EDUMATSAINS
JURNAL PENDIDIKAN MATEMATIKA DAN SAINS
E-ISSN: 2527-7235
Volume 11 Issue. 1, July 2026, pp 269-284
http://ejournal.uki.ac.id/index.php/edumatsains

Extended Mathematical Connections among Pre-Service Mathematics Teachers: A Systematic Literature Review

Alim Wicaksono[1], Al Jupri[2*], Tia Purniati [3]

[1,2,3] Pendidikan Matematika FKIP

e-mail: aljupri@upi.edu

Article Info

Article history:
Received: May 12th,2026
Revised: July 25th, 2026
Accepted: July 27th, 2026
Available online: July 31st, 2026

https://doi.org/10.33541/edumatsains.v11i1.8154

Abstract

Mathematical connection is considered one of essential aspect to learn mathematics. Framework that extends this connection has become a trend among scholars in many parts of the world especially. Therefore, this research is to provide a comprehensive literature review about extended mathematical connection among pre-service mathematics teacher. Utilizing PRISMA flow diagram, this research 15 articles from a credible source that published within 2017-2026. Based on the database, there are 154 registers paper founded. The articles were going through identification stage which removed 43 duplicated. The screening process was conducted that exclude 89 papers based on inclusion-exclusion criteria. The included articles were examined the eligibility and accessibility which resulted in 15 papers. Studies were analyzed by years, mathematical topics, mathematical connection challenges, and the learning implication. The finding of the research highlight that extended mathematical connection research has risen in the past three years with qualitative as a dominant methods and various mathematical topics such as algebra, geometry, and arithmetic. There is significant gap between university mathematics and school curriculum resulting in low different representation connection and relied on procedural knowledge. Extended Mathematical connection serves as a tool to enhance conceptual understanding, specific types of connection, and learning experiences.

Keywords: mathematics, mathematical connection, pre-service teacher, PRISMA framework, systematic literature review

1. Introduction

Establishing mathematical connection is consider essential aspect of mathematical learning, as it enables students to understand relationships between different mathematical topic, apply knowledge to solve problems in everyday life context, and recognize mathematics as an interconnected discipline (Gavin, 2024). Mathematical connection is considered important in mathematics education to developed it in the teaching and learning mathematics (Toh & Choy, 2021). Furthermore, making connection is a significant aspect for teacher and student in abstracting and generalizing within mathematical concepts (García-García & Dolores-Flores, 2021). There are two types of mathematical connection: intra-mathematical connections that formed between mathematical facts, concepts, principals, and procedures (Murphy et al., 2024) and extra- mathematical connections that

created within mathematical concepts and non-mathematical contexts (Gamboa et al., 2021).

Development of Extended Theory of Mathematical Connections or (ETMC) by (Rodríguez-Nieto et al., 2022) broad the intra-mathematical connection to several indicators namely feature/property, procedural, if-then, part-whole, different representations, and instruction- oriented. Pre-service teachers are expected to making these types of mathematical connection as a key component of pedagogical content knowledge that can support the teaching quality for establish the connection on students (De Gamboa et al., 2022). When teachers fail to make relation between mathematical concept, students are tending to consider mathematics as an isolated procedure rather than an integrated subject (Mhlolo et al., 2012).

Several studies have highlighted that pre-service teachers often face challenge to making connection in teaching mathematics (Şahal et al., 2024; Wang et al., 2023). Pre-service teacher's ability to make and teach mathematical connections is often limited by their understanding, many teachers focus on procedural knowledge of each topic without determined the relation between them (Banjo et al., 2025; Banjo & Luneta, 2025). Furthermore, pre-service teachers experienced challenge to make various types of intra-mathematical connections, such as implication, feature, meaning, procedural, and different representations (Del Carmen et al., 2024). Although, teachers should be assisting students to developing their competencies such as making relation between conceptual and procedural knowledge, acknowledging different representation, utilizing connection within mathematical topic and other disciplines, and regarding mathematics as an integrated whole (Low & Wong, 2021). The poor intra-mathematical connection often leads to student's low mathematical knowledge (Banjo & Luneta, 2025).

Numerous systematic literature review (SLR) studies have investigated how mathematical connections in general or in a way that affect certain ability (Aulia et al., 2026; Ridwan & Kusnandi, 2025; Silvina et al., 2025). These studies explore various aspects of mathematical connection in many educational research. Based on Aulia et al., (2026) study, mathematical connection in junior high school ability is in the low to moderate category and this ability improve the quality of mathematical problem solving. On other hand, Silvina et al., (2025) showed that the dominant research in Indonesia focus on student's mathematical connection ability associated with problem-solving and contextual learning. While research on extended mathematical connection on pre-service teachers has grown significantly (Hardi et al., 2022; Suanto et al., 2026), there is still a lack of comprehensive systematic literature review that identified gaps and recommendation how to enhanced this ability on pre-service mathematics teacher.

