A Decade of Project-Based Learning in Mathematics Education: A Systematic Literature Network Analysis

Audra Pramitha Muslim[1], Darhim[2*], Tatang Herman[3], Al Jupri[4]

Department of Mathematic Education, Universitas Pendidikan Indonesia
Jalan Dr. Setiabudi, Bandung, West Java, Indonesia
[1]*audrapramitha@upi.edu*; [2*]*darhim@upi.edu*; [3]*tatangherman@upi.edu*;
[4]*aljupri@upi.edu*

Abstrak

Pembelajaran Berbasis Proyek (PjBL) telah menjadi salah satu pendekatan pembelajaran paling populer dalam pendidikan matematika selama satu dekade terakhir. Penelitian ini bertujuan menganalisis tren penelitian PjBL dalam pendidikan matematika tingkat sekolah menengah melalui pendekatan Systematic Literature Network Analysis (SLNA). Artikel dikumpulkan dari database Scopus dan diseleksi berdasarkan kriteria inklusi yang ketat sehingga menghasilkan 15 artikel relevan. Analisis menunjukkan adanya peningkatan signifikan pada tren penelitian PjBL dengan penerapan yang beragam dan efektif, terutama dalam mendukung keterampilan abad 21 seperti berpikir kritis, kolaborasi, dan pemanfaatan teknologi. Namun, terdapat kesenjangan dalam integrasi teknologi yang optimal serta konteks yang lebih inklusif dalam aplikasi PjBL. Penelitian ini memberikan kontribusi penting dengan memetakan tren dan mengidentifikasi peluang penelitian di masa depan untuk meningkatkan efektivitas PjBL dalam pendidikan matematika.
Kata Kunci: Pembelajaran Berbasis Proyek; Pendidikan Matematika; Siswa Sekolah Menengah.

Abstract

Project-Based Learning (PjBL) has become one of the most popular learning approaches in mathematics education over the past decade. This tudy aims to analyse the research trend of PjBL in mathematics education at secondary school level through Systematic Literature Network Analysis (SLNA) approach. Articles were collected from Scopus database and selected based on strict inclusion criteria resulting in 15 relevant articles. The analysis showed a significant increase in the trend of PjBL research with diverse and effective applicaions, especially in supporting 21st century skills such as critical thinking, collaboration and technology utilization. However, there are gaps in optimal technology integration as well as more inclusive contexts in PjBL applications. This research makes an important contribution by mapping trends and identifying future research opportunities to enhance the effectiveness of PjBL in mathematics education.
Keywords: Project-Based Learning; Mathematics Education; Secondary School Students.

I. INTRODUCTION

Mathematics education is key in building students' logical and analytical thinking skills. In the last ten years Project-Based Learning (PjBL) has grown rapidly as an approach that encourages active and contextualized learning. This model allows students to connect theory with practical application through authentics projects. Previous research shows that PjBL is effective in enhancing 21st century skills such as critical thinking, collaboration and technological literacy (Bowen & Peterson, 2018; Holmes & Hwang, 2016; Effendi, Ummah, & Cahyono, 2023).

However, despite its many advantages, the implementation of PjBL in mathematics education faces significant challenges. One of the these is the lack of research that provides a holistic picture of trends and development in PjBL in mathematics education (Kartikasari, Rahman, & Ahyan, 2023). Many studies focus on learning outcomes in specific contexts, without looking at broades patterns or exploring the need for technological adaptations in project-based teaching. Therefore, this study aims to systematically map the development of PjBL, identify key trends, and reveal opportunities for further research.

According to Muchlis et al. (2023), PjBL not only develops critical thinking ability, but also facilitates collaborative learning, communication, and the development of project management skills in student, which are indispensable in learning mathematics (Bowen & Peterson, 2018; Carmichael et al., 2010). In addition, PjBL allows students to be actively involved in projects that are relevant to real life, so they can develop better collaborative and analytical skills (Mahasneh & Alwan, 2018 Craig & Marshall, 2019; Nurhikmayati & Suhendar, 2020)

Empirical research shows that PjBL can improve student engagement and learning outcomes, especially when accompanied by authentic tasks, where students can see the relevance of mathematical concepts in a real-world context (Holmes & Hwang, 2016). For example, in an engineering context, concepts such as gradient and y-intercept can be understood more deeply when students apply them to solve engineering problems (Holmes & Hwang, 2016). PjBL is also considered an effective learning strategy in improving statistical literacy and deeper mathematical skills (Carmichael et al., 2010).

Through the PjBL approach used in mathematics learning, it is expected to provide a comprehensive understanding of how PjBL is integrated in mathematics education and its contribution to the development of 21st century skills, such as critical thinking, collaboration, and statistical literacy (Carmichael et al., 2010; Holmes & Hwang, 2016; Hasna, Sagita, & Utami, 2024). A study mentioned that cooperative learning models such as PjBL can also increase students' learning and motivation (Muslim, 2020; Muslim, 2016; Ismail et al., 2024). In addition, the research cited from (Bowen & Peterson, 2018; Holmes & Hwang, 2016) is also expected to significantly contribute to the development of more innovative and effective teaching strategies in the future.

However, despite the large body of research supporting the effectiveness of PjBL, most of these studies focus on

learning outcomes in specific areas without looking at the overall development of the literature, particularly in the context of mathematics education. Systematic analyses of the development and application of PjBL in mathematics education over the past ten years are relatively limited (Bowen & Peterson, 2018). Therefore, this study aims to provide a more comperehensive picture of the trends and directions of PjBL research in mathematics education globally over a decade (2014-2024) through *Systematic Literature Network Analysis* (SLNA). This approach allows for the identification of emerging patterns and trends in PjBL research and exposes areas that require further explotion (Bowen & Peterson, 2018; Holmes & Hwang, 2016). As such, this study differs from previous studies in that it seeks to provide a more complete mapping of the network of literature in the field of mathematics education.

The research questions addressed in this study are i) What is the trend of using PjBL in mathematics learning? ii) What is the state of the art of PjBL research? and iii) (3) What are the most important research areas in terms of PjBL considering its evolution over time?

II. METHOD

This research uses the Systematic Literature Network Analysis (SLNA) approach, which combines Systematic Literature Review (SLR) with bibliographic network analysis into two stages. This SLNA method is adapted to the approach proposed by (*Abstract Purpose – The Purpose of This Paper Is to Identify and Discuss the Most Important Research Areas on Information Sharing in Supply Chains and Related Risks , Taking into Account Their Evolution over Time . This Paper Sheds Light on What Is Happeni*, n.d.)(Cliccchia et al. 2019). The following figure shows the research procedure.
