

**IMPLEMENTATION OF PROBLEM-BASED INTERACTIVE E-MODULES AND
SCHOOL CULTURE IN STIMULATING STUDENT ENGAGEMENT IN
ELEMENTARY SCHOOL MATHEMATICS LEARNING:
A BIBLIOMETRIC ANALYSIS (2022-2026)**

Anggita Dwi Saputri¹, Woro Sumarni^{2*}, Ellianawati³, Bambang Subali⁴
Universitas Negeri Semarang

¹anggitasaputri050696@students.unnes.ac.id,

²woro@mail.unnes.ac.id, ³ellianawati@mail.unnes.ac.id,

⁴bambangfisika@mail.unnes.ac.id

ABSTRACT

This study aims to analyze research trends related to the implementation of problem-based interactive e-modules and school culture in stimulating student engagement in elementary school mathematics learning through a bibliometric approach. The study used secondary data obtained from the Scopus database covering publications from 2022 to 2026. A total of 162 relevant documents were analyzed using VOSviewer and Biblioshiny to identify publication trends, productive countries and institutions, dominant subject areas, keyword co-occurrence, and emerging research themes. The results showed a significant increase in publication output during the study period, indicating growing scholarly interest in digital learning innovation and student-centered mathematics education. The United States, Indonesia, and China were identified as the most productive countries, while Social Sciences and Computer Science became the dominant subject areas. Keyword co-occurrence analysis revealed that student engagement, interactive e-modules, instructional design, and problem-based learning were the most influential research themes. Overlay visualization indicated a shift from implementation-oriented studies toward learner-centered approaches emphasizing engagement, reflection, and instructional improvement. Density visualization further demonstrated that student engagement and effectiveness evaluation were the most intensively studied topics. However, school culture remains relatively underexplored compared to digital learning and instructional effectiveness themes. Therefore, future studies are encouraged to integrate digital learning innovation with sociocultural and contextual educational dimensions to create more meaningful mathematics learning experiences. Overall, this study provides a comprehensive overview of the development of research in elementary mathematics education and offers valuable insights for future educational innovation in the digital era.

Keywords: bibliometric analysis, problem-based learning, interactive e-module, school culture, student engagement, mathematics learning.

ABSTRAK

Penelitian ini bertujuan untuk menganalisis tren penelitian terkait implementasi e-modul interaktif berbasis masalah dan budaya sekolah dalam meningkatkan keterlibatan siswa pada pembelajaran matematika sekolah dasar melalui pendekatan bibliometrik. Penelitian menggunakan data sekunder yang diperoleh dari database Scopus dengan rentang publikasi tahun 2022–2026. Sebanyak 162 dokumen relevan dianalisis menggunakan aplikasi VOSviewer dan Biblioshiny untuk mengidentifikasi tren publikasi, negara dan institusi produktif, bidang kajian dominan, ko-okurensi kata kunci, serta tema penelitian yang berkembang. Hasil penelitian menunjukkan adanya peningkatan signifikan jumlah publikasi selama periode penelitian yang menandakan meningkatnya perhatian akademik terhadap inovasi pembelajaran digital dan pembelajaran matematika yang berpusat pada siswa. Amerika Serikat, Indonesia, dan China menjadi negara dengan kontribusi publikasi tertinggi, sedangkan bidang ilmu sosial dan ilmu komputer menjadi bidang kajian dominan. Analisis ko-okurensi kata kunci menunjukkan bahwa *student engagement*, *interactive e-module*, *instructional design*, dan *problem-based learning* merupakan tema penelitian yang paling berpengaruh. Visualisasi overlay memperlihatkan adanya pergeseran fokus penelitian dari aspek implementasi menuju pendekatan yang lebih berorientasi pada keterlibatan siswa, refleksi pembelajaran, dan peningkatan instruksional. Sementara itu, visualisasi density menunjukkan bahwa keterlibatan siswa dan evaluasi efektivitas menjadi topik yang paling banyak diteliti. Namun demikian, budaya sekolah masih relatif kurang dieksplorasi dibandingkan tema pembelajaran digital dan efektivitas pembelajaran. Oleh karena itu, penelitian selanjutnya disarankan untuk mengintegrasikan inovasi pembelajaran digital dengan dimensi sosiokultural dan kontekstual pendidikan guna menciptakan pengalaman belajar matematika yang lebih bermakna. Secara keseluruhan, penelitian ini memberikan gambaran komprehensif mengenai perkembangan penelitian dalam pendidikan matematika sekolah dasar serta menjadi dasar bagi pengembangan inovasi pendidikan di era digital.

Kata Kunci: analisis bibliometrik, *problem-based learning*, e-modul interaktif, budaya sekolah, keterlibatan siswa, pembelajaran matematika.

A. Introduction

Mathematics is one of the fundamental subjects in elementary education because it plays an essential role in developing logical thinking, problem-solving abilities, reasoning skills, and numeracy literacy. Mathematics learning at the elementary school level serves as the

foundation for students to understand more complex concepts in higher levels of education. Therefore, effective mathematics instruction is crucial to support students' academic success and lifelong learning competencies (OECD, 2023).

Despite its importance, mathematics is frequently perceived by elementary school students as a difficult and abstract subject. Traditional teacher-centered instructional approaches often limit students' opportunities to actively participate in the learning process, resulting in low motivation, reduced engagement, and poor learning outcomes. Student engagement has become one of the most critical factors influencing learning success because engaged students tend to demonstrate higher levels of participation, persistence, and academic achievement (Martin & Bolliger, 2022). Consequently, enhancing student engagement has emerged as a major concern among educators and researchers in mathematics education.