Therefore, a systematic literature review is needed to synthesize and then analyse existing studies related to mathematical connections among pre-service mathematics teachers. By systematically identifying, reviewing, and analysing relevant research, this study aims to provide a comprehensive overview of extended mathematical connections in the context of pre-service teacher education. Therefore, this systematic literature review was directed by these research questions:

RQ1: What are the research aspects of studies on mathematical connections among pre-service mathematics teachers in terms of research's publication year, method, and mathematic topics?
RQ2: What challenges are reported in developing extended mathematical connections by pre- service mathematics teachers?
RQ3: How are extended mathematical connections developed or implemented in the learning experiences of pre-service mathematics teachers?

2. Method

The aim of this research was to provide a comprehensive overview of extended mathematical connections in the context of pre-service teacher education by systematic literature review (SLR) to find, select and preciously analyze relevant studies (Juandi, 2021). Systematic literature review (SLR) was conducted following the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-analyses) guidelines. This framework ensures a clear and systematic steps to the literature review process such as defining research objectives, conducting comprehensive searches, extracting and analyzing research data, and laying out conclusions (Tricco et al., 2018). The PRISMA components involved identification, screening, eligibility, and inclusion (Kholid et al., 2023). The articles were obtained from the databases widely established in educational research such as ERIC and Scopus. For the convenience of this study, the Web of Science and HAL databases were not included due to overlapping research with Scopus and insufficient amount of mathematical connection research. The literature research was conducted in 15 March 2026.
The search included in this SLR published over a recent 10-year period, from 2017 to 2026. The search string was formulated to include as many articles related with research focus as possible. The search string was formulated to include as many articles related to the research focus as possible, as follows: TITLE-ABS-KEY (("extended mathematical connection*" OR "extended mathematics connection*" OR "mathematical connection*" OR "mathematics connection*" OR "mathematical connections" OR "connections in mathematics" OR "mathematical relationship*" OR "mathematical linking") AND ("pre-service teacher*" OR "preservice teacher*" OR "prospective teacher*" OR "pre-service mathematics teacher*" OR "prospective mathematics teacher*" OR "teacher candidate*" OR "student teacher*")) AND PUBYEAR > 2016 AND PUBYEAR < 2027 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (DOCTYPE , "ar"))
Furthermore, the inclusion criteria were determined to added research article that discussing about mathematical connection in teaching and learning geometry or within other disciplines learning that focus on geometry aspect supported by mathematical connection. Research outside educational context or publications not addressing mathematical connection as one of the research focuses were excluded. The inclusion and exclusion criteria presented on Table 1 below.

Table 1 Criteria of Inclusion and Exclusion

Criteria	Inclusion	Exclusion
Article title	An appropriate title that involved "Mathematical connection" and "pre-service teacher".	Did not match with the research topic and had irrelevant tittle
Year of publication	Publications from 2017 to 2026	Publication outside the specific range
Language	English	Other
Field of article study	Mathematics Education or Social Science	Other
Indexed	Indexed Q4 – Q1 in Scopus	Other
Research Subject	Pre-service teacher	Other

In the identification stage, using the predetermined research string, the result obtained total of 154 results from the two databases (Scopus and Eric). After the removal of 43 records of duplicates, a total of 111 titles and abstract were going to screening process for acknowledging the relevance of each study. This screening step was conducted that exclude based on inclusion-exclusion criteria resulted in 26 articles selected for full text-eligibility assessment. Full-text reports could not be retrieved for 4 of the 26 articles. After that, 3 articles from 18 assessed articles were excluded upon through full-text review because they did not meet the requirements because not focus on mathematical connection as an objective of the research and not involve pre-service teachers as a research subject. The automation research on Scopus using research filter such as article document type, open access and English language, mathematics and social science subject area, and full text available on ERIC, guaranteeing ease and consistent studies included in the review. Furthermore, the PRISMA process is presented in Figure 1 below:

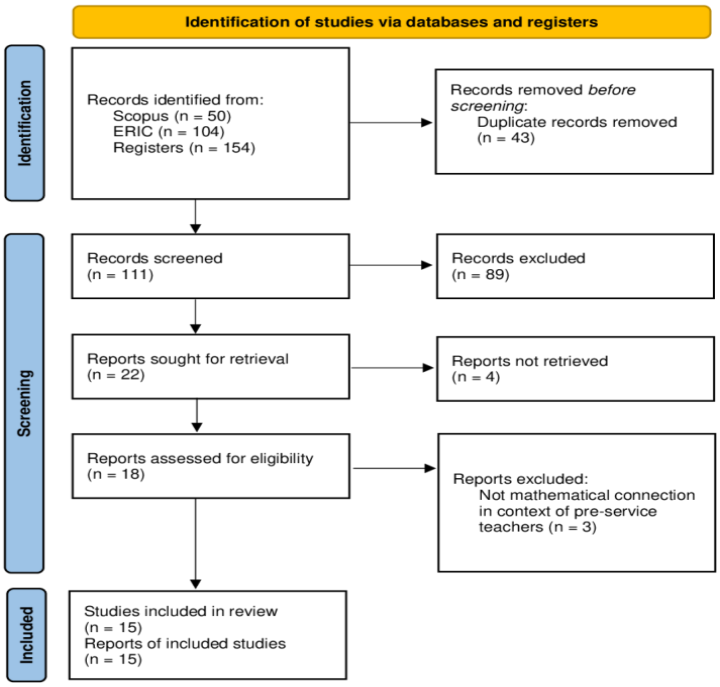

Figure 1 PRISMA flow diagram

As shown in the PRISMA flow diagram in the Figure 1, a final exclusion of 3 reports due to them not being in the context of pre-service teachers, resulted in 15 core studies being included in this review.

