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A Trend Analysis of Module Development for Mathematics Teaching in Asia

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Abstract

The development of well-structured modules fit to students' needs was an effective approach to enhancing understanding of abstract concepts, promoting self-directed learning, and making the teaching and learning (T&L) of mathematics more interactive. This study examines research trends, development approaches, research designs, and methodologies related to mathematics module development based on 22 articles published in the Web of Science (WoS) and Scopus databases from 2020 to 2024. The findings indicate Indonesia twelve articles and Malaysia five articles as major contributors, with mixed-method approaches and quasi-experimental designs most frequently employed. Keyword network analyses highlight emphasis on technology integration, problem-based learning, and interactive module design. Additionally, 86.4% of the reviewed studies focused on secondary education, while only 13.6% examined primary school contexts, suggesting a research gap at the foundational level. This study highlights the need for more inclusive mathematics module development that incorporates the latest technologies and considers the long-term impact on students' achievement and interest in mathematics.

Keywords: Asia, Bibliometric Analysis, Mathematics Teaching, Module Development

Introduction

The construction of a module that is planned and tailored to the needs of students is one of the effective approaches in the teaching and learning process. According to Rasdi et al. (2021), the development of modules based on needs analysis, theory, literature review, evaluation and curriculum reviews has produced useful modules. Modules can be developed and adapted for self-learning, collaborative learning, or digital learning, depending on the needs and teaching context. Modules are also an important tool to support self-learning, especially in subjects such as mathematics, where students often face challenges in understanding abstract concepts (Zawawi et al. 2020). The application of right modules will improve

students' ability to understand and apply the concepts along with an enjoyable and meaningful learning experience. In recent years, the integration of innovative educational tools such as Augmented Reality (AR) Batik modules and context-based learning frameworks like Modul Fajar CUTeEM has further demonstrated how to well-structured learning modules can bridge the gap between abstract theory and real-world application (Pahmi et al., 2022). The flexibility inherent in modules makes them a tool with great potential to improve educational effectiveness, especially in subjects such as mathematics which are often seen as challenging and unfun subjects by students.

Integrated Literature Context

This literature review aims to identify important elements in the development of Mathematics teaching and learning (T&L) modules in Asia. Modules are important pedagogical tools designed to improve the effectiveness of T&L by providing structured guidance to students and teachers. In Asia, there are various approaches used in Mathematics T&L. The factors that influence the approach to development Mathematics T&L modules are cultural factors, education systems and local needs. Mathematics T&L modules are teaching materials that are systematically planned to help students understand mathematical concepts in depth. These modules often contain components such as learning objectives, interactive activities, support materials and assessments. According to Fauzi and Ramli (2019), a good Mathematics T&L Module should support student-centered learning and promote active problem solving. Similarly, a study by Sidek and Jamaludin (2005) emphasized that effective mathematics modules should be self-directed and flexible to accommodate students' varied learning paces, interactive to enhance engagement and organized according to their skill levels.

Moreover, Asian countries such as Japan, Singapore, and South Korea have long been known for their effectiveness in mathematics teaching and learning systems. In Japan, the approach in mathematics teaching emphasizes problem-based learning where students are encouraged to solve problems creatively and critically (Lee & Shimizu, 2019). Meanwhile, in Singapore, mathematics modules were designed to build basic skills such as arithmetic and geometry through the use of visual methods such as bar models (Ng, 2017). This approach has helped students understand the relationship between numbers and mathematical operations well.

A study by Lim et al. (2020) showed that the integration of technology in mathematics teaching modules such as the use of mobile applications and interactive software can increase student motivation and achievement. In addition, culture also plays an important role in the design of mathematics teaching modules. In Malaysia and Indonesia, a contextual approach is used to relate mathematics to students' daily life situations (Ahmad et al., 2021). Local elements such as traditional games were used to teach basic mathematical concepts.

Empirical studies show that well-designed mathematics T&L modules can improve understanding of mathematical concepts (Rahman et al., 2018), encourage students' interest in mathematics and help students develop problem-solving and critical thinking skills (Hassan et al., 2020). However, there are challenges in the development and implementation of modules, including lack of teacher training and limited access to quality materials, especially in rural areas.

Although many studies have been conducted on the development of Mathematics modules, there are still several research gaps that need attention. First, studies on the effectiveness of digital modules in rural areas are still lacking, while access to technology is an important factor in ensuring the effectiveness of T&L (Lim et al., 2020). Second, there is a lack of comparative studies between Asian countries that can provide a more comprehensive picture of the effectiveness of modules in the context of different education systems (Lee & Shimizu, 2019). In addition, more in-depth research is also needed to understand the role of culture in module development, as cultural factors have a significant influence on the design, acceptance and effectiveness of Mathematics modules (Ahmad et al., 2021).