The rapid advancement of digital technology has transformed educational practices worldwide. The integration of digital learning resources provides new opportunities to create interactive and meaningful learning experiences. Interactive e-modules, in particular, have gained

increasing attention as innovative learning media that combine text, images, videos, animations, and interactive activities within a single platform. Such features enable students to learn independently while maintaining active involvement in the learning process (Mayer, 2021). Previous studies have shown that interactive e-modules can improve students' understanding of mathematical concepts, learning motivation, and academic performance (Gunawan et al., 2023).

Among various instructional approaches, Problem-Based Learning (PBL) has been widely recognized as an effective strategy for promoting active learning and higher-order thinking skills. PBL encourages students to solve authentic problems, collaborate with peers, and apply their knowledge in meaningful contexts. Through problem-solving activities, students become more engaged in constructing knowledge and developing critical thinking abilities (Subali et al., 2024). Therefore, integrating PBL into interactive e-modules offers considerable

potential for creating engaging and student-centered mathematics learning environments.

In addition to instructional strategies and digital technologies, school culture plays a significant role in shaping students' learning experiences. School culture encompasses the values, beliefs, norms, and social interactions that influence teaching and learning processes within educational institutions. A positive school culture can foster students' motivation, sense of belonging, collaboration, and participation in classroom activities. Furthermore, integrating local values and contextual elements into learning materials can make mathematics learning more relevant and meaningful to students' daily lives. Consequently, the combination of problem-based interactive e-modules and supportive school culture may contribute significantly to enhancing student engagement in mathematics learning.

The growing interest in educational technology, problem-based learning, and student

engagement has generated a substantial body of literature over recent years. Numerous studies have investigated the effectiveness of interactive e-modules, digital learning environments, and innovative pedagogical approaches in improving mathematics education. However, the existing literature remains fragmented, and there is limited understanding of how research on problem-based interactive e-modules, school culture, and student engagement has evolved as an integrated research domain. Moreover, the increasing volume of publications necessitates a systematic approach to identify major research themes, influential contributors, and emerging trends.

Bibliometric analysis has become a valuable method for examining the intellectual structure and development of a particular research field. By analyzing publication patterns, citation networks, and keyword relationships, bibliometric studies can provide comprehensive insights into research productivity, collaboration networks, thematic

evolution, and future research directions (Waltman et al., 2022). The use of bibliometric tools such as VOSviewer and Bibliometrix enables researchers to visualize scientific knowledge structures and identify emerging research opportunities (van Eck & Waltman, 2010; Aria & Cuccurullo, 2017).

Although bibliometric studies have been conducted in the fields of educational technology and digital learning, limited attention has been given specifically to the intersection of problem-based interactive e-modules, school culture, student engagement, and elementary mathematics learning. This gap highlights the need for a comprehensive mapping of the existing literature to better understand current developments and future research directions.

Therefore, this study aims to conduct a bibliometric analysis of publications indexed in Scopus between 2022 and 2026 related to the implementation of problem-based interactive e-modules and school culture in enhancing student engagement in elementary school

mathematics learning. Specifically, this study seeks to: (1) analyze publication trends and research productivity; (2) identify the most influential countries, institutions, and subject areas; (3) examine keyword co-occurrence patterns and thematic clusters; and (4) explore emerging research trends and potential future directions. The findings are expected to provide valuable insights for researchers, educators, instructional designers, and policymakers seeking to develop innovative and engaging mathematics learning environments in the digital era.

B. Method

2.1 Data Collection

This study employed a bibliometric analysis approach to explore research trends related to the implementation of problem-based interactive e-modules and school culture in stimulating student engagement in elementary school mathematics learning during the period 2022–2026. Bibliometric analysis is a quantitative method used to map the development, patterns, and structure of scientific

publications within a specific research field.

The data used in this study were secondary data obtained from reputable academic databases, primarily **Scopus and Google Scholar**, due to their comprehensive coverage of international and national publications. These databases are commonly used in bibliometric studies because they provide rich metadata and compatibility with analysis tools such as VOSviewer and Biblioshiny.

The data collection process was conducted using the **Publish or Perish (PoP)** software to retrieve relevant articles. The search strategy involved a combination of keywords, including:

- “problem-based learning” OR “PBL”
- “interactive e-module” OR “e-learning module”
- “student engagement”
- “elementary school” OR “primary school”
- “mathematics learning”

The search was limited to publications published between

2022 and 2026, written in English or Indonesian, and indexed in the selected databases.

Inclusion criteria for selecting articles were:

1. Articles focusing on problem-based learning or problem-based digital modules in mathematics education.
2. Studies conducted at the elementary/primary school level.
3. Research discussing student engagement, motivation, or participation.
4. Peer-reviewed journal articles or conference proceedings.

Exclusion criteria included:

1. Articles not related to mathematics learning.
2. Studies outside the elementary education level.
3. Non-academic publications such as books, theses, or opinion papers.

After the initial search, duplicate records were removed. The remaining articles were then screened based on titles, abstracts, and keywords to ensure relevance to the research topic. This process follows systematic review

procedures such as PRISMA to ensure data validity and transparency.

The final dataset was exported in RIS or CSV format and analyzed using **VOSviewer** to visualize co-authorship networks, keyword co-occurrence, and publication trends. This mapping helps identify dominant themes such as problem-solving skills, digital learning integration, and student engagement in mathematics learning.