3. Result and Discussion

3.1 Annual Publication Trends

An analysis of 15 included articles shows that research on extended mathematical connections on pre-service teacher has increased throughout 2024 – 2025 period. The highest number of publications occurred in 2024 (5 articles) while in 2025 the number declined to 3 articles. The publication shows a trend that has been increasing year by year especially in 2025 due to complete definition of Extended Theory of Mathematical Connection by Rodríguez-Nieto et al. (2022). The publication trends were showed in Figure 2 below.

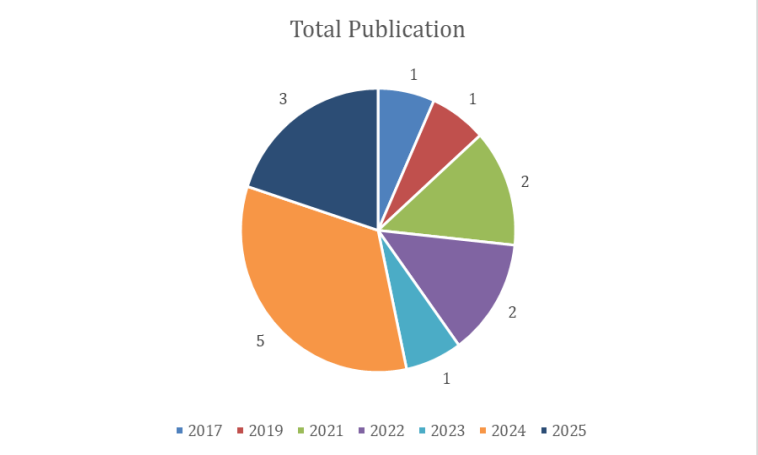

Figure 2 Total Publication Trends

Based on the Figure 2, the trend of mathematical connection studies on pre-service teacher is increased due to diversity in research about mathematical connection. The rise in publications following 2022 directly correlates with the formalization of the ETMC framework by Rodríguez-Nieto et al. (2022). Research about mathematic connection has been narrowed to particular mathematical topic such as linear equations (León del Carmen et al., 2024) and statistic (Quilang & Lazaro, 2022). This in line with problem in Pramasdyahsari (2021) studies that pre-service teachers often struggle to connect mathematical knowledge on university-level with school curricula, thereby addressing mathematical connection to specific materials can hinder their ability to teach better. The mathematical connection studies also expanded on certain aspect that focus on connections to real life and technology (Hardi et al., 202). The connecting abilities assisted by technology help students relate abstract mathematical concepts to real-world scenarios (Sengsamak et al., 2021).

3.2 Dominant Research Methods

Based on the classification of research methods, the distribution of the methodological approaches used in the 15 reviewed articles is illustrated in Figure 3 below.

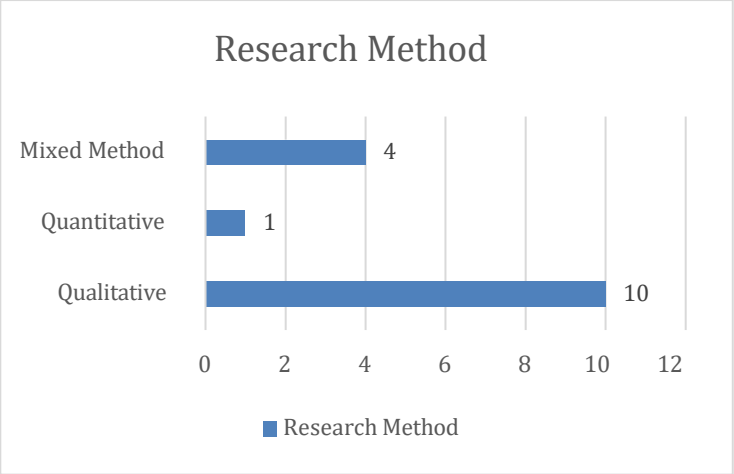

Figure 3 Research Method Trends

Studies on extended mathematical connection among pre-service teacher is dominated by qualitative approaches with 10 articles. Qualitative research methods dominate because ETMC captures internal cognitive processes that require a deeper understanding to uncover how pre-service teachers establish connection schemes. This aligns with Rodríguez-Nieto et al. (2022) research, that integrated ETMC with the Onto-Semiotic Approach to analyze cognitive and semiotic configurations in mathematical reasoning. The amount of qualitative research method about extended mathematical connection also caused by the research types that focuses on ethnography and cases study. Meanwhile, mixed-method approaches only reached 4 studies that focuses on extended mathematical connection. These approaches indicated that mathematical connection may be observed in dual perspective to reveal how students use the various types of connection while providing numerical result (Caviedes et al., 2024). There is only one quantitative approach which attempting to use statistical measurement on extended mathematical connection ability (Bodur et al., 2024).