Research Questions

The development of modules in mathematics teaching and learning aims to identify students' needs in mathematics learning, especially the challenges faced in understanding abstract and complex concepts. The development of appropriate mathematics learning modules can also increase the level of understanding and needs of students. Zulkefli et al. (2019) stated that continuous evaluation of modules was very important to ensure that the content of the modules remains relevant and effective.

Therefore, this bibliometric analysis was conducted on articles using modules in Asia that have been published in two selected databases in the last five years between 2020 and 2024. This present study aims to review the identified research questions, such as :

i. What are the research trends in the development of Mathematics T&L modules such as publications by country, citations, keyword networks and publications by year?
ii. What are the approaches, study designs, research methods and levels of study that are widely carried out?

Methodology

Data Collection and Data Search Strategies

In designing bibliometric research, some researchers and experts recommend using various databases, including Eric, Ebsco, WoS and Scopus. However, this recommendation may result in unreliable research results because there is a possibility of duplication of information searched. In certain fields such as education, most journals are indexed in comprehensive databases such as WoS and Scopus. To maintain data integrity and simplicity, this study exclusively used the WoS database for bibliometric analysis (Ismail, 2024). On December 12, 2024, information from the core collection of the WoS platform supervised by Clarivate Analytics was applied for this present study.

The database serves as an optimal tool for conducting bibliometric analysis (Korom, 2019). The search was conducted covering the period from 2020 to 2024 and the data was systematically analyzed. The appropriate search keywords used were TS = ("MATHEMATIC*" AND "MODULE*" AND "DEVELOPMENT") OR ("MATHEMATIC*" AND "EDUCATION" AND "MODULE*") were used for both databases. The initial search on title, abstract or keywords generated 6 445 results in SCOPUS and 6 769 results in WoS. This number was classified to year and generated 1 874 and 2 650 in SCOPUS and WoS respectively.

This search was then further screened by document category, i.e. articles only, 1033 articles for SCOPUS and 2349 articles for WoS. The next screened was by language, i.e. English, and then by subject area. There were 246 articles for SCOPUS and 236 articles for Wos. In the final

selection to ensure that only relevant articles were included, focus was given to articles that discussed the construction of modules for teaching and learning mathematics in Asia only. There were 116 and 57 articles in SCOPUS and WoS respectively. The overall data screening process is illustrated in Figure 1.