2.2 Data Analysis

The data analysis in this study was conducted using bibliometric techniques to identify patterns, trends, and relationships within the collected publications. The analysis focused on mapping the development of research related to problem-based interactive e-modules, school culture, and student engagement in elementary school mathematics learning during the 2022–2026 period.

The cleaned dataset, obtained from the data collection stage, was

exported in **RIS** or **CSV** format and analyzed using **VOSviewer** and **Biblioshiny** (R-package based on Bibliometrix). These tools were selected due to their capability to visualize bibliometric networks and provide comprehensive statistical analysis.

The analysis procedures included:

1. **Descriptive Analysis**

This step aimed to identify the number of publications per year, most productive authors, countries, journals, and citation counts. It helps to show the growth and distribution of research in the field.

2. **Co-authorship Analysis**

Co-authorship analysis was conducted to examine collaboration patterns among researchers, institutions, and countries. This analysis reveals the research network and identifies influential contributors in the field.

3. **Co-occurrence (Keyword) Analysis**

Keyword co-occurrence analysis was performed to identify the main research

themes and topics. Frequently appearing keywords such as *problem-based learning*, *interactive e-module*, *student engagement*, *school culture*, and *mathematics learning* were analyzed to determine thematic clusters.

4. Citation and Co-citation Analysis

Citation analysis was used to identify the most influential articles, authors, and journals. Meanwhile, co-citation analysis helped reveal the intellectual structure and foundational references within the research domain.

5. Visualization Mapping

The results of the analysis were visualized using network, overlay, and density maps generated by VOSviewer.

- **Network visualization** shows relationships between items (authors, keywords, etc.).
- **Overlay visualization** indicates the evolution of research over time.
- **Density visualization** highlights the most

frequently studied topics.

6. Trend Analysis

Trend analysis was conducted to observe the evolution of research topics over time, particularly the integration of digital learning tools, problem-based approaches, and the role of school culture in enhancing student engagement.

Through these analyses, the study provides a comprehensive overview of the research landscape and identifies emerging trends, research gaps, and potential directions for future studies in elementary mathematics education.

C. Result and Discussion

3.1 Deskripsi Lingkungan Sosial Keluarga Mahasiswa

3.1.1 Distribution by Year

The bibliometric analysis of 162 documents retrieved from the Scopus database reveals a significant increase in research related to the implementation of problem-based interactive e-modules, school culture, and student engagement in

elementary school mathematics learning during the period 2022–2026.

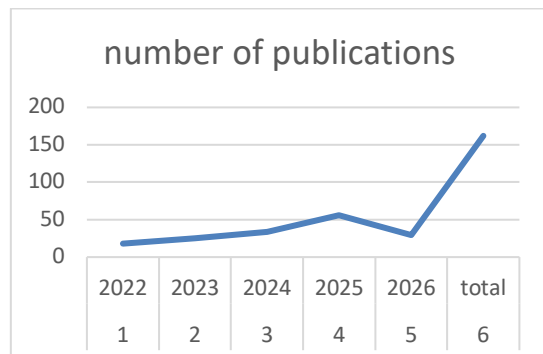


Figure 1 Documents by Year (2022-2026)

The publication data indicate a consistent growth in research output over the study period. In 2022, a total of 18 publications were identified, increasing to 25 publications in 2023. The upward trend continued in 2024 with 34 publications and experienced a substantial rise in 2025, reaching 56 publications. As of March 2026, 29 publications had been recorded. Overall, the final dataset consisted of 162 documents.

Note: The 2026 data represent publications indexed up to March 2026 and do not reflect the complete publication output for the year.

The increasing number of publications from 2022 to 2025 demonstrates the growing scholarly interest in developing digital learning media that can enhance student engagement in

elementary school mathematics education. This trend reflects the broader digital transformation in education, which encourages the adoption of innovative technology-based learning approaches to create more interactive, contextual, and student-centered learning experiences.

The substantial growth in publications observed in 2025 indicates that the integration of Problem-Based Learning (PBL) into interactive e-modules has become a major focus in mathematics education research. Researchers have increasingly explored how digital technologies can support students in understanding mathematical concepts through authentic and real-world problem situations. Such approaches are believed to enhance students' cognitive, emotional, and behavioral engagement during the learning process.

In addition, the emergence of school culture as a recurring research theme suggests a growing recognition of the importance of integrating school values, norms, and social environments into digital learning

designs. The incorporation of school culture is considered essential because it enables learning experiences to become more meaningful and relevant to students' daily lives, thereby fostering a stronger sense of belonging and encouraging active participation in classroom activities.

The increasing publication trend also indica

3.1.2 Distribution by Country

The geographical distribution of publications provides insights into the countries that contribute most actively to research on the implementation of problem-based interactive e-modules, school culture, and student engagement in elementary school mathematics learning. Analysis of the 162 documents indexed in the Scopus database revealed contributions from various countries across Asia, Europe, North America, and Oceania, indicating the global relevance of this research area.

