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Learning Trajectory Research in Indonesian Realistic Mathematics Education: A Bibliometric Analysis, 2015–2025

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A B S T R A C T

Learning trajectory (LT) and Realistic Mathematics Education (RME) are increasingly combined to support progressive concept development through contextual activity, modelling, and anticipated student reasoning. However, the Indonesian literature remains fragmented across topics, educational levels, and methodological traditions, making it difficult to identify the field's development and underexplored directions. This study maps Indonesian LT research within the RME framework from 2015 to 2025 using bibliometric analysis. Metadata were retrieved from Google Scholar with Publish or Perish version 8. Of 101 initial records, 46 journal articles met the predefined relevance, publication-type, language, time-range, and duplication criteria. Records were cleaned in Mendeley, keywords were standardized, and co-occurrence patterns were analysed using VOSviewer version 1.6.20 with full counting. Publication output increased markedly after 2021 and peaked in 2022. LT, hypothetical learning trajectory (HLT), RME, and design research formed the central thematic structure, with later studies increasingly connected to problem solving, reasoning, communication, representation, and conceptual understanding. Design research remained the predominant methodology, whereas higher-education applications were comparatively limited. The study contributes an evidence-based map of publication growth, thematic evolution, methodological concentration, and research gaps. Future work should broaden database coverage and examine LT-RME designs in university mathematics, particularly abstract domains such as calculus and linear algebra.

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1. Introduction

Contemporary mathematics education increasingly emphasizes conceptual understanding, reasoning, representation, and problem solving rather than isolated procedural performance. Students are expected to connect mathematical ideas across representations and use them in meaningful situations, yet abstract concepts and decontextualized exercises can make this development difficult. Recent research therefore gives greater attention to instructional designs that sequence students' activity and reasoning progressively and that connect informal strategies to formal mathematics (Andriatna et al., 2025;Jäder & Johansson, 2025; Khairunnisak et al., 2024)

Learning trajectory research provides a framework for such sequencing. A learning trajectory commonly links a mathematical goal, an account of students' developing thinking, and instructional tasks designed to support movement along that development. The construct emerged from work on hypothetical learning trajectories and was subsequently extended to instruction, lesson planning, and broader learning progressions (Simon, 2020;Clements & Sarama, 2004;Sztajn et al., 2012 ; Ernest, 1991; Donthu et al., 2021) These studies show that

trajectories are not fixed scripts; rather, they function as empirically revisable conjectures about how particular mathematical ideas may develop.

Realistic Mathematics Education provides a compatible instructional foundation because it begins from experientially real situations, encourages progressive mathematization, and uses models as bridges from situated activity to formal reasoning. Seminal and subsequent studies have shown how context problems and emergent models can support the reinvention of mathematical ideas in school and advanced mathematics (Gravemeijer & Doorman, 1999; van den Heuvel-Panhuizen, 2003; (Jupri & Drijvers, 2016). Empirical work in Indonesia has also reported positive outcomes of RME for achievement, multi-representation, problem solving, and communication (Laurens et al., 2018); Muhtarom et al., 2019;(Ulandari Lavenia, 2019); Nuraida & Amam, 2019).

The convergence of LT and RME has generated a growing body of Indonesian design studies across fractions, algebra, geometry, sets, arithmetic, and other topics. Examples include fraction trajectories, project-based set trajectories, social-arithmetic trajectories, and set-concept designs using RME (Purnomo et al., 2021;Astuti & Wijaya, 2021; Umasugi et al., 2022;Juana et al., 2023). More recent syntheses also indicate continuing interest in RME for mathematical literacy and conceptual understanding (Farah Ayyun Taqiya & Juandi, 2023; Hamidah et al., 2024;(Nurrahmah, 2026)). Nevertheless, these studies are dispersed across journals and often emphasize individual interventions rather than the structure of the research field as a whole.