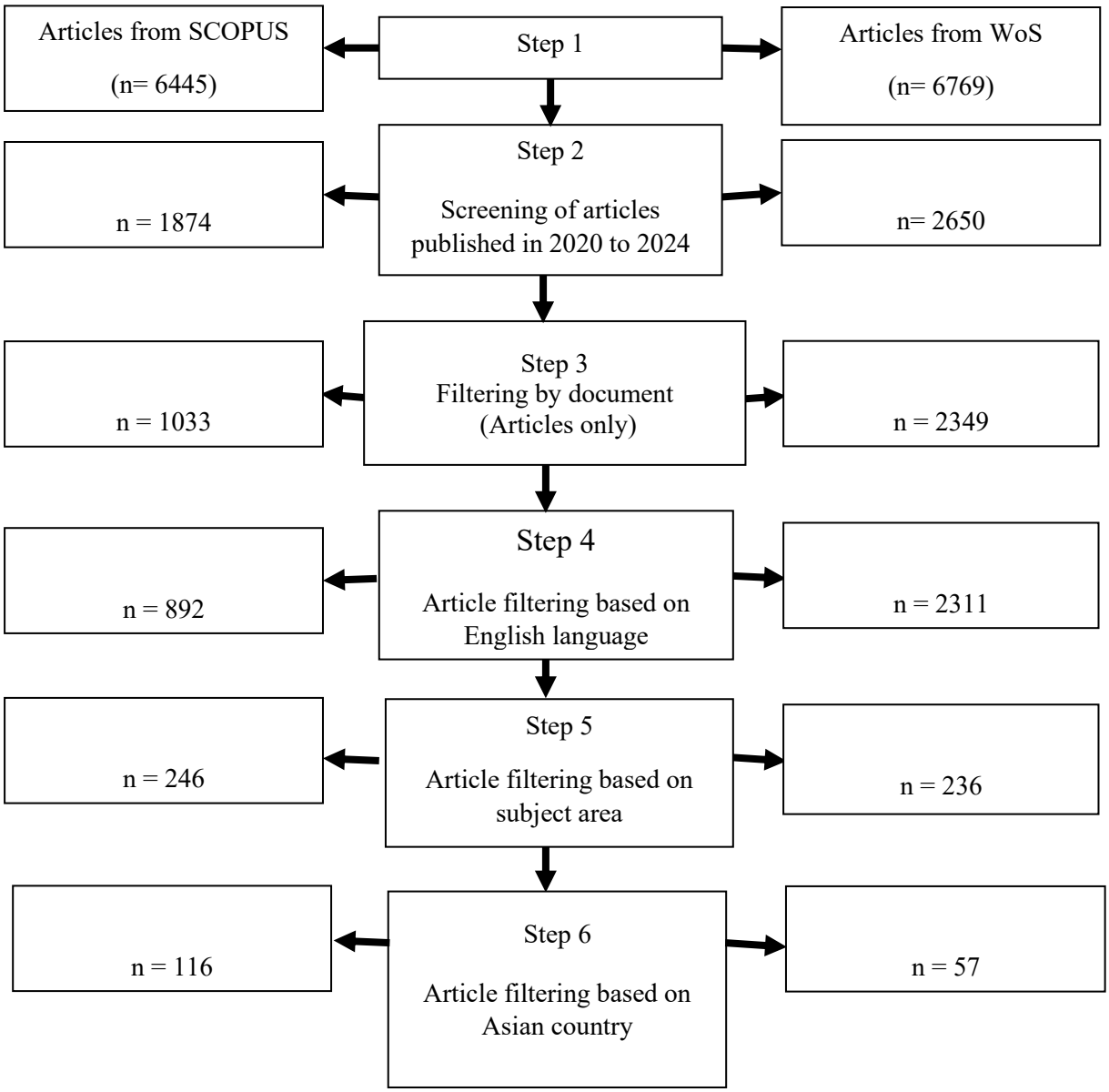

Figure 1. Data extraction process (Korom, 2019)

Next, articles that have been screened in SCOPUS and WoS will go through the next stage using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The method has been widely used for decades in analyzing articles through systematic literature reviews. In this systematic review, PRISMA consists of four phases: identification, screening, eligibility, and inclusion.

According to Rafael et al. (2021), the PRISMA Statement and its extensions are evidence-based, minimum set of recommendations designed primarily to promote transparent and complete reporting of systematic reviews. PRISMA has been improved with the latest version called PRISMA 2020 and according to Peter and David (2021), the changes made between

PRISMA 2020 and its previous versions highlight the changes of the times and not only in representing content that reflects scientific progress, but also in focusing on supporting the implementation.

The first phase in PRISMA was the identification phase. This phase was implemented as in Figure 1, which is the data extraction process (Korom, 2019). In this phase, there were 116 articles that were selected in the SCOPUS database and 57 articles in the WoS database. This was followed by the Second Phase, which is the screening phase where all articles from both databases were combined and repeated articles were excluded, there were 32 articles. This made the total number of articles accepted 141.

Of these 141 articles, the screening process was carried out again where only articles in the field of Mathematics were accepted. This made 87 articles accepted and 54 articles outside the field of Mathematics were excluded. In the third phase, which is the qualification phase, from the 87 articles accepted. The screening process was carried out again where only articles that met the criteria as in Table 1 were accepted. There were 20 articles excluded due to unavailable access. In addition, articles that did not meet the criteria for building modules in mathematics teaching were also excluded. Only 22 articles eligible for acceptance in phase four, the acceptance phase.

Table 1
Prescribed article inclusion criteria

Criteria	**Entry**
Accessible	Articles are fully accessible
Level of Study	Only primary and secondary school levels are accepted
Mathematics T&L	Only articles involving the construction of mathematics modules are accepted

Figure 2 below shows the four-phase PRISMA flow chart where all accepted articles have gone through four phases.