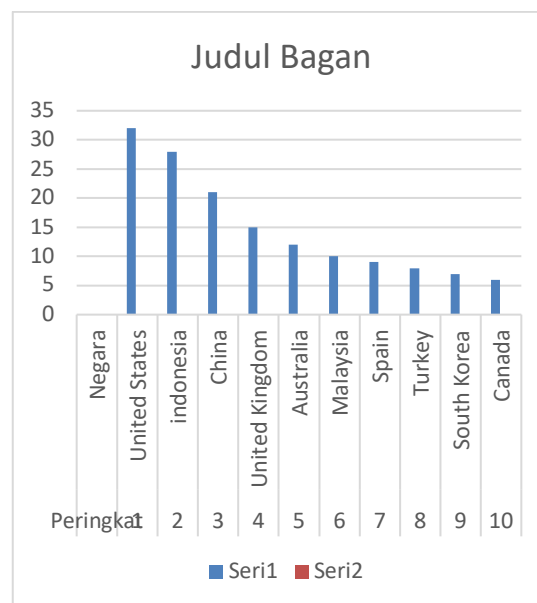


Figure 2 Documents by Country/Territory

The results show that the **United States** contributed the highest number of publications, accounting for 32 documents (19.8%), followed by **Indonesia** with 28 documents (17.3%), **China** with 21 documents (13.0%), **United Kingdom** with 15 documents (9.3%), and **Australia** with 12 documents (7.4%). Other contributing countries included Malaysia, Spain, Turkey, South Korea, and Canada, each producing a smaller but significant number of publications.

The dominance of the United States reflects its strong research capacity in educational technology, digital learning, and innovative pedagogical approaches. American researchers

have extensively investigated the integration of technology-enhanced learning environments, problem-based learning strategies, and student engagement frameworks across different educational levels.

Indonesia emerged as the second most productive country, demonstrating a growing academic interest in developing contextual and technology-based learning solutions for elementary education. This finding is particularly significant because Indonesia has actively promoted digital transformation in education and the integration of innovative learning media to improve students' mathematical literacy and learning outcomes. The high publication output also suggests increasing awareness among Indonesian researchers regarding the importance of incorporating local contexts and school culture into learning designs.

China ranked third in publication productivity, reflecting its substantial investment in educational innovation and digital learning research. Chinese studies frequently focus on technology integration, adaptive learning systems, and student-centered

instructional approaches that support engagement and academic achievement.

The contributions from the United Kingdom and Australia further highlight the international nature of this research field. Researchers in these countries have emphasized the role of active learning, problem-solving skills, and culturally responsive educational practices in fostering meaningful student engagement. Their studies often explore how digital learning environments can be designed to support collaborative learning and improve students' mathematical understanding.

The distribution of publications also reveals a growing contribution from developing countries, particularly in Southeast Asia. Countries such as Indonesia and Malaysia have shown increasing research productivity during the 2022–2026 period, indicating that interest in digital mathematics learning and student engagement is no longer concentrated solely in developed nations. This trend suggests a broader global commitment to improving educational

quality through innovative teaching approaches and technology integration.

Overall, the country distribution analysis demonstrates that research on problem-based interactive e-modules, school culture, and student engagement in elementary mathematics education has attracted worldwide attention. The diversity of contributing countries highlights the universal importance of developing effective and engaging mathematics learning environments that address both technological and sociocultural dimensions of education.

3.1.3 Distribution by Affiliation

The analysis of institutional affiliations provides an overview of the universities and research institutions that have made significant contributions to research on the implementation of problem-based interactive e-modules, school culture, and student engagement in elementary school mathematics learning. Examining affiliation productivity helps identify leading research centers and institutions actively involved in advancing this

field. Figure 3. Distribution of Publications by Affiliation (2022–2026) The results indicate that several universities played a prominent role in producing research related to the topic. Among the most productive institutions were Universitas Negeri Semarang, Universitas Pendidikan Indonesia, Universiti Malaya, The University of Melbourne, and Beijing Normal University. These institutions have consistently published studies focusing on digital learning innovation, mathematics education, student engagement, and culturally responsive teaching practices

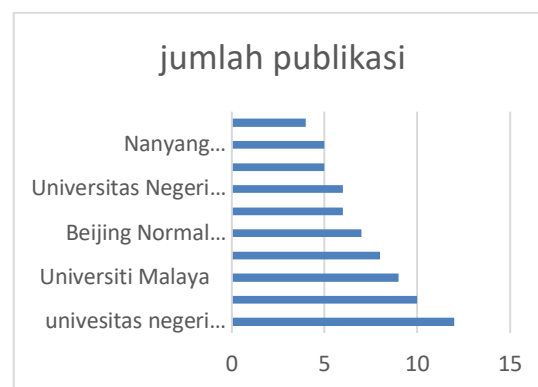


Figure 3 Documents by Affiliation

The prominent contribution of **Universitas Negeri Semarang** reflects its strong commitment to educational research, particularly in mathematics education, educational technology, and innovative learning

media. The institution has actively explored the integration of digital learning tools and problem-based approaches to improve student engagement and learning outcomes.

Similarly, **Universitas Pendidikan Indonesia** and **Universitas Negeri Yogyakarta** have demonstrated substantial research productivity in the areas of elementary education, mathematics learning, and curriculum innovation. Their contributions indicate the growing interest among Indonesian higher education institutions in addressing challenges related to digital transformation and student engagement in mathematics classrooms.

Internationally, institutions such as **Universiti Malaya**, **The University of Melbourne**, and **Beijing Normal University** have contributed significantly to the development of research on technology-enhanced learning and student-centered pedagogies. These universities have emphasized the importance of integrating innovative digital resources with effective instructional strategies to create meaningful learning experiences for students.

The presence of institutions from different regions also highlights the collaborative and interdisciplinary nature of this research field. Many studies were conducted through partnerships between universities, research centers, and educational organizations, allowing researchers to examine diverse educational contexts and share best practices for implementing interactive learning media.

