change likely reflects pandemic era recognition that social emotional internal factors significantly affect remote and hybrid mathematics learning. During this phase, research increasingly began to consider multiple internal dimensions together rather than examining single constructs in isolation.

Phase 3 (2023–2024, yellow nodes): Recent research prominently features technology mediated terms (technology, engineering, STEM, creativity, development) and broader engagement constructs (academic engagement, students' motivation). This phase points to a growing emphasis on integrated models that examine how technology rich environments relate to several internal dimensions simultaneously. The prominence of "elementary schools" and "elementary school child" in this phase also indicates increasing recognition that internal factors may operate differently across developmental levels, calling for age appropriate research and interventions.

Taken together, this temporal evolution suggests a gradual reorientation of research emphasis from narrowly focused studies of single internal factors toward more integrated examinations of how motivation, emotion, cognition, and interest are studied in connection with technology and classroom context, rather than a fully established theoretical paradigm shift.

Discussion: Integration of Findings

The five cluster structure and temporal patterns together suggest several key insights about internal dimensions research in elementary mathematics engagement:

First, self-efficacy clearly appears as the most central internal dimension in the co-occurrence network, with the largest node size and strongest link strength values within Cluster 2. This pattern indicates that studies on internal dimensions have been dominated by self-efficacy and motivation constructs, while other affective dimensions such as productive disposition or mathematical identity remain far less visible in the mapped literature (Rohman et al. (2023). Bibliometric evidence from the density and overlay maps also shows that self-efficacy continues to occupy a stable position across the entire 2019–2025 period, whereas newer constructs emerge only in later years, reinforcing the sustained centrality of self-efficacy within the field (Scoping Review, 2024; Yang et al., 2024).

Second, technology functions increasingly as a context for studying internal dimensions rather than merely as a tool. The concentration of technology, STEM, engineering, and creativity terms in Cluster 1, combined with their relatively recent average publication years,

suggests that post pandemic research has shifted toward examining how digital and hybrid learning environments relate to motivation, interest, and cognitive engagement in mathematics (Marpaung et al, 2024; Azzahra Nurlatifah & Purniati, 2025b). In the bibliometric map, technology-related terms form bridges to both motivation and achievement nodes, indicating that contemporary studies tend to frame technology-mediated learning as an environment that can activate or hinder internal dimensions, rather than as an add-on to traditional instruction (Kartika et al., 2024; Wiryanto et al. (2024).

Third, the mapped network reveals clear gaps in developmental and longitudinal perspectives. Although terms such as "child", "elementary schools", and "students motivation" appear in Clusters 3 and 4, they do not form dense subclusters that differentiate lower and upper elementary grades or long-term trajectories. This suggests that most studies treat elementary students as a single group and rely on cross-sectional designs. From a bibliometric standpoint, the relative scarcity of terms associated with growth, trajectories, or longitudinal analysis indicates that questions about how motivation, self-efficacy, and emotion evolve across grades remain underexplored in the current corpus (Street et al., 2024; Mega & Meiliasasi., 2024)

Fourth, teacher related terms in Cluster 3 highlight the recognized role of teachers in supporting students' internal development, but the conceptual pathways remain only partially specified in the bibliometric structure. Terms such as "teacher", "classroom management", "instructional strategy", and "belief" cluster together, and they connect to self-efficacy and motivation nodes, suggesting that teacher practices are frequently studied as antecedents or contextual factors Mega & Faisal Madani., 2023; Indrawati et al. (2024). However, the network does not show a strong presence of more fine-grained mechanisms (e.g., feedback types, questioning patterns, or discourse moves), indicating that many studies still conceptualize teacher influence at a relatively broad level. This points to the need for future work that more precisely links specific instructional practices to distinct internal dimensions, while also accounting for contextual and methodological moderators such as measurement timing and sample characteristics (Wahyuningtyas et al., 2018).

Fifth, metacognitive constructs appear only at the periphery of the network, often attached to broader terms such as self regulated learning or problem solving rather than forming a separate, dense cluster. This peripheral position suggests that, within the mapped dataset, metacognition is acknowledged but not yet treated as a central organizing construct in elementary mathematics engagement research. The bibliometric pattern therefore aligns with the conclusion that metacognitive dimensions are conceptually important but remain empirically underrepresented, especially compared with motivation and self-efficacy (Hariyani et al. 2024; Abolla et al., 2024).