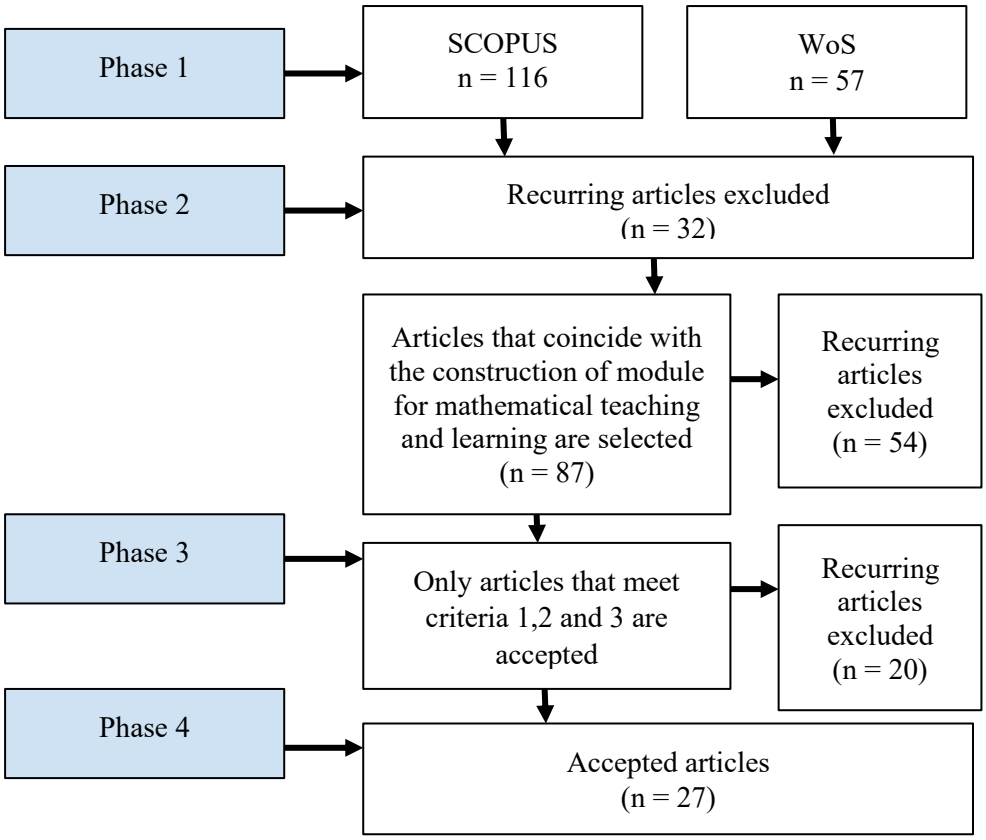

Figure 2: PRISMA four-phase flow chart adapted from page et al. (2021)

Analysis Methods

There are various types of systematic review papers, including narrative reviews that incorporate a framework to establish a future research agenda (Migliavacca et al., 2020), scoping reviews that map key concepts, types of evidence and aim for model/framework development (Munn et al., 2022), meta-analyses (Knoll & Matthes, 2017), bibliometric analyses (Donthu et al., 2021) and umbrella reviews that summarize evidence from multiple systematic reviews on a broad question (Faulkner et al., 2022).

This research uses a combined bibliometric and SLR approach, similar to the method that was used by Linnenluecke et al. (2020). Bibliometrics are often used to outline the academic framework of a particular field of study (Li et al., 2017) and to explore various research themes (Blanco-Mesa et al., 2017). Conducting a systematic review of the literature was important to synthesize research content, minimize bias (Tranfield et al., 2003) and determine areas that require further investigation (Kumar et al., 2019; Talan & Sharma, 2019).

In this study, bibliometric analysis was used to examine the field of study in question, which was then supplemented by content analysis focusing on key themes (Baker et al., 2020). Boyack and Klavans (2010) detailed the use of standard bibliometric methods, such as citation and co-citation analysis, to explore how documents refer to each other.

In this study, trends in publications were analyzed by country, citations, keyword networks and publications by year, study design, study methods and level of study, in addition to conducting a comprehensive content analysis (Donthu et al., 2021). To achieve this goal, we used the software VOS viewer. VOS viewer generates visual maps showing the association of

items with their spatial distance, based on the "visualization of similarities" (VOS) technique (van Eck & Waltman, 2010). We specifically used VOS viewer for our citation, co-citation and keyword analyses. An initial set of 173 articles were analyzed using VOS viewer, with the process illustrated in Figure 2.

Findings

Analysis of Publications by Country

The findings from the 22 articles showed that five countries are involved in contributing to the development of modules for Mathematics Teaching in Asia. Figure 3 shows that Indonesia recorded the highest number of articles, 12 articles, followed by Malaysia with 5 articles and the Philippines with 3 articles, respectively. Meanwhile, Turkey and Nigeria each contributed one article. While Table 2 shows the articles that have been written by country.