3.3 Mathematical Topics

Articles analysis showed that the most dominant topic used in these studies is algebra and arithmetic that reached four each. Based on the classification of mathematical topics, the distribution of mathematical connection on particular material illustrated in Figure 4.

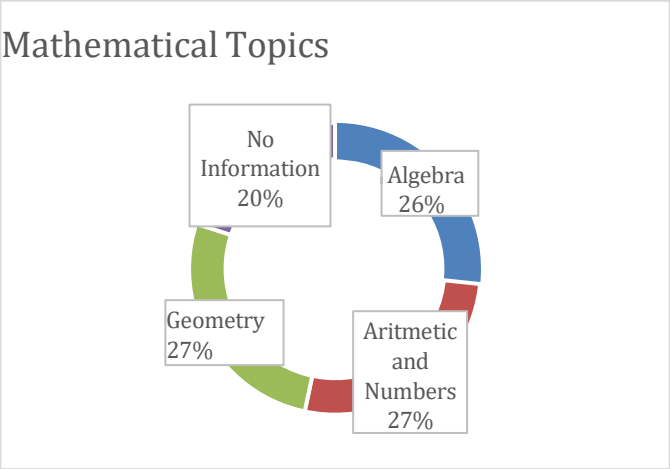

Figure 4 Mathematical Topic Trends

This symmetrical distribution presents a significant academic finding between algebra geometry and arithmetic in line with Rodríguez-Nieto et al. (2023) studies that the ability to establish mathematical connections is universally recognized as a critical cognitive requirement across all major mathematical domains, rather than a topic-specific skill. These three topics dominate ETMC research because each topic represents a specific type of mathematical connection. Arithmetic and numbers are researched to test how pre-service teachers make mathematical connections between mathematical concept and real-world problems (Zeljic et al., 2021). Geometry is studied to test how pre-service teachers make feature/property connections by linking visual shapes to formal properties (Leme da Silva & Jahn, 2024). Meanwhile, algebra is examined to test how different representation and procedural connections is developed by linking symbolic expressions to tables, graphs, or general rules (Bila et al., 2024).

3.4 Mathematical Connections Challenge

Extended mathematical connection is considered one of the important aspects that need to developed in learning experiences (De Gamboa et al., 2022). Although, there are several challenges in order to developed mathematical connection on pre-service teacher. Based on the mathematical connection challenge that presented in each included studies, the analysis literature stated in Table 2 below.

Table 2 Mathematical Connection Challenge

Author	Challenge
Şahal et al. (2024)	1. Limited access of learning media 2. Struggled in applying abstract mathematical concept
Yonwilad et al. (2025)	Traditional and task-centered learning methods
Quilang & Lazaro (2022)	1. Struggle with connecting different representation 2. Lack of reasoning skills for statistical data
Foster & Lee (2021)	Lack of specific studies on "how and when" teachers develop connections
Hardi et al. (2022)	1. Low connection ability due to online learning constraints 2. Technical barriers in digital platforms
Sony (2025)	1. Disconnect between higher-ed and school curriculum 2. Low ability to link advanced math (Calculus/Algebra) to school topics
Kaya & Keşan (2023)	Difficulty linking daily life to mathematical topics
Daniel (2017)	1. Dominance of procedural knowledge. 2. View of math as isolated procedures
Rodríguez-Nieto et al. (2025)	1. Difficulty defining concepts in own words 2. Struggles with linking volume to other measurements 3. Hardship in defining geometric shapes
Weingarden (2024)	Failure to understand how connections manifest in teaching
Del Carmenet al., (2024)	Inability to synthesize multiple solution strategies
Hatisaru et al. (2024)	1. Difficulty modeling daily life into linear equations 2. Over-reliance on procedural steps
Wang et al. (2023)	1. Narrow and procedural connections 2. Lack of advanced reasoning (reversibility connections) 3. Limited strategic competence
Gil et al. (2019)	1. Fragmented knowledge and inconsistent terminology 2. Failure to anticipate forward concepts (algebraic reasoning)
Rodríguez-Nieto & Alsina (2022)	1. Limited access of learning media 2. Struggled in applying abstract mathematical concept

The development of extended mathematical connections among pre-service mathematics teachers (PSMTs) is primarily dependent on procedural knowledge. Research indicates that while PSMTs are often fluent in executing procedural steps, they struggle to understand the conceptual knowledge behind that procedure (Del Carmen et al., 2024; Hatisaru et al., 2024; KAYA & KEŞAN, 2023). The number of studies that reported procedural knowledge challenges confirming Banjo & Luneta (2025) report that teacher is tend to rely on formalized steps rather than constructing conceptual understanding. As stated in García-García & Dolores-Flores (2021) procedural is one of the connection types in mathematical connection that also included explanations why and how to apply them. Novita et al. (2025) argue that procedural knowledge without conceptual understanding led to difficulties in solving

real-world problems. This persistent issue stems from pre-service teachers' own prior learning experiences, which were predominantly shaped by traditional, task-centered, and formulaic instruction (Jao et al., 2021). Difficulties in connecting different representations is affect by their perceptions about the urgency of multiple representastion on absctract mathematical concept, if teachers are not confident or value the conncetion between disctinct representation they may not prioritize them to teach (Ipek & Mainali, 2025).