Sixth, creative thinking and cognitive flexibility are present but relatively sparse in the co-occurrence structure, typically linked to terms in the technology cluster (e.g., project-based learning, STEM, creativity) rather than forming their own thematic cluster. This indicates that creativity related internal dispositions are often studied in specific intervention contexts and have not yet become a dominant theme across the broader engagement literature. The low density of these terms suggests a promising direction for future research that more systematically integrates creative and flexible thinking as core internal dimensions of

engagement in elementary mathematics, rather than treating them as secondary outcomes of particular instructional programs. Khairizka & Wandini, 2024;Hasanah & Pasaribu., 2020).

Critical Reflections on the Bibliometric Patterns

Several critical observations emerge when examining the structure and gaps in the internal dimensions literature. First, metacognition remains underrepresented despite its theoretical importance. Although metacognitive constructs and self-regulated learning appear in the network, they do not form a dense cluster of their own and are mainly connected as peripheral terms. This suggests that, compared with self-efficacy and motivation, metacognition receives less systematic attention in elementary mathematics engagement research, even though studies by Hariyani et al. (2024) and Abolla et al. (2024) indicate its important mediating role between instructional design and problem solving outcomes. Future research should investigate why metacognitive dimensions remain less visible and whether this reflects genuine underinvestigation or limitations in how these constructs are operationalized and reported.

Second, the dominance of self-efficacy may be influenced by database characteristics. Google Scholar indexes a large volume of psychology and motivation oriented journals, which are more likely to publish self-efficacy studies than work on less operationalized constructs such as productive disposition, mathematical identity, or epistemic beliefs. While self-efficacy is undoubtedly central to engagement theory, the strong concentration in Cluster 2 may partly reflect database coverage bias rather than solely reflecting substantive research priorities. Comparative analyses using complementary databases (such as Scopus or ERIC) would help clarify whether this pattern is robust across different indexing systems.

Third, the expansion of technology related terms (Cluster 1) is closely tied to pandemic era shifts in instructional practice. The temporal overlay visualization shows that technology, STEM, engineering, and creativity terms concentrate in the 2023-2024 period, coinciding with post pandemic efforts to integrate digital tools into mathematics instruction. While this growth reflects genuine pedagogical innovation, it also suggests that recent research may overemphasize technology mediated contexts relative to face to face or low tech settings that remain prevalent in many elementary schools, particularly in resource constrained environments. Future research should examine whether technology mediated internal dimensions differ fundamentally from those in traditional settings or whether underlying psychological mechanisms remain consistent across modalities.

Fourth, developmental trajectories remain underexplored. Although terms like "child" and "elementary school" appear prominently, the network does not reveal strong clusters focused on grade level differences or longitudinal changes in internal dimensions across elementary years (K-6). This gap is particularly important given that motivation, self-efficacy, and mathematics attitudes are known to decline as students progress through elementary grades. Research addressing when, why, and how these declines occur and which interventions are most effective at different developmental stages would strengthen both theory and practice.

Practical Implications

For elementary mathematics educators and curriculum developers, the bibliometric patterns suggest several practical directions:

1. Self-efficacy building should be an explicit goal from the earliest years, for example through structured mastery experiences, clear formative feedback, and chances to experience gradual success on challenging tasks. These strategies can help prevent the early formation of negative self-beliefs that are difficult to reverse later.
2. Mathematics anxiety and other negative emotions need to be managed deliberately rather than treated as incidental. Supportive classroom climates that normalize mistakes, emphasize growth instead of social comparison, and provide emotional scaffolding are essential for maintaining engagement, especially when students meet abstract or complex topics. These emotional considerations are particularly important in technology rich environments, where increased cognitive load may heighten anxiety for some learners.
3. Technology should be integrated with clear pedagogical purposes, not adopted as an end in itself. Digital tools can provide immediate feedback (supporting self-efficacy), gamified practice (enhancing intrinsic motivation), and collaborative problem solving spaces (strengthening relational aspects of engagement). At the same time, current literature suggests that technology mediated approaches often reflect better resourced contexts, so teachers and policymakers in low-resource settings need adaptable models that do not depend solely on high end infrastructure.
4. Interventions should take a holistic view of internal dimensions. The cluster structure shows that motivation, self-efficacy, emotion, and teacher-related factors are tightly interconnected, implying that programs targeting only one dimension risk overlooking important interactions. Learning experiences that jointly foster motivation, confidence, emotion regulation, and emerging metacognitive skills are likely to produce more durable engagement than those focused on a single construct. Developmental differences across grades should also guide design: strategies that are effective in early grades may not suit upper elementary students, and vice versa, underscoring the need for age-appropriate, stage-sensitive approaches.