Bibliometric analysis is useful for this problem because it can quantify publication growth and map relationships among keywords, themes, and research fronts. Established bibliometric guidelines recommend transparent database selection, cleaning procedures, and the combination of performance indicators with science-mapping techniques (Budiarto et al., 2025; Aria & Cuccurullo, 2017; Donthu et al., 2021; Klarin, 2024). VOSviewer is particularly suitable for visualizing co-occurrence networks and temporal overlays (Jajang Rahmatudin et al., 2025). Although bibliometric studies have examined mathematics education and RME more broadly (Angraini & Muhammad, 2023; Budiarto et al., 2025), a focused mapping of Indonesian LT research within the RME framework remains limited.

Accordingly, this study provides a bibliometric map of Learning Trajectory research within Realistic Mathematics Education in Indonesia from 2015 to 2025. It addresses three questions: (1) What publication trend is visible for LT-RME research during 2015–2025? (2) What dominant and emerging themes are revealed by keyword co-occurrence and overlay visualization? and (3) How are methods, mathematical topics, and educational levels distributed across the field? The study's novelty lies in integrating temporal, thematic, and methodological mapping to identify where LT-RME research is concentrated and where future work—especially in higher education—remains underdeveloped.

2. Methods

This study used a descriptive bibliometric design to examine the development of Learning Trajectory research within the Realistic Mathematics Education framework in Indonesia. Bibliometric analysis was selected because it enables systematic examination of publication productivity and conceptual structure through bibliographic metadata, while co-word analysis can reveal dominant and emerging research themes (Donthu et al., 2021; Klarin, 2024; (Aria & Cuccurullo, 2017).

2.1. Data Source, Search Strategy, and Selection

Data were collected from Google Scholar through Publish or Perish (PoP) version 8. The search covered 2015–2025 and combined the terms; the explicit Boolean search string applied across titles, abstracts, and keywords was structured as: "learning trajectory," or "hypothetical learning trajectory," AND "realistic mathematics education," or "PMRI,". "hypothetical learning trajectory" or " local instructional trajectory" and "mathematic education" or mathematical learning". The initial retrieval produced 101 records. Inclusion criteria were journal articles published in English or Indonesian during the selected period and directly relevant to LT/HLT and RME/PMRI. Duplicate records, non-article materials, and publications that addressed only one component without substantive relevance to the study focus were excluded. After screening and cleaning, 46 journal articles were retained, consistent with the dataset reported in the original manuscript.

2.2. Data Cleaning and Bibliometric Analysis

Records were exported in RIS format and managed in Mendeley. Keyword variants were standardized before analysis: "RME," "Realistic Mathematics Education," and "PMRI" were consolidated under Realistic Mathematics Education (RME); "Hypothetical Learning Trajectory" and "HLT" were consolidated as Hypothetical Learning Trajectory (HLT); and spelling variants of learning trajectory were unified. VOSviewer version 1.6.20 was then used for author-keyword co-occurrence analysis with full counting and for network and overlay visualization. VOSviewer is widely used for science mapping because it constructs and displays similarity-based bibliometric networks in an interpretable visual form (Kadirhanoğulları et al., 2024).

Table 1. Bibliometric analysis parameters

No.	Parameter	Description
1	Data source	Google Scholar
2	Retrieval tool	Publish or Perish version 8
3	Publication period	2015–2025
4	Initial records	101 publications
5	Final dataset	46 journal articles
6	Analysis software	VOSviewer version 1.6.20
7	Analysis type	Keyword co-occurrence
8	Unit of analysis	Author keywords
9	Counting method	Full counting
10	Visualization	Network and overlay visualization

3. Results

3.1. Publication Trend

The annual distribution shows a low and irregular publication level from 2015 to 2020, followed by a clear increase after 2021. Publication output peaked in 2022 with 12 articles, decreased to seven in 2023, increased again to 11 in 2024, and reached seven in 2025. The post-2021 pattern indicates a transition from a small specialist topic toward a more visible line of inquiry within Indonesian mathematics education.