Furthermore, a significant pedagogical and curricular gap exists between advanced university mathematics and the school curriculum. Several studies reported that PSMTs challenged to bridge abstract mathematical concepts on university level with the topics they are expected to teach (Rodríguez-Nieto & Alsina, 2022; Şahal et al., 2024; Sony, 2025). Teacher is expected to construct concrete learning experiences as an early representation to abstract mathematical concept (Seto et al., 2020). In line with that, teacher enabled to relate the abstract concept with real-world contexts to make it more relatable and understandable for students (Resnick & Stieff, 2024). As stated in Gavin (2024) that mathematical connection is developed for solving real world problems.

These challenges have profound implications for the design of the pre-service mathematics teacher education curriculum. Courses should be structured around pedagogical practices that allow pre-service teachers to experience and reflect on how abstract mathematical concepts connect to classroom instruction (Dışbudak-Kuru & Işıksal-Bostan, 2023). Additionally, teacher education curricula should incorporate instructional models such as Realistic Mathematics Education (RME) and Contextual Teaching and Learning (CTL). These models encourage future teachers to design mathematical tasks across different domains that connect to real-world contexts, ultimately helping them develop deeper mathematical connection abilities and recognize the relevance of advanced mathematics in school settings (Pambudi & Sugiarti, 2022).

3.5 Implementation and Learning Experiences of Mathematical Connections

The mathematical connections are considered as one of the essential aspects in learning mathematics (Banjo & Luneta, 2025). As a result, there are several mathematical connections implication in learning process from the included studies that stated in table 3 below.

Table 3 Mathematical Connection Implementation

Author	Implementation
Şahal et al. (2024)	1. Translates abstract mathematical symbols into concrete ideas 2. Eliminate the confusion between different mathematical representations
Yonwilad et al. (2025)	1. Assist PSMT to acknowledge mathematics as an integrated discipline 2. Encourages collaborative activities during team-based task
Quilang & Lazaro (2022)	1. Assist PSMT to determine the meaning of raw data in statistic 2. Improve the ability to choose the correct procedure
Foster & Lee (2021)	Develop motivation on PSMT due to becoming adept at relating mathematical concept
Hardi et al. (2022)	Allow PSMT to teach mathematics in various learning styles
Sony (2025)	1. Connecting high-level university mathematics to school topics 2. Develop motivation on PSMT
Kaya & Keşan (2023)	1. Connecting mathematics to the real-life problems 2. Enhances the ability to create original mathematic problems
Daniel (2017)	1. Connecting high-level university mathematics to school topics 2. Eliminate the confusion between different mathematical representations
Rodríguez-Nieto et al. (2025)	1. Facilitate the relation between formal geometry to ethnomathematics 2. Develop motivation on PSMT
Weingarden (2024)	1. Assist teacher to mastering specific mathematical topic 2. Develop motivation on PSMT
Del Carmen et al., (2024)	1. Improve ability to relating mathematical concept with real-world context 2. Reduce reliance on procedural knowledge
Hatisaru et al. (2024)	1. Developing reasoning among pre-service mathematics teacher 2. Eliminate the confusion between different mathematical representations
Wang et al. (2023)	Preventing fragmented mathematics learning
Gil et al. (2019)	Improve the ability to choose the correct procedure for probability problems
Rodríguez-Nieto & Alsina (2022)	1. Connects mathematic to Science, Technology, Engineering 2. Connecting mathematics to the real-life problems

The implementation of mathematical connections in pre-service mathematics teacher (PSMT) education serves as a tool to enhance conceptual understanding and reduce procedural knowledge reliance. Based on the analysis, a mathematical connection capable of bridging between abstract concept to concrete ideas in such a way that eliminating the confusion between different mathematical representations (Hatisaru et al., 2024; Şahal et al., 2024). The connection between different representation may also be developed through task that required teacher to presenting multiple depiction (Johnson, 2022). In addition, the different representation type of connection allowed pre-service teaching to inferring the raw data in statistic (Quilang & Lazaro, 2022). Therefore, teachers should emphasize the relationships between different representations through course, question, and task that point out mathematical connection (Pérez & Piquet, 2022).

Furthermore, the results demonstrate that extended mathematical connection assisted with technology and culture are central to enhancing learning experiences (Rodríguez-Nieto et al., 2025; Rodríguez-Nieto & Alsina, 2022). Technology has the potential to enhances mathematical learning to provide visualization and exploration of mathematical concept thus enable teacher to experiment with that concept (David & Weinstein, 2024). Alternatively, embedding cultural context into mathematics education through ethnomathematics acts as a link to connect abstract concepts to live experiences and everyday practices (Nur et al., 2022). By connecting formal concept to cultural practices, such as brick-making (Rodríguez-Nieto et al., 2025), or real-life story problems (Kaya & Keşan, 2023), pre-service mathematics teacher could visualize mathematics effectively.