Furthermore, the affiliation analysis demonstrates that research productivity is not concentrated in a single country or institution. Instead, knowledge production is distributed across a network of universities that share a common interest in improving mathematics education through digital innovation and contextual learning approaches. This pattern reflects the increasing global recognition of the importance of student engagement and the role of technology in supporting effective learning.

Overall, the affiliation distribution analysis reveals that both national and international institutions have played important roles in advancing research on problem-based interactive e-

modules, school culture, and student engagement in elementary school mathematics learning. The strong participation of universities from Asia, Europe, and Australia indicates the expanding academic interest in developing innovative and culturally relevant learning environments for elementary education.

3.1.4 Distribution by Subject Area

The subject area analysis was conducted to identify the academic disciplines that contributed most significantly to research on the implementation of problem-based interactive e-modules, school culture, and student engagement in elementary school mathematics learning. The classification of subject areas was based on the categories provided by the Scopus database, enabling a comprehensive understanding of the interdisciplinary nature of this research field.

Figure 4. Distribution of Publications by Subject Area (2022–2026)

The results indicate that the research field is dominated by **Social Sciences**, which accounted for 78

publications (48.1%). This category encompasses studies related to education, instructional strategies, student engagement, and curriculum development. The second-largest contributor was **Computer Science** with 34 publications (21.0%), reflecting the increasing interest in digital technologies and interactive learning media within mathematics education.

Furthermore, **Mathematics** ranked third with 22 publications (13.6%), followed by **Engineering** with 12 publications (7.4%) and **Psychology** with 8 publications (4.9%). Other subject areas, including Decision Sciences, Business, Management and Accounting, Arts and Humanities, and Environmental Sciences, contributed a smaller but meaningful proportion of publications, highlighting the multidisciplinary nature of the research domain.

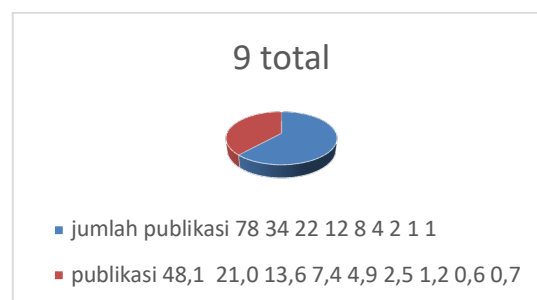


Figure 4 Documents by Subject Area

The dominance of **Social Sciences** demonstrates that research on problem-based interactive e-modules and school culture is closely associated with educational issues, teaching and learning processes, and student competency development. Most studies within this category focus on how innovative instructional approaches can enhance student engagement and improve mathematics learning outcomes.

The substantial contribution of **Computer Science** highlights the growing importance of educational technology in this research area. Numerous studies have investigated the development of interactive e-modules, digital learning systems, online learning platforms, and multimedia-based instructional tools designed to improve students' learning experiences. This finding suggests that the integration of technology and education has become a major research focus in recent years.

Meanwhile, the contribution of **Mathematics** reflects the central role of mathematics education in the analyzed publications. Studies within

this subject area primarily examine the effectiveness of problem-based interactive e-modules in enhancing students' problem-solving abilities, numeracy literacy, conceptual understanding, and engagement during mathematics learning activities.

The presence of **Psychology** as a significant subject area indicates that psychological factors such as learning motivation, interest, student engagement, and learning experiences are essential components of the research field. This finding suggests that the successful implementation of digital learning media depends not only on technological aspects but also on psychological factors that influence students' participation and involvement in learning.

Overall, the subject area distribution demonstrates that research on the implementation of problem-based interactive e-modules and school culture is inherently multidisciplinary. The involvement of various academic disciplines reflects the complexity of contemporary educational challenges, which require the integration of pedagogical approaches, digital

technologies, mathematics education, and educational psychology. Such interdisciplinary collaboration plays a crucial role in generating innovative and sustainable learning solutions that promote student engagement in elementary school mathematics learning.

3.2 Keyword Co-occurrence Analysis

Keyword co-occurrence analysis was conducted to identify the conceptual structure and research themes within studies related to the implementation of problem-based interactive e-modules and school culture in enhancing student engagement in elementary school mathematics learning. The analysis was performed using VOSviewer based on author keywords extracted from 162 publications indexed in the Scopus database between 2022 and 2026.

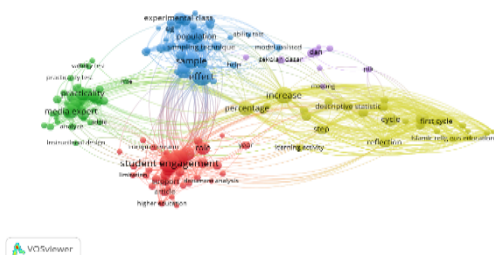


Figure 5 Network Visualization of Keyword Co-occurrence

3.2.1 Cluster 1: Student

Engagement and Learning Outcomes

The red cluster is centered on the keyword **student engagement**, which appears as one of the most dominant and highly connected terms in the network. This cluster includes related keywords such as *role*, *support*, *article*, *comprehension*, *limitation*, *document analysis*, and *higher education*. The strong interconnections among these keywords indicate that student engagement has become a central concern in studies investigating the effectiveness of innovative learning approaches.