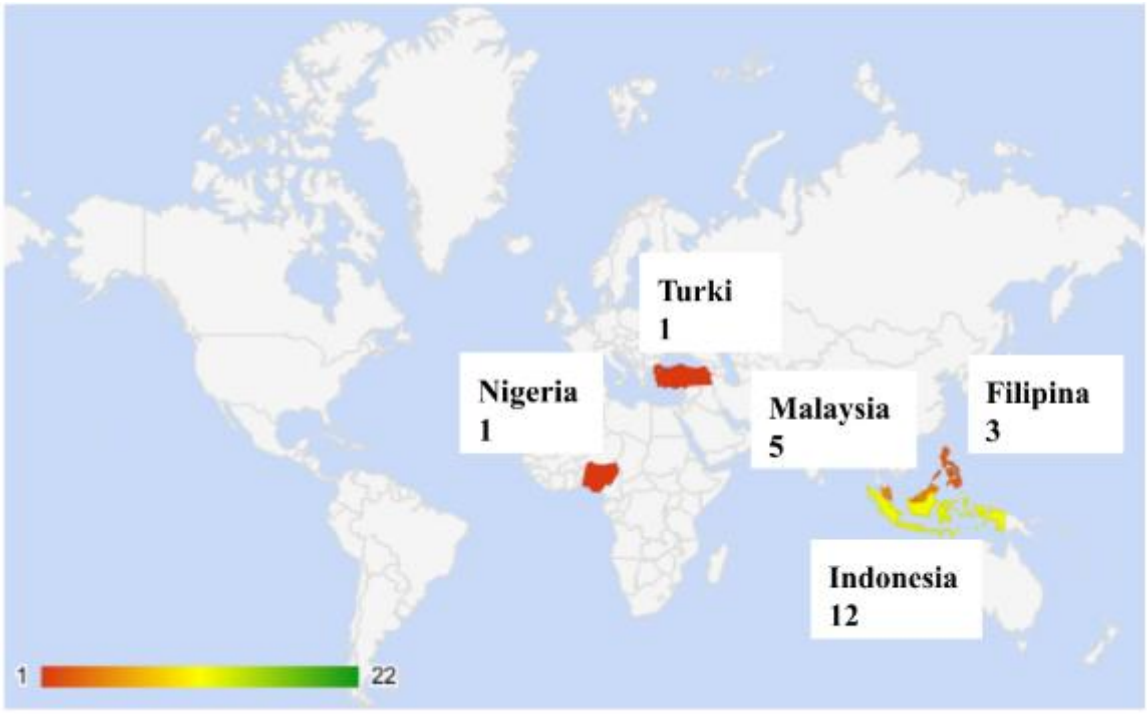

Figure 3: Number of articles by country contributing to the development of modules for Mathematics Teaching in Asia

Table 2
Titles of articles by country contributing to the development of modules for Mathematics Teaching in Asia from year 2020 to 2024

Country	Article
Indonesia (12)	*Design of mathematical e-module based on inquiry learning model to stimulate the creative skills (Aziz & Suparman, 2020)* *Effectiveness of learning mathematics derivative materials using modules equipped with cooperative models in high schools (Lumbantoruan & Manalu, 2024)* *Developing MoAR-Integrated Printed Learning Modules to Improve Mathematical Problem-Solving Abilities in Geometry Learning (Hakim et al, 2024)* *Design of e-module with RME approach to improve the creative thinking ability of students (Achmad & Suparman, 2020)* *Effectiveness of Mathematical Learning Module in Community Education Unit (Isa & Djuko, 2023)* *FOSTERING MATHEMATICAL CONNECTIONS AND HABITS OF MIND: A PROBLEM-BASED LEARNING MODULE FOR ELEMENTARY EDUCATION (Purnomo et al, 2024)* *A Project-based learning into flipped classroom for ePUB3 electronic mathematics learning module (eMLM)-based on course design and implementation (Ramadhani & Fitri, 2020)* *Development of a mathematics module on circle material based on the small group discussion model (Lumbantoruan & Ditasona, 2024)* *Designing a digital teaching module based on mathematical communication in relation and function (Setiyani et al., 2020)* *An ePub learning module and students' mathematical reasoning ability: A development study (Hidayat et al., 2022)* *DEVELOPMENT OF SUNDANESE GAMELAN ETHNOMATHEMATICS E-MODULE FOR JUNIOR HIGH SCHOOL MATHEMATICS LEARNING (Supriyadi et al., 2024)* *Design of realistic mathematics education approach to improve critical thinking skills (Hikayat et al., 2020)*
Malaysia (5)	*The Effect of Using Augmented Reality Module in Learning Geometry on Mathematics Performance among Primary Students (Nadzri et al. 2023)* *Development and Validation of a Teaching Module based on the Traditional Approach of the Japanese Bansho Plan Towards the Mastery of Quadratic Equations (How et al., 2024)* *Mathematics module based on STEAM and Quranic approach: A study for student's perception (Muzakkir et al., 2024)* *The Effectiveness of the Implementation of Three Dimensions Geometry KARA Module on Higher Order Thinking Skills(HOTS) and Motivation (Suanto et al., 2023)* *Testing the validity and reliability of metaseller tutoring module for the purpose of mathematics learning intervention (Bakar & Ismail, 2020)*
Filipina (3)	*Designing and Developing Video Lessons in Mathematics Using Code-Switching: A Design-Based Research (Sagge & Segura, 2023)* *Development of a Mathematics Module using the 5E Learning Model (Paguirigan E.M.& Paguirigan M.J.R., 2024)* *VIDEO ASSISTED LEARNING MODULE (VALM) FOR THE LEAST LEARNED COMPETENCIES IN GENERAL MATHEMATICS (Santiago & Nabayra, 2024)*
Turki (1)	*Can Music Support Calculation Skills? A Pilot Study Using Electrophysiological Measures (Korkmaz & Temur, 2022)*
Nigeria (1)	*Rethinking strategy on developing students' levels of geometric thinking in Sokoto state, Nigeria (Hassan et al., 2023)*

Citation Analysis

In terms of citation analysis, one article was cited and became a reference for 22 other articles, namely Designing a Digital Teaching Module Based on Mathematical Communication in Relation and Function (Setiyani et al., 2020). This article received the highest citation compared to 21 other articles. In addition, the article "A Project-Based Learning into Flipped Classroom for ePUB3 Electronic Mathematics Learning Module (eMLM) - Based on Course Design and Implementation" by Rahmi Ramadhani and Yulia Fitri (2020) and the article "An ePub Learning Module and Students' Mathematical Reasoning Ability: A Development Study" (Hidayat et al., 2024) have each been cited 17 times. Meanwhile, one article has been cited 15 times, which is equivalent to 4.5% of the total citations, while another article has been cited 5 times. Three articles have been included in other articles as references and cited twice. In addition, there are six articles that are cited only once. Meanwhile, eight articles did not receive any citations.