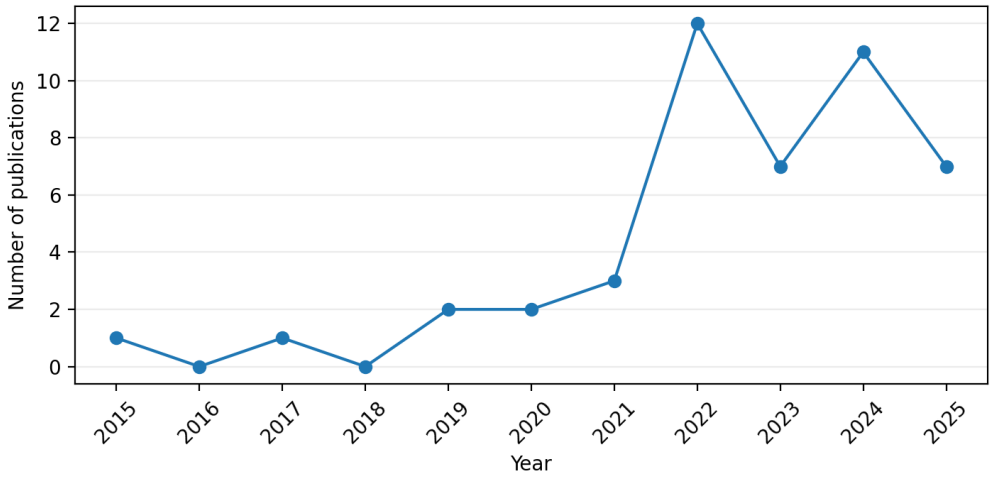


Figure 1. Publication trend of Learning Trajectory–RME research, 2015–2025

Dominant Research Themes

Keyword co-occurrence analysis places learning trajectory, hypothetical learning trajectory, design research, and realistic mathematics education near the conceptual center of the network. These terms connect with problem solving, mathematical reasoning, representation, communication, algebra, fractions, geometry, and conceptual knowledge. The network therefore reflects three intertwined strands: instructional-design methodology, targeted mathematical competencies, and topic-specific applications.