The presence of keywords such as *support* and *comprehension* suggests that researchers increasingly focus on how instructional interventions can enhance students' understanding and participation during mathematics learning. Furthermore, the keyword *role* highlights the importance of teachers, learning media, and school environments in fostering active engagement among elementary school students. Overall, this cluster emphasizes that student engagement

is a key determinant of successful mathematics learning and remains a major focus of contemporary educational research.

3.2.2 Cluster 2: Interactive E-Module Development and Practicality Evaluation

The green cluster is dominated by keywords including **practicality**, **media expert**, **validity test**, **practicality test**, **instructional design**, **ADDIE**, **analyze**, and *RME*. This cluster reflects studies focusing on the design, development, and evaluation of interactive learning media, particularly problem-based e-modules used in mathematics education.

The frequent occurrence of *media expert*, *validity test*, and *practicality test* indicates that many researchers evaluate the quality and feasibility of digital learning materials before implementation in classrooms. In addition, the appearance of the *ADDIE* model suggests that systematic instructional design approaches are widely adopted in the development of interactive e-modules. The cluster demonstrates that ensuring the validity, practicality, and effectiveness

of digital learning resources is a crucial stage in improving mathematics learning experiences and student engagement.

3.2.3 Cluster 3: Effectiveness of Problem-Based Learning Interventions

The blue cluster revolves around keywords such as **effect**, **sample**, **population**, **sampling technique**, **experimental class**, **ability test**, and *model assisted*. These keywords indicate a strong emphasis on experimental and quantitative research aimed at measuring the effectiveness of problem-based learning interventions and interactive e-modules.

The prominence of *effect* as a central keyword suggests that researchers frequently investigate the impact of instructional innovations on students' learning outcomes and engagement levels. Keywords such as *experimental class* and *ability test* further indicate the use of quasi-experimental research designs to compare learning performance between control and experimental groups. This cluster highlights the growing body of empirical evidence

supporting the implementation of problem-based interactive e-modules in elementary mathematics education.

3.2.4 Cluster 4: School Culture and Elementary Education Context

The purple cluster contains keywords such as **sekolah dasar**, **PTK**, **model assisted**, and *dan*. Although relatively smaller than other clusters, it reflects the contextual dimension of the research field. The presence of *sekolah dasar* (elementary school) indicates that many studies specifically focus on primary education settings.

This cluster also demonstrates the importance of contextual learning environments and school culture in supporting student engagement. Research within this area often examines how local educational contexts, classroom culture, and school-based learning practices influence the implementation of innovative instructional media. Consequently, school culture emerges as an important factor in creating meaningful and engaging mathematics learning experiences.

3.2.5 Cluster 5 : Learning

Improvement Through
Reflective Practice

The yellow cluster is characterized by keywords such as **increase**, **percentage**, **cycle**, **reflection**, **step**, **learning activity**, **descriptive statistic**, and *first cycle*. These keywords are commonly associated with classroom action research and continuous improvement practices.

The central keyword *increase* indicates that many studies aim to measure improvements in student engagement, participation, and learning outcomes following the implementation of innovative learning interventions. Meanwhile, the keywords *cycle* and *reflection* suggest the application of iterative instructional improvement processes, where learning strategies are continuously evaluated and refined. This cluster demonstrates that reflective teaching practices and ongoing evaluation play important roles in maximizing the effectiveness of problem-based interactive e-modules in elementary mathematics classrooms.

3.3 Research Trends Analysis

3.3.1 Dominant Research Themes and Emerging Trends

The overlay visualization analysis was conducted to identify dominant research themes and emerging trends in studies related to the implementation of problem-based interactive e-modules and school culture in enhancing student engagement in elementary school mathematics learning. The visualization generated by VOSviewer illustrates the temporal evolution of keywords, allowing the identification of topics that have received continuous attention as well as newly emerging research directions.

The dominance of **student engagement** demonstrates that researchers increasingly recognize student participation and involvement as critical factors influencing mathematics learning success. Studies have consistently examined how innovative instructional approaches, particularly problem-based interactive e-modules, can enhance students' cognitive, emotional, and behavioral engagement.

Similarly, keywords such as **effect**, **sample**, and **experimental class**

indicate that a substantial proportion of the literature focuses on evaluating the effectiveness of instructional interventions through quantitative and experimental research designs. Researchers have sought empirical evidence regarding the impact of interactive learning media on learning outcomes, problem-solving abilities, and student engagement.

Another dominant theme is represented by **practicality**, **media expert**, and **validity test**, which reflect the increasing emphasis on the development and evaluation of digital learning media. These studies commonly investigate the quality, feasibility, and usability of interactive e-modules before their implementation in elementary mathematics classrooms.

In addition to the dominant themes, several emerging topics can be identified. Keywords such as **reflection**, **cycle**, **learning activity**, **descriptive statistic**, and **increase** appear in more recent publications, indicating growing interest in classroom action research and continuous instructional improvement. These themes suggest that

stage of research development. This trend reflects the increasing adoption of empirical methods to evaluate the effectiveness of problem-based learning interventions and interactive e-modules.

The most recent topics are represented by yellow-colored keywords, including **student engagement**, **role**, **support**, **article**, **practicality test**, **reflection**, **cycle**, and **increase**. The prominence of these keywords indicates a shift toward research that emphasizes student-centered learning, engagement enhancement, and continuous improvement of instructional practices.

Particularly noteworthy is the emergence of **student engagement** as one of the newest and most influential keywords in the network. Its central position and strong connections with other keywords suggest that enhancing student engagement has become a major research priority in elementary mathematics education. Likewise, the increasing occurrence of **practicality** and **reflection** highlights researchers' growing interest in developing

effective digital learning media and evaluating their implementation in authentic classroom settings.