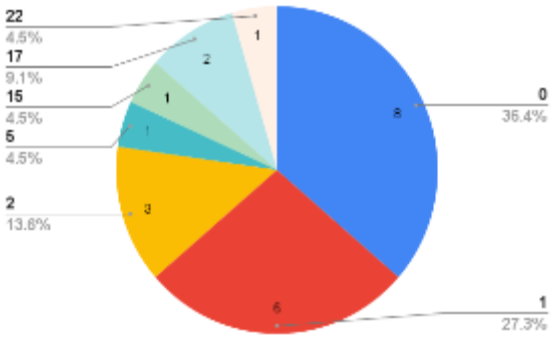

Figure 4: Number of citations by article in development of modules for Mathematics Teaching in Asia

Keyword Network Analysis

According to Hasumi and Chiu (2022), the keywords used by the author play an important role in identifying the main focus of an academic article. Using VOS Viewer software, an analysis was conducted to identify the main themes in the study of Module Construction for Mathematics Teaching and Learning in Asia. This analysis found 269 main keywords in 57 articles from 2020 to 2024. VOS Viewer software was used to analyze the keywords used with a minimum frequency of two. The results of the keyword analysis were extracted and represented in figure 4. Each keyword was divided into six dominant clusters, represented by red, green, blue, yellow, purple and light blue nodes for each cluster.

Referring to figure 5, it was found that there were several main clusters. The largest cluster was centered on the keyword "education". This shows that most of the articles published during the period under study focused on the educational aspect. The keywords "learning", "motivation", "experience" and "school" show a focus on pedagogy and learning experiences in the context of education. This shows that the importance of education in this study was especially in the fields of science and mathematics. The clusters related to "teachers" and "mathematics curriculum" show that the role of teachers and the mathematics curriculum were the main focus in the teaching and learning process. This was in line with the trend of studies that focus on teaching and learning approaches using modules that could influence the effectiveness of mathematics learning. The keywords "science", "instruction" and "beliefs" show that there are studies that examine teachers' beliefs about mathematics teaching and its impact on student understanding.

There was another important cluster, “stem”, which was associated with the keywords “spatial ability” and “augmented reality”. This shows that there was an integration of technology and spatial abilities and capabilities in STEM (Science, Technology, Engineering and Mathematics) learning. Finally, the cluster focusing on “thinking” and “mathematical models” reflects the study of mathematical thinking and mathematical models in education. This association showed that aspects of critical thinking and the use of mathematical models in education were also a focus of study.

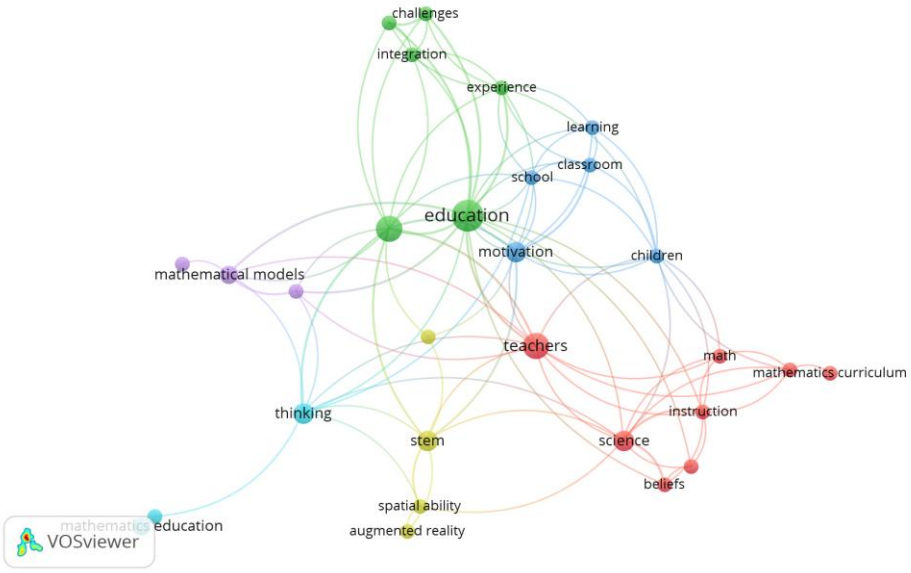

Figure 5: Analysis of frequently appearing keywords in Module Construction for Mathematics Teaching and Learning in Asia

Publication Analysis by Year

Figure 6 shows the trend of publication of articles related to module development for Mathematics T&L in Asia over a five-year period, from 2020 to 2024. The year 2024 recorded the highest number of publications with nine articles, followed by the year 2020 with six articles. In 2023, a total of five articles were published, while 2022 recorded only two articles. In contrast, no articles on module development for Mathematics T&L in Asia were published in 2021. There was a decrease from 2020 to 2021 while there was an increasing trend in the number of articles published from 2022 to 2024. The data displayed shows a more balanced increase in the use of approaches and designs in 2023 and 2024.