Research Limitations

This study has several limitations. First, reliance on Google Scholar may introduce coverage bias, potentially missing articles indexed exclusively in discipline specific databases. Second, text mining from titles and abstracts may not capture full conceptual depth present in article bodies. Third, the study focuses on English language publications, potentially overlooking non English research on internal dimensions. Fourth, binary counting treats all co-occurrences equally, not distinguishing between central theoretical contributions and peripheral mentions. Future bibliometric studies could address these limitations through multi-database searches, full text analysis, and weighted counting methods.

CONCLUSION

This bibliometric study mapped 995 peer-reviewed articles on internal dimensions of elementary students' mathematics engagement published between 2019 and 2025, using Google Scholar data analyzed through text mining and co-occurrence techniques in VOSviewer. The analysis identified 76 key terms organized into five clusters, showing that self-efficacy and motivation form the most central internal dimensions, while technology increasingly functions as a context for examining motivation, interest, and cognitive engagement rather than as a stand-alone tool. At the same time, developmental, relational, metacognitive, and creativity-related constructs remain underrepresented and rarely form dense subclusters, indicating important gaps in longitudinal perspectives and in the mechanisms linking specific teacher practices to students' internal resources.

Temporal overlay patterns point to an evolving emphasis from studies of isolated psychological factors toward designs that consider multiple internal dimensions jointly, particularly within technology-enhanced learning environments, without claiming a complete paradigm shift. Practically, these findings underscore the need for holistic, developmentally sensitive, and contextually grounded interventions that simultaneously foster motivation, strengthen self-efficacy, regulate emotions such as mathematics anxiety, and gradually incorporate metacognitive and creative dispositions into elementary mathematics pedagogy.

REFERENCES

Abolla, M. B., Yurniwati Yurniwati, & Faisal Madani. (2024). The Effect of Schema-Based Instruction to Improve Mathematics Problem-Solving Ability of Elementry Students. *Jurnal Elementaria Edukasia*, *7*(2), 2827–2836. https://doi.org/10.31949/jee.v7i2.9439

Almuhaimin Sarnav Ituga, & Alman. (2023a). Self-Effıcacy, Self-Regulatıon Dan Self-Confıdence Terhadap Kemampuan Pemecahan Masalah Matematika SD. *Jurnal Elementaria Edukasia*, *6*(3), 1499–1509. https://doi.org/10.31949/jee.v6i3.6350

Almuhaimin Sarnav Ituga, & Alman. (2023b). Self-Effıcacy, Self-Regulatıon Dan Self-Confıdence Terhadap Kemampuan Pemecahan Masalah Matematika SD. *Jurnal Elementaria Edukasia*, *6*(3), 1499–1509. https://doi.org/10.31949/jee.v6i3.6350

Azzahra Nurlatifah, P., & Purniati, T. (2025). Systematic Literature Review: Penerapan Game Edukasi untuk Meningkatkan Motivasi Belajar Matematika. *Jurnal Pendidikan Matematika*, *4*(1), 115–127.

Basileo, L. D., Otto, B., Lyons, M., Vannini, N., & Toth, M. D. (2024). The role of self-efficacy, motivation, and perceived support of students' basic psychological needs in academic achievement. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1385442

Cipta, E. S., Komalasari, K., Rohdiyana, B., Nurlaela, D., & Badiyah, N. (2024). *Analisis Bibliometrik Tentang Tren Studi Pembelajaran Matematika di Sekolah Dasar Berdasarkan Data Scopus*. https://doi.org/10.30999/shibyan.v2i1.3515

Firmansyah, F., Irnandi, I., Siregar, N. N., Simamora, E. W., & Indriyani. (2024). Development of Comic Media to Improve Problem Solving Abilities and Interest in Learning Mathematics Subjects of Elementary School. *Jurnal Elementaria Edukasia*, *7*(3), 3119–3133. https://doi.org/10.31949/jee.v7i3.10081

Geary, D. C., Hoard, M. K., Nugent, L., & Scofield, J. E. (2021). In-class attention, spatial ability, and mathematics anxiety predict across-grade gains in adolescents' mathematics achievement. *Journal of Educational Psychology*, *113*(4), 754–769. https://doi.org/10.1037/edu0000487

Gultom, L. D. ., & Sihombing, W. (2024). Pengaruh *Self Efficacy* dan Motıvası Belajar Melaluı Model Pembelajaran Tıpe STAD terhadap Hasıl Belajar pada Sıswa Kelas XI SMK Negerı 1 Sıbolga. *Jurnal Review Pendidikan Dan Pengajaran*, *7*(1), 1232–1235. https://doi.org/10.31004/jrpp.v7i1.25078.