The overlay visualization therefore reveals a clear evolution of research focus. Early studies concentrated on instructional implementation and methodological aspects, while more recent studies increasingly emphasize student engagement, practical application of interactive e-modules, reflective learning practices, and the integration of school culture into mathematics learning. These findings indicate that future research is likely to continue exploring innovative and contextualized learning environments that foster meaningful student participation and improve learning outcomes in elementary mathematics education.

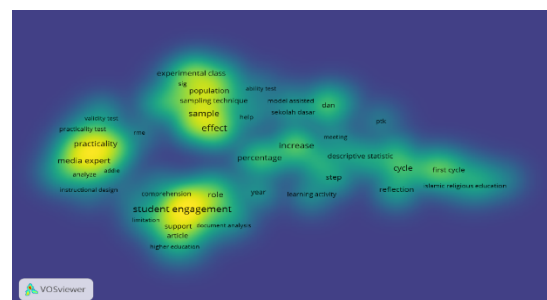


Figure 7 Density Visualization of Keyword Co-occurrence

3.3.2 Density Visualization

The density visualization reveals several highly concentrated research areas. The brightest regions are centered on the keywords **student engagement**, **effect**, **sample**, **practicality**, and **media expert**, indicating that these topics represent the core focus of the literature during the period 2022–2026.

Among these keywords, **student engagement** appears as the most prominent topic. Its central position and high density demonstrate that researchers have increasingly emphasized students' cognitive, emotional, and behavioral participation in mathematics learning. The strong connections between student engagement and keywords such as *role*, *support*, *comprehension*, and *article* suggest that studies have extensively examined factors influencing students' active involvement in learning activities.

Another high-density area is represented by the keywords **effect** and **sample**, which are closely linked to terms such as *population*, *sampling technique*, *experimental class*, and

ability test. This pattern indicates that a significant proportion of studies employ quantitative and experimental research methods to evaluate the effectiveness of problem-based interactive e-modules and other instructional interventions in improving mathematics learning outcomes.

The cluster surrounding **practicality** and **media expert** also exhibits a high level of density. Keywords such as *validity test*, *practicality test*, *ADDIE*, *instructional design*, and *analyze* are strongly associated with this area. These findings suggest that many researchers focus on the development, validation, and feasibility assessment of interactive e-modules before their implementation in educational settings.

Moderate-density areas include keywords such as **increase**, **percentage**, **reflection**, **cycle**, and **learning activity**. These topics are generally associated with classroom action research and continuous improvement efforts aimed at enhancing student engagement and learning performance. Their presence indicates growing interest in reflective

instructional practices and iterative learning interventions.

In contrast, keywords such as **PTK**, **school culture-related contexts**, **Islamic religious education**, and several methodological terms appear in lower-density areas, indicating that these topics remain relatively underexplored compared to the dominant themes. Nevertheless, these areas represent potential opportunities for future research, particularly regarding the integration of school culture and contextual learning environments into mathematics education.

Overall, the density visualization confirms that research in this field is primarily concentrated on three major areas: **student engagement**, **effectiveness evaluation**, and **interactive e-module development**. These themes form the intellectual foundation of the research domain and continue to shape current scholarly discussions regarding innovative approaches to elementary mathematics learning.

3.4 Discussion

The bibliometric findings provide a

comprehensive overview of the development of research on the implementation of problem-based interactive e-modules and school culture in enhancing student engagement in elementary school mathematics learning between 2022 and 2026. The increasing number of publications during this period indicates growing academic interest in innovative learning approaches that combine digital technology, problem-based pedagogy, and contextual learning environments.

The publication trend analysis demonstrates that research productivity has increased significantly in recent years. This growth reflects the expanding adoption of digital learning technologies in elementary education and the increasing recognition of student engagement as a critical factor influencing learning success. The findings suggest that educators and researchers are actively seeking effective instructional strategies capable of addressing challenges in mathematics learning while simultaneously promoting meaningful student participation.

The keyword co-occurrence analysis

highlights **student engagement** as the central concept within the research field. This finding aligns with contemporary educational theories that emphasize active learning, learner autonomy, and meaningful classroom participation. Student engagement is increasingly viewed not only as an outcome of effective instruction but also as a prerequisite for achieving higher-order thinking skills, problem-solving abilities, and long-term academic success.

Furthermore, the prominence of keywords such as **effect**, **experimental class**, **sample**, and **ability test** indicates that researchers have devoted considerable attention to evaluating the effectiveness of instructional innovations through empirical studies. This trend suggests a strong commitment to evidence-based educational practices, where new learning media and pedagogical approaches are systematically tested before being widely implemented.

The high density of keywords related to **practicality**, **media expert**, **validity test**, and **instructional design** reflects the growing importance of developing high-quality

digital learning resources. Interactive e-modules have emerged as a promising educational innovation because they combine multimedia features, learner interaction, and contextual learning experiences. The extensive focus on validation and practicality testing demonstrates researchers' efforts to ensure that these learning tools are both pedagogically sound and practically applicable in elementary school settings.

The overlay visualization further reveals a shift in research priorities over time. Earlier studies primarily focused on methodological and implementation-related issues, whereas more recent studies increasingly emphasize student engagement, reflective learning practices, and instructional improvement. This evolution indicates a movement toward more holistic educational approaches that consider not only learning outcomes but also students' experiences and participation throughout the learning process.