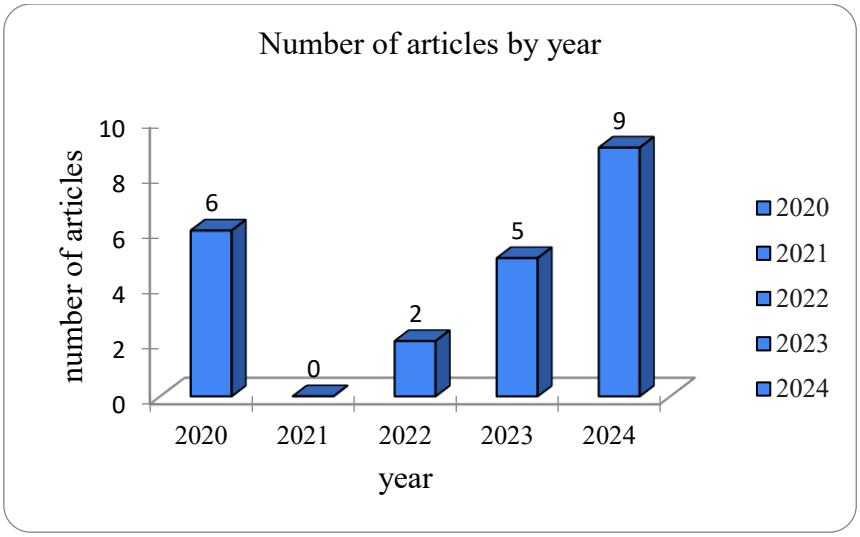

Figure 6: Graph of Article Publications by Year in Module development for Mathematics Teaching and Learning in Asia

Analysis of Study Design and Research Methods

Table 3 shows the analysis of designs and approaches used in module development studies for Mathematics T&L in Asia from 2020 - 2024. The mixed-method approach was the most widely used approach, with 10 articles, followed by Design and Develop Research (DDR), quantitative, qualitative and Education Develop Research (EDR) approaches, with 5, 3, 2 respectively.

Table 3

Analysis of design and approach to development of Mathematics T&L modules in Asia from 2020 – 2024

Year	Quantitative	Qualitative	Mix Method	DDR	EDR	Total
2020	0	1	3	1	1	6
2021	0	0	0	0	0	0
2022	0	0	2	0	0	2
2023	2	0	2	1	0	5
2024	1	1	3	3	1	9
Total	3	2	10	5	2	**22**

Figure 7 shows an analysis of the research methods used in the study of the development of Mathematics T&L modules in Asia 2020 - 2024. There were 12 categories of research methods identified involving 22 articles that have been extracted. The quasi-experimental method was the most frequently used method, which was 8 articles. This method was used to evaluate the effectiveness of a study, especially in quantitative approaches. While the interview and survey methods were 4 articles each, the R&D method, observation, questionnaire were 3 each and the code-switching method, case study, exploration, descriptive survey, evaluation test and literature review were 1 each.

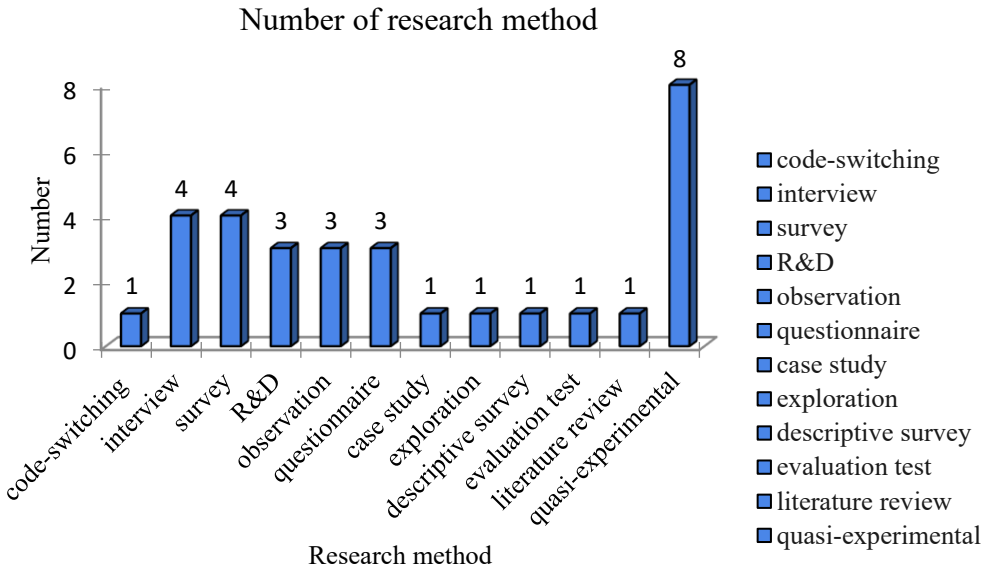

Figure 7: Research methods in the development modules of Mathematics teaching and learning in Asia for year 2020 to 2024

Analysis by level of study

Figure 8 shows the analysis of articles by level of study in the development of Mathematics T&L modules. After the data was extracted, the focus of the study was more on the study of module development in secondary schools with 19 (86.4%) articles while primary schools involved 3 (13.6 %) articles.