Hasanah, D., & Habibah Pasaribu, L. (2020). *Peningkatan Self-Efficacy dan Motivasi Belajar Siswa Melalui Model Pembelajaran Realistik Increasing Student Self-Efficacy and Learning Motivation Using The Realistic Mathematics Learning Model*. *1*(1), 1.

Indrawati, D., Habibie, R. K., Budiyono, & Zuhdi, U. (2024). What factors are barriers and enablers to implementing differentiated mathematics instruction in elementary schools? *Jurnal Elementaria Edukasia*, *7*(4), 3270–3281. https://doi.org/10.31949/jee.v7i4.11993

Kartika, K., Yurniwati Yurniwati, & Karsih. (2024). The Impact Project Based Learning of Animation-Assisted Videos on the Capability for Creative Thinking in Light of Self Efficacy. *Jurnal Elementaria Edukasia*, *7*(2), 2837–2848. https://doi.org/10.31949/jee.v7i2.9305

Khairizka, W. I., & Wandini, R. R. (2024). An Open-Ended Based Realıstıc Mathematıcs Learnıng Approach To Students' Creatıve Mathematıcal Thınkıng Abılıtıes. *Jurnal Elementaria Edukasia*, *7*(2), 2759–2771. https://doi.org/10.31949/jee.v7i2.9652

Lensi Hariyani, Yurniwati Yurniwati, & Ade Dwi Utami. (2024). The Effect Of Discovery Learning In Mathematics Learning On Computational Thinking In Terms Of Self-Regulated Learning (Srl) In Student. *Jurnal Elementaria Edukasia*, *7*(2), 2801–2814. https://doi.org/10.31949/jee.v7i2.9551

Lo, C. K., & Hew, K. F. (2021). Student Engagement in Mathematics Flipped Classrooms: Implications of Journal Publications From 2011 to 2020. In *Frontiers in Psychology* (Vol. 12). Frontiers Media S.A. https://doi.org/10.3389/fpsyg.2021.672610

Marpaung, D. W., Wiryanto, & Tatag Yuli Eko Siswono. (2024). Canva-Based MPI Analysis of Critical Thinking Skills for Class VI Elementary School Mathematics Story Problems. *Jurnal Elementaria Edukasia*, *7*(4), 3443–3454. https://doi.org/10.31949/jee.v7i4.11796

Mega, AM. M. P., & Faisal Madani. (2023). Analisisis Assesmen Autentik Pembelajaran Matematika Sekolah Dasar. *Jurnal Elementaria Edukasia*, *6*(2), 778–788. https://doi.org/10.31949/jee.v6i2.5659

Mega, AM. M. P., & Meiliasasi. (2024). Analysıs Of Students' Problem-Solvıng Abılıtıes On Hıgher Order Thınkıng Skıll (Hots) Geometry Problems In Terms Of Spatıal Reasonıng. *Jurnal Elementaria Edukasia*, *7*(2), 2786–2800. https://doi.org/10.31949/jee.v7i2.9574

Papageorgiou, E., Wong, J., Liu, Q., Khalil, M., & Cabo, A. J. (2025). A Systematic Review on Student Engagement in Undergraduate Mathematics: Conceptualization, Measurement, and Learning Outcomes. In *Educational Psychology Review* (Vol. 37, Issue 3). Springer. https://doi.org/10.1007/s10648-025-10046-y

Rahmawati, S. R., & Nopriana, T. (2024). Self Efficacy Siswa: 7 Indikator Keyakinan Diri dan Tantangan dalam Pembelajaran Matematika SMP. *Suska Journal of Mathematics Education*, *10*(2), 101. https://doi.org/10.24014/sjme.v10i2.32726