An important finding of this study is the relatively limited visibility of keywords

directly related to **school culture** within the network. Although school culture is included in the conceptual framework of many studies, it has not yet emerged as a dominant research theme compared to student engagement and instructional effectiveness. This finding suggests a significant research gap and highlights opportunities for future investigations exploring how school values, classroom climate, local culture, and social interactions influence the successful implementation of problem-based interactive e-modules.

Based on these findings, future research should focus on integrating problem-based learning, interactive digital media, and school culture into a comprehensive instructional framework. Such integration has the potential to create more meaningful and contextually relevant mathematics learning experiences while fostering higher levels of student engagement. Moreover, interdisciplinary collaboration among educational researchers, instructional designers, and school practitioners will be essential for developing sustainable and innovative learning solutions that meet the needs of elementary school

students in the digital era.

In conclusion, the bibliometric analysis demonstrates that research on problem-based interactive e-modules and student engagement has experienced substantial growth and diversification. While digital learning innovation and instructional effectiveness remain dominant themes, the role of school culture represents an emerging area with considerable potential for future scholarly exploration and educational development.

3.5 Conclusion

This bibliometric study analyzed 162 Scopus-indexed publications published between 2022 and 2026 to map the research landscape concerning the implementation of problem-based interactive e-modules and school culture in enhancing student engagement in elementary school mathematics learning. The findings reveal a significant increase in publication output during the analyzed period, indicating growing scholarly interest in innovative learning approaches that integrate digital technology, problem-based learning,

and contextual educational environments.

The distribution analysis showed that research in this field is dominated by contributions from countries with strong educational research capacities, particularly the United States, Indonesia, China, the United Kingdom, and Australia. Likewise, several universities and research institutions have played important roles in advancing knowledge related to mathematics education, educational technology, and student engagement.

Keyword co-occurrence analysis identified several dominant research themes, including **student engagement, effectiveness of learning interventions, interactive e-module development, instructional design, and learning improvement through reflective practices**. Among these themes, student engagement emerged as the most influential topic, reflecting the increasing emphasis on active student participation as a key factor in successful mathematics learning.

The overlay visualization demonstrated an evolution of research

trends from methodological and implementation-oriented studies toward more learner-centered approaches focusing on engagement, practicality, reflection, and continuous instructional improvement. Furthermore, the density visualization highlighted student engagement, effect, practicality, and media expert evaluation as the most intensively studied topics within the field.

Despite the growing body of research, the analysis revealed that **school culture** remains relatively underrepresented compared to digital learning and instructional effectiveness themes. Therefore, future studies should explore more deeply how school values, learning environments, and sociocultural contexts can support the implementation of problem-based interactive e-modules and strengthen student engagement in mathematics learning.

Overall, the findings suggest that the integration of problem-based interactive e-modules and positive school culture has considerable potential to create meaningful, engaging, and effective mathematics

learning experiences for elementary school students. This study also provides a valuable foundation for future research and educational innovation in the digital learning era.

3.6 Acknowledgement

The authors would like to express their sincere gratitude to the Faculty of Education and the Graduate School of Universitas Negeri Semarang for their academic support throughout this study. Special appreciation is extended to all researchers and institutions whose publications contributed to the bibliometric dataset analyzed in this research.

The authors also acknowledge the developers of Scopus, Publish or Perish, VOSviewer, and Biblioshiny for providing valuable databases and analytical tools that facilitated the completion of this study. Finally, the authors are grateful to colleagues, reviewers, and all parties who provided constructive feedback and support during the research and writing process.

REFERENCES

- Gunawan, G., Harjono, A., Sahidu, H., & Herayanti, L. (2023). The effectiveness of interactive e-modules in improving students' learning outcomes and engagement. *Journal of Educational Technology Systems*, 52(1), 45–60.
- Martin, F., & Bolliger, D. U. (2022). Engagement matters: Student perceptions on the importance of engagement strategies in technology-enhanced learning. *Online Learning Journal*, 26(2), 205–222.
- Mayer, R. E. (2021). *Multimedia Learning* (3rd ed.). Cambridge University Press.
- Nieveen, N. (2022). Educational design research and the development of quality learning materials. In T. Plomp & N. Nieveen (Eds.), *Educational Design Research* (pp. 89–110). Netherlands Institute for Curriculum Development.
- OECD. (2023). *PISA 2022 Results: The State of Learning and*

- Equity in Education*. OECD Publishing.
- Prensky, M. (2022). Digital learning and student engagement in the twenty-first century classroom. *Educational Technology Research and Development*, 70(4), 1451–1468.
- Subali, B., Ellianawati, E., & Sumarni, W. (2024). Problem-based learning and digital module integration in elementary mathematics education. *International Journal of Instruction*, 17(1), 325–340.
- Suryani, N., Setiawan, A., & Putria, A. (2023). Development of problem-based interactive e-modules for elementary mathematics learning. *Journal of Physics: Conference Series*, 2426(1), 012015.
- van Eck, N. J., & Waltman, L. (2024). VOSviewer manual: Visualizing bibliometric networks. Leiden University.
- Waltman, L., van Eck, N. J., & Noyons, E. C. M. (2022). Bibliometric mapping of educational technology research: Trends and future directions. *Scientometrics*, 127(8), 4321–4340.
- Zhang, D., Zhao, J. L., Zhou, L., & Nunamaker, J. F. (2023). Can e-learning replace classroom learning? A review of digital learning effectiveness and student engagement. *Communications of the ACM*, 66(5), 75–82.