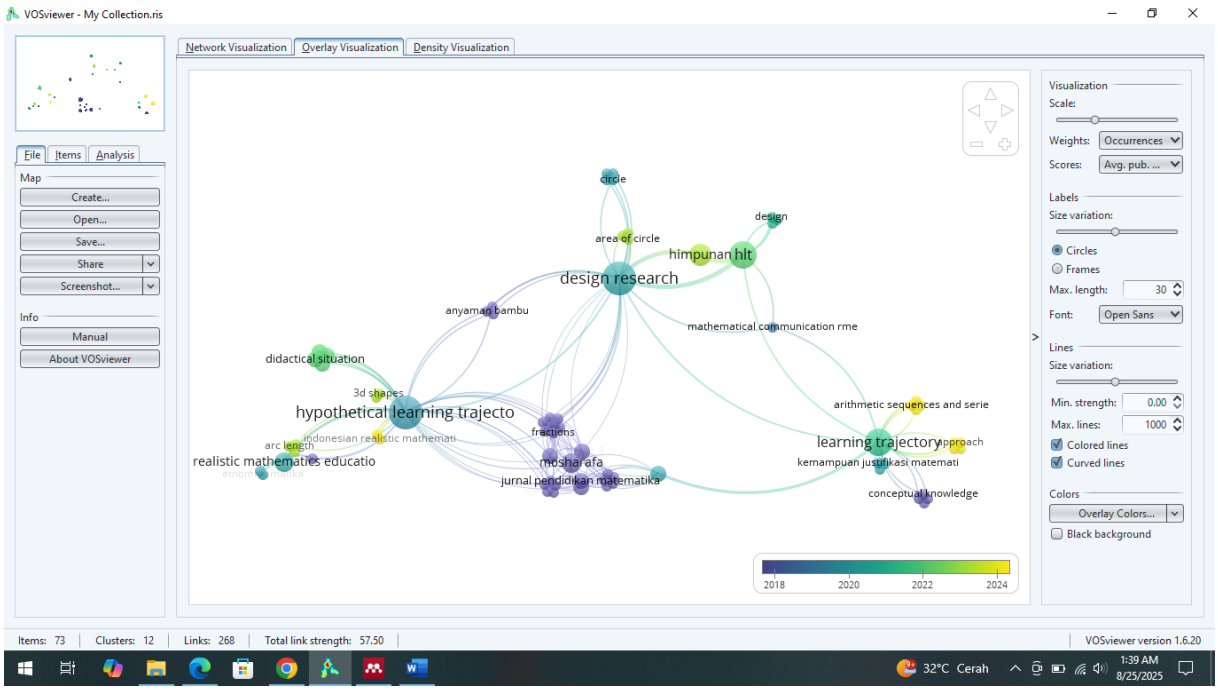


Figure 2. Keyword co-occurrence and overlay visualization generated with VOSviewer

Table 2. Selected highly cited and field-shaping studies in the dataset

Authors	Study focus	Year	Citations*
Ulandari, Amry, & Saragih	RME materials for problem solving and self-efficacy	2019	284
Nuraida & Amam	HLT-RME for mathematical communication	2019	60
Hendriana & Fitriani	Mathematical abstraction with RME and van Hiele levels	2019	13
Edo & Tasik	RME design research in vocational mathematics	2019	10
Angraini & Muhammad	Bibliometric trends of RME research	2023	13

Development of Research Topics, Methods, and Educational Levels

The overlay visualization suggests that earlier work, concentrated around 2018–2020, was more strongly associated with learning design, hypothetical learning trajectories, and design research. After 2021, the network shifts toward implementation-oriented outcomes such as problem solving, reasoning, communication, representation, and conceptual understanding. This pattern is consistent with the field moving from building and testing instructional pathways toward evaluating what those pathways facilitate in classroom practice.

Table 3. Illustrative Learning Trajectory studies using RME/related design approaches

Study	Method	Topic	Level	Main finding
(Yuliani et al., 2024)	Design research	Algebra	Junior high	HLT needed adaptation to student characteristics
(Purnomo et al., 2021)	Design research	Fractions	Secondary	Fraction sub-constructs fostered additive-to-multiplicative transitions
(Risdiyanti & Prahmana, 2021)	Design research	Sets	Secondary	Enabled project-based set concept building
(Khoirunnisak & Rizkianto, 2020)	Development study	Coordinates/ justification	Junior high	Trajectory-based materials were valid but constrained
(Khoirudin & Rizkianto, 2018)	Development study	Reasoning	Junior high	HLT supported anticipation of student reasoning in problem-based learning.
(Meirida et al., 2021)	Design research	Geometry	School level	GeoGebra-supported realistic contexts strengthened

Study	Method	Topic	Level	Main finding
				spatial/conceptual development.
(Juana et al., 2023)	Design research	Set concept	School level	RME trajectory supported progressive construction of set concepts.
(Umasugi et al., 2022)	Design research	Social arithmetic	Elementary	Culinary context supported contextual-to-formal mathematical reasoning.
(Mumu et al., 2026)	Design research	Research methodology	Higher education	HLT supported methodological reasoning of prospective mathematics teachers.
(Primasari et al., 2021)	Educational design research	Cube nets	Elementary	Cultural game context supported a validated RME learning trajectory.
(Edo & Tasik, 2019)	Design research	Applied mathematics	Vocational college	RME design supported meaningful mathematics learning in a tertiary vocational setting.

Across the mapped studies, design research remains the dominant methodological orientation. Most applications occur at elementary and secondary levels, whereas higher-education work is comparatively sparse. This imbalance is especially notable because learning trajectories are well suited to abstract domains that require coordinated development of representations and reasoning.

4. Discussion

The principal finding is the acceleration of LT-RME publication after 2021. This pattern should not be interpreted as proof of causal expansion in the field, but it does indicate stronger research visibility and a denser body of work available for synthesis. Similar bibliometric logic has been used to identify maturation and thematic shifts in research fields by examining changes in productivity and conceptual networks (Aria & Cuccurullo, 2017; Kadirhanoğulları et al., 2024). In the present dataset, the rise in output coincides with broader use of learning trajectories as practical instructional-design tools rather than only theoretical descriptions of students' thinking.