Finally, the development of mathematical connections plays a crucial role in establishing motivation (Sony, 2025; Weingarden, 2024). Teachers who engage in developing mathematical connection may have an impact on improving motivation specifically when teachers observe students understanding and applying mathematical concept in various context (Jingga, 2019). Based on the analysis, mathematical connection may assisted teachers to adept at relating mathematical concept which leads to developing motivation (Foster & Lee, 2021). This suggests that mathematical connections create a positive feedback loop; as teachers become more proficient in bridging conceptual gaps, student comprehension increases, which in turn further reinforces the teacher's instructional motivation.

4. Conclusion

Conclusion

In conclusion, this systematic review demonstrates that while pre-service mathematics teachers often face challenges such as procedural dependency and difficulties in linking abstract theory to school-level topics, the development of mathematical connections serves as a vital bridge to conceptual mastery. By implementing contextualized strategies, including ethnomathematics and investigative tasks, teacher education programs can shift the focus from rote memorization toward a more integrated understanding of the discipline. This transition not only eliminates representational confusion and enhances logical reasoning but also significantly boosts professional motivation and pedagogical self-efficacy. Ultimately, prioritizing mathematical connections is essential to ensure that future educators are equipped to present mathematics as a coherent, meaningful, and culturally relevant system of thought rather than a collection of fragmented procedures.

References

Aulia, S., Jamil, A. F., & Khusna, A. H. (2026). Systematic Literature Review: Mathematical Connections in Solving Contextual Mathematics Problems. Journal of Teaching and Learning Mathematics, 3(2), 34–41. https://doi.org/10.22219/jtlm.v3i2.43722 Banjo, B. O., & Luneta, K. (2025). Mathematical Connections in Mathematics Instruction at Senior Phase Classrooms in

South Africa. African Journal of Research in Mathematics, Science and Technology Education, 29(3), 346–360. https://doi.org/10.1080/18117295.2025.2536437 Banjo, B. O., Luneta, K., & Rodríguez-Nieto, C. A. (2025). Exploring teachers' perceptions of mathematical connections in the mathematics curriculum and teaching. Eurasia Journal of Mathematics, Science and Technology Education, 21(9). https://doi.org/10.29333/ejmste/16883 Bila, H., Maphutha, K., & Mutodi, P. (2024). Learners' algebraic and geometric connections when solving Euclidean geometry riders. Pythagoras, 45(1). https://doi.org/10.4102/PYTHAGORAS.V45I1.810 Bodur, A. T., Ürek, H., & Kobak Demir, M. (2024). Investigation of the Mathematical Connection Self Efficacies of Pre-Service Teachers: A Quantitative Study From Turkey. Pedagogika, 154(2), 57–79. https://doi.org/10.15823/p.2024.154.4 Caviedes, S., De Gamboa, G., & Badillo, E. (2024). Mathematical connections involved in area measurement processes. Research in Mathematics Education, 26(2), 237–257. https://doi.org/10.1080/14794802.2024.2370333 Daniel, L. (2017). The Interplay between Pre-Service Teachers' Intentions and Enacted Mathematical Content Knowledge in the Classroom. Mathematics Education Research Group of Australasia. David, L., & Weinstein, N. (2024). Using technology to make learning fun: technology use is best made fun and challenging to optimize intrinsic motivation and engagement. European Journal of Psychology of Education, 39(2), 1441–1463. https://doi.org/10.1007/s10212-023-00734-0 De Gamboa, G., Caviedes, S., & Badillo, E. (2022). Mathematical Connections and the Mathematics Teacher's Specialised Knowledge. Mathematics, 10(21), 4010. https://doi.org/10.3390/math10214010 Del Carmen, A. L., Del Carmen, W. L., García-García, J., & Salgado-Beltrán, G. (2024). Mathematical connections made by preservice mathematics teachers when solving tasks about systems of linear equations. International Electronic Journal of Mathematics Education, 19(4). https://doi.org/10.29333/iejme/15590 Foster, J. K., & Lee, H. Y. (2021). Prospective Teachers' Pedagogical Considerations of Mathematical Connections: A Framework to Motivate Attention to and Awareness of Connections. Mathematics Teacher Education and Development, 23(4), 95–118. Gamboa, G. de, Badillo, E., Couso, D., & Márquez, C. (2021). Connecting Mathematics and Science in Primary School STEM Education: Modeling the Population Growth of Species. Mathematics, 9(19), 2496. https://doi.org/10.3390/math9192496 García-García, J., & Dolores-Flores, C. (2021). Pre-university students' mathematical connections when sketching the graph of derivative and antiderivative functions. Mathematics Education Research Journal, 33(1), 1–22. https://doi.org/10.1007/s13394-019-00286-x Gavin, M. K. (2024). Curriculum Considerations for Developing Mathematical Talent in Elementary Students. Education Sciences, 14(7), 796. https://doi.org/10.3390/educsci14070796 Gil, I., Zamudio-Orozco, L., & King, B. (2019). After presenting multiple solution strategies, what's next? Examining the mathematical connections made by preservice teachers. Journal of Mathematics Education at Teachers College, 10(2), 9–20. This is an open access article under the HYPERLINK "https://creativecommons.org/licenses/by-sa/4.0/" CC BY-SA license. Copyright ©2022 by Author. Published by Universitas Kristen Indonesia 11 Edumatsains, Volume xx, Issue. xx, Month 2023, pp xx-xx Hardi, H., Wahyudi, W., Suyitno, H., Kartono, K., & Sukestiyarno, Y. (2022). The mathematic connection ability of pre-service teacher during online learning according to their learning style. Journal of Technology and Science Education, 12(1), 230.