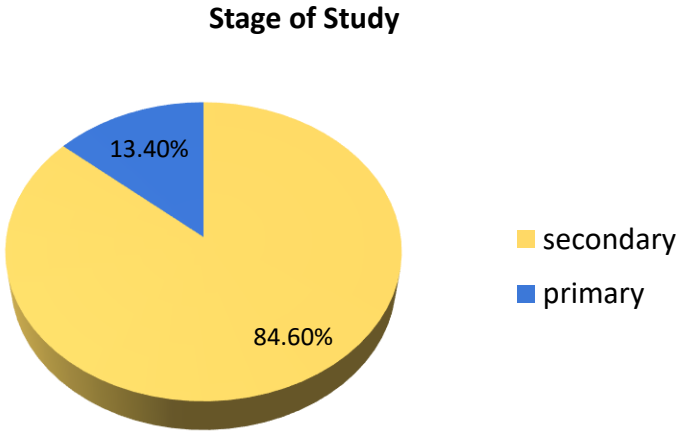

Figure 8: Stages of study in the development of Mathematics T&L modules in Asia

Discussion

The findings of this study indicate the rapid development of Mathematics module development research in Asia, with significant contributions from Indonesia and Malaysia. The high number of publications from these two countries reflects the continuous efforts to improve the effectiveness of Mathematics teaching through modules adapted to local contexts and based on technology. In contrast, Japan, South Korea and Singapore place more emphasis on the integration of e-learning, teacher collaboration and approaches such as the

Flipped Classroom, which reflect different educational priorities but still move towards the same goal of empowering 21st century teaching and learning.

Citation analysis shows the great influence of the article Setiyani et al. (2020) which is a key reference in the development of digital modules. The emphasis on project-based learning (PBL) and digital modules reflects the shift to student-centered pedagogy. However, there were some articles that did not receive citations, possibly because the field of study was still new or has received less exposure.

From a methodological perspective, mixed-method approaches and quasi-experimental methods are the dominant choices because they provide researchers with the opportunity to evaluate the effectiveness of modules more comprehensively. The use of design models such as ADDIE, 5E module and Assure module shows the need for repeated evaluation and cyclical module development. However, the analysis shows an imbalance in the focus of the study, when 86.4% of the modules were developed for secondary schools compared to only 13.6% for primary schools, while primary schools also need module support to build a strong mathematical foundation.

The impact of the COVID-19 pandemic also affected publication patterns, with no articles published in 2021, but slowly increasing again in 2022 to 2024. This shows that although the pandemic was constraining research, it was also driving innovation in the development of digital modules and more flexible T&L strategies.

Future Research

Future research could focus on the development of a more inclusive Mathematics module by integrating the latest technology such as artificial intelligence into teaching and learning practices. Such integration has the potential to enhance student engagement, personalize learning experiences, and improve conceptual understanding. In addition, future studies should also explore longitudinal approaches to evaluate the long-term impact of these modules on student achievement, as sustained evidence was crucial in determining the effectiveness and scalability of the modules across diverse educational contexts.

Conclusion

This systematic literature review and bibliometric analysis aims to identify the effectiveness of the use of mathematics modules on students' achievement and interest in mathematics. SCOPUS and WoS were two databases used to collect 22 articles that met all acceptance criteria. The results of the study show that the development of quality Mathematics T&L modules that were appropriate to the local context was very important to increase efforts to develop these modules at the secondary school level or at the primary school level to ensure that all students, especially in Malaysia, benefit from effective learning approaches.

In addition, the results of the study can also contribute ideas to future researchers in selecting the scope to be studied on the construction of modules in the subject of mathematics. This contribution can fill the gap in future research. Previous studies have focused more on Indonesia than other Asian countries. Therefore, researchers in other Asian countries, especially Malaysia, were recommended to conduct future studies on the effectiveness of modules on students' achievement and interest in the subject of mathematics.

In addition, future studies were proposed to develop Mathematics modules more inclusively by taking into account the use of the latest technology and the long-term impact on students' achievement and interest in mathematics. This can produce higher quality studies and provide a positive impact on the field of mathematics education, especially for the development of modules in mathematics learning. It is hoped that this study can serve as a guide for researchers, educators and policy makers in planning and implementing the use of learning modules that are more effective and relevant to current educational needs.

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