The centrality of LT, HLT, RME, and design research is theoretically coherent. (akker jan van de, gravemeijer koeno, Mc kenney susan 2013 ;Abrika et al., 2023) framed HLT as a conjectured route connecting goals, learning activities, and anticipated learning processes, while later work positioned trajectories as resources for instruction and teacher decision making (Sztajn et al., 2012; Anwar et al., 2023). RME adds a complementary account of progressive mathematization through contextual problems and models (Sya'Bani et al., 2021; van den Heuvel-Panhuizen, 2003). Their integration therefore provides both a developmental hypothesis and an instructional mechanism for revising that hypothesis through classroom evidence.

The shift toward outcomes such as reasoning, problem solving, communication, representation, and conceptual understanding is also supported by empirical RME literature. Studies have reported benefits for cognitive achievement, multi-representation, problem solving, self-efficacy, and communication (Widana, 2021; Mataheru et al., 2024; Muhtarom et al., 2019; Ulandari Lavenia at all, 2019; Nuraida & Amam, 2019). Recent reviews of mathematical literacy likewise describe RME as a recurring approach for connecting contextual activity with mathematically meaningful interpretation (Farah Ayyun Taqiya & Juandi, 2023;Hamidah et al., 2024). These converging findings help explain why the bibliometric network increasingly links LT-RME research with competency-oriented keywords.

Methodologically, the dominance of design research is consistent with the nature of learning trajectories as conjectures that must be tested and revised. Design experiments explicitly combine intervention development with theory building through iterative classroom cycles (Alim et al., 2020) and recent mathematics-education scholarship continues to emphasize the role of local theory development in design-based research (Komatsu et al., 2025). This orientation is visible in the Indonesian studies summarized here, where preliminary design, teaching experiments, and retrospective analysis are repeatedly used to refine instructional pathways.

A substantive gap concerns educational level. The mapped literature is concentrated in elementary and secondary mathematics, with fewer higher-education applications. Yet RME has been shown to support advanced topics such as calculus through context problems and modelling (akker Jan Van Den, 2013) , and the dataset contains emerging evidence that LT designs can be used in teacher education and tertiary vocational contexts (Edo & Tasik, 2019; Mumu et al., 2026). This suggests a promising agenda for university mathematics, especially linear algebra, calculus, statistics, and other domains where students must coordinate symbolic, graphical, numerical, and contextual representations.

The study also has methodological limitations. Google Scholar offers broad coverage but less controlled indexing than Scopus or Web of Science, and citation values in Publish or Perish are dynamic. The final corpus of 46 articles is therefore best interpreted as a transparent map of the selected search strategy rather than an exhaustive census of all LT-RME scholarship. Future studies should triangulate Google Scholar with Scopus, Web of Science, Dimensions, or Crossref; document the full search string and screening flow; and compare co-word results across databases. Such practices would improve reproducibility and align the study more closely with contemporary bibliometric recommendations (Jajang Rahmatudin et al., 2025; Aria & Cuccurullo, 2017; Guyottot & Le Fur, 2023; Klarin, 2024).

5. Conclusion

This bibliometric study shows that Indonesian research integrating Learning Trajectory and Realistic Mathematics Education expanded markedly after 2021 and developed from a primarily design-oriented focus toward broader attention to mathematical competencies. LT, HLT, RME, and design research constitute the conceptual core of the field, while problem solving, reasoning, communication, representation, and conceptual understanding have become increasingly visible in recent work. The methodological landscape is still dominated by design research, and most studies are situated in elementary and secondary education.

The main scholarly contribution of this study is a combined temporal, thematic, and methodological map that identifies higher education as a comparatively underexplored context. Because the analysis relies on Google Scholar and a 46-article corpus, the findings should be interpreted within those boundaries. Future bibliometric studies should use multiple databases, while empirical research should extend LT-RME designs to university mathematics, particularly abstract courses such as calculus and linear algebra.

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