https://doi.org/10.3926/jotse.1198 Hatisaru, V., Stacey, K., & Star, J. R. (2024). Mathematical connections in preservice secondary mathematics teachers' solution strategies to algebra problems. Jingga, A. A. (2019). Mathematical connections made by teacher in Linear program: An Ethnographical study. Journal of Educational and Social Research, 9. Johnson, H. L. (2022). Task design for graphs: Rethink multiple representations with variation theory. Mathematical Thinking and Learning, 24(2), 91–98. Juandi, D. (2021). Heterogeneity of problem-based learning outcomes for improving mathematical competence: A systematic literature review. Journal of Physics: Conference Series, 1722(1), 012108. KAYA, D., & KEŞAN, C. (2023). THE CONNECTION OF MATHEMATICS WITH REAL-LIFE SITUATIONS: PRESERVICE ELEMENTARY MATHEMATICS TEACHERS' PERCEPTIONS OF CREATING AND EVALUATING STORY PROBLEMS. International Online Journal of Primary Education, 12(2), 118–135. https://doi.org/10.55020/iojpe.1135191 Kholid, M. N., Hendriyanto, A., Sahara, S., Muhaimin, L. H., Juandi, D., Sujadi, I., Kuncoro, K. S., & Adnan, M. (2023). A systematic literature review of Technological, Pedagogical and Content Knowledge (TPACK) in mathematics education: Future challenges for educational practice and research. Cogent Education, 10(2). https://doi.org/10.1080/2331186X.2023.2269047 Leme da Silva, M. C., & Jahn, A. P. (2024). Geometric Transformations in Geometry Teaching: different appropriations in modern mathematics. Bolema: Boletim de Educação Matemática, 38. https://doi.org/10.1590/1980-4415v38a2302891 León del Carmen, A., León del Carmen, W., García-García, J., & Salgado-Beltrán, G. (2024). Mathematical connections made by preservice mathematics teachers when solving tasks about systems of linear equations. International Electronic Journal of Mathematics Education, 19(4), em0799. https://doi.org/10.29333/iejme/15590 LOW, L., & WONG, L. F. (2021). Using Connecting Mathematical Tasks for Coherence, Connections and Continuity. In Mathematics — Connection and Beyond (pp. 95–120). WORLD SCIENTIFIC. https://doi.org/10.1142/9789811236983_0006 Mhlolo, M. K., Venkat, H., & Schfer, M. (2012). The nature and quality of the mathematical connections teachers make. Pythagoras, 33(1). https://doi.org/10.4102/pythagoras.v33i1.22 Murphy, C., Hatisaru, V., & Chick, H. (2024). Editorial for a special issue on mathematical connections in the teaching and learning of mathematics. Research in Mathematics Education, 26(2), 231–236. https://doi.org/10.1080/14794802.2024.2372378 Novita, R., Putra, M., & Junita, S. (2025). Conceptual and procedural knowledge in students' fraction division thinking: Insights from a hermeneutic phenomenological study. Journal on Mathematics Education, 16(4), 1233–1256. https://doi.org/10.22342/jme.v16i4.pp1233-1256 Nur, A. S., Kartono, Zaenuri, & Rochmad. (2022). Teacher's perception of culture-based mathematics learning. AIP Conference Proceedings, 2633(1), 030007. Pérez, A. de la F., & Piquet, J. D. (2022). Uso de las conexiones entre representaciones por parte del profesor en la construcción del lenguaje algebraico. Bolema: Boletim de Educação Matemática, 36(72), 389 410. https://doi.org/10.1590/1980-4415v36n72a17 This is an open access article under the HYPERLINK "https://creativecommons.org/licenses/by-sa/4.0/" CC BY-SA license. Copyright ©2022 by Author. Published by Universitas Kristen Indonesia 12 Edumatsains, Volume xx, Issue. xx, Month 2023, pp xx-xx Pramasdyahsari, A. S. (2021). Developing the scripting task for