Resi Ratna Suminar, Meiliasari, & Nurjannah. (2024). Improving Geometry Problem Solving Abilities Through Spatial Reasoning-Based Problem Based Learning in Elementary Schools. *Jurnal Elementaria Edukasia*, *7*(2), 2736–2749. https://doi.org/10.31949/jee.v7i2.9308

Riana Bagaskorowati, Tresnani, Widiya Alita, Novi Nur Samiadi, & Novriko Burhan. (2023). Upper Class Elementary School Student Engagement in Math Subject Merdeka Curricula: Post Covid Study Case in Jakarta Province Indonesia. *International Journal of Elementary Education*, *7*(1), 134–142. https://doi.org/10.23887/ijee.v7i1.58471

Rohman, K., Turmudi, T., Budimansyah, D., & Syaodih, E. (2023). Development of a Productive Disposition Skills Instrument for Elementary School Students. *Jurnal Elementaria Edukasia*, *6*(2), 650–660. https://doi.org/10.31949/jee.v6i2.5259

Street, K. E. S., Malmberg, L. E., & Stylianides, G. J. (2022). Changes in students' self-efficacy when learning a new topic in mathematics: a micro-longitudinal study. *Educational Studies in Mathematics*, *111*(3), 515–541. https://doi.org/10.1007/s10649-022-10165-1

Suci Haryudita, R., & Noer, H. (2024). Peningkatan Kemampuan Representasi Matematis dan Motivasi Belajar Siswa Menggunakan Media Pembelajaran. In *Jurnal Pendidikan Matematika* (Vol. 8, Issue 1). http://journal.stkip-andi-matappa.ac.id/index.php/histogram/index

Uğraş, H. (2025). Research on mathematics anxiety in primary school: bibliometric analysis and evaluation of trends. In *Frontiers in Psychology* (Vol. 16). Frontiers Media SA. https://doi.org/10.3389/fpsyg.2025.1545556

Valenzuela-Peñuñuri, R., Tapia-Fonllem, C. O., Fraijo-Sing, B. S., & Manríquez-Betanzos, J. C. (2024). Academic motivation and affective engagement toward science and math: the mediating role of self-efficacy. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1385848

Wacner Simamora, E., Haryanto, H., & Siboro, asiroha. (2025). The Influence of Problem Based Learning Model on Cognitive Learning Outcomes of Mathematics in Grade V Elementary School Students. *Jurnal Elementaria Edukasia*, *8*(2), 5. https://doi.org/10.31949/jee.v

Wahyudi, N., Wahyuni, S., & Supeno. (2025). Improving Elementary Students' Learning Outcomes and Critical Thinking Skills through the Implementation of the PBL Model with PhET. *Jurnal Elementaria Edukasia*, *8*(3), 395–408. https://doi.org/10.31949/jee.v8i3.15234

Wahyuningtyas, N., Febrianingsih, L., Matematika, T., & Tulungagung, I. (2018). Pengaruh Self Efficacy dan Motivasi terhadap Hasil Belajar Matematika Siswa. In *Maret* (Vol. 4, Issue JP2M).

Wijaya, T. T., Hidayat, W., Hermita, N., Alim, J. A., & Talib, C. A. (2024). Exploring Contributing Factors to PISA 2022 Mathematics Achievement: Insights From Indonesian Teachers. *Infinity Journal*, *13*(1), 139–156. https://doi.org/10.22460/infinity.v13i1.p139-156

Wiryanto, Habibie, R. K., & Nurlaily, V. A. (2024). Hypothetical Learning Trajectory Strategy in Ethno-Realistic Mathematics Education: An Exploration of Damar Kurung. *Jurnal Elementaria Edukasia*, *7*(3), 3062–3071. https://doi.org/10.31949/jee.v7i3.10455

Xia, Q., Yin, H., Hu, R., Li, X., & Shang, J. (2022). Motivation, Engagement, and Mathematics Achievement: An Exploratory Study Among Chinese Primary Students. *SAGE Open*, *12*(4). https://doi.org/10.1177/21582440221134609

Yang, Y., Maeda, Y., & Gentry, M. (2024). The relationship between mathematics self-efficacy and mathematics achievement: multilevel analysis with NAEP 2019. *Large-Scale Assessments in Education*, *12*(1). https://doi.org/10.1186/s40536-024-00204-z

Zakariya, Y. F. (2022). *Improving students' mathematics self-efficacy: A systematic review of intervention studies*.