mathematical connection between the university and school mathematics content. Journal of Physics: Conference Series, 1957(1), 012003. https://doi.org/10.1088/1742-6596/1957/1/012003 Quilang, L. J. L., & Lazaro, L. L. (2022). Mathematical connections made during investigative tasks in statistics and probability. International Journal of Evaluation and Research in Education, 11(1), 239 249. https://doi.org/10.11591/ijere.v11i1.21730 Resnick, I., & Stieff, M. (2024). The role of theory in research and practice: Characterizing cognition and context within mathematics education. In Fourth International Handbook of Mathematics Education (pp. 271–292). Springer. Ridwan, M. A., & Kusnandi, K. (2025). A SYSTEMATIC LITERATURE REVIEW: MATHEMATICAL CONNECTION ABILITY REVIEWED FROM SELF-EFFICACY. Research and Development Journal of Education, 11(2), 844. https://doi.org/10.30998/rdje.v11i2.21762 Rodríguez-Nieto, C. A., & Alsina, Á. (2022). Networking Between Ethnomathematics, STEAM Education, and the Globalized Approach to Analyze Mathematical Connections in Daily Practices. Eurasia Journal of Mathematics, Science and Technology Education, 18(3). Rodríguez-Nieto, C. A., Cervantes-Barraza, J. A., & Font Moll, V. (2023). Exploring mathematical connections in the context of proof and mathematical argumentation: A new proposal of networking of theories. Eurasia Journal of Mathematics, Science and Technology Education, 19(5), em2264. https://doi.org/10.29333/ejmste/13157 Rodríguez-Nieto, C. A., Font Moll, V., Borji, V., & Rodríguez-Vásquez, F. M. (2022). Mathematical connections from a networking of theories between extended theory of mathematical connections and onto-semiotic approach. International Journal of Mathematical Education in Science and Technology, 53(9), 2364–2390. https://doi.org/10.1080/0020739X.2021.1875071 Rodríguez-Nieto, C. A., Pabón-Navarro, M. L., Cantillo-Rudas, B. M., & Moll, V. F. (2025). The potential of ethnomathematical and mathematical connections in the pre-service mathematics teachers' meaningful learning when problems-solving about brick-making. Infinity Journal, 14(2), 419–444. https://doi.org/10.22460/infinity.v14i2.p419-444 ŞAHAL, M., DOĞAN, M., & ÖZDEMİR, A. Ş. (2024). Examination of Types of Mathematical Connections that Pre-service Mathematics Teachers Use in Teaching Processes. International Journal of Modern Education Studies, 8(2). https://doi.org/10.51383/ijonmes.2024.354 Sengsamak, S., Chonchaiya, R., & Toopsuwan, C. (2021). A Study on Flipped Classroom based on Donald and Maki's Approach for Developing Mathematical Connection In Exponential and Logarithmic Functions to Real-Life Situations for Grade 10 Students. International Conference "The Future of Education." Seto, C., Goh, Y. Y., Teh, W., & Chang, S. H. (2020). Concrete-pictorial-abstract approach: Fostering understanding in mathematics. In Mathematics Teaching In Singapore - Volume 1: Theory-informed Practices (pp. 35–51). https://doi.org/10.1142/9789811220159_0003 Silvina, M., Rohati, R., & Kumalasari, A. (2025). Mathematical Connection Research in Indonesia: A Bibliometric Study (2020–2025). Journal of General Education and Humanities, 5(1), 49–60. https://doi.org/10.58421/gehu.v5i1.740 Sony, S. D. (2025). Preservice Teachers' Perspectives on Connections within Mathematical Concepts: A Qualitative Study. Mathematics Teacher Education and Development, 27(2), 2. Suanto, E., Yuanita, P., Zulnaidi, H., Siregar, N. C., & Mafarja, N. (2026). Enhancing Pre-Service Teachers' Mathematical Reasoning and Connections through Experiential Learning-Based Modules: This is an open access article under the

HYPERLINK "https://creativecommons.org/licenses/by-sa/4.0/" CC BY-SA license. Copyright ©2022 by Author. Published by Universitas Kristen Indonesia 13 Edumatsains, Volume xx, Issue. xx, Month 2023, pp xx-xx A Quasi-Experimental Study. Journal of Educational and Social Research, 16(1), 307–320. https://doi.org/10.36941/jesr-2026-0253 Toh, T. L., & Choy, B. H. (2021). Mathematics — Connection and Beyond. WORLD SCIENTIFIC. https://doi.org/10.1142/12279 Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., … Straus, S. E. (2018). PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Annals of Internal Medicine, 169(7), 467–473. https://doi.org/10.7326/M18-0850 Wang, Y., Wang, J., Raymond, F., & Wang, J. (2023). Elementary pre-service teachers' horizon knowledge for teaching addition and subtraction: An analysis of video presentations. Eurasia Journal of Mathematics, Science and Technology Education, 19(6). https://doi.org/10.29333/ejmste/13202 Weingarden, M. (2024). The role of mathematical connections in object-level and meta-level learning: a potential lens for supporting pre-service teacher learning. Research in Mathematics Education, 26(2), 258–282. https://doi.org/10.1080/14794802.2024.2371542 Yonwilad, W., Nongharnpituk, P., Khansila, P., & Pongwiritthon, K. (2025). Enhancing Teamwork Skills and Mathematical Conceptual Connections through Board Game Development in a Cooperative Learning Environment. Educational Process: International Journal, 17. https://doi.org/10.22521/edupij.2025.17.361 Zeljic, M., Boricic, M. D., & Maricic, S. (2021). Problem Solving in Realistic, Arithmetic/algebraic and Geometric Context. Egitim ve Bilim, 46(208), 413–430. https://doi.org/10.15390/EB.2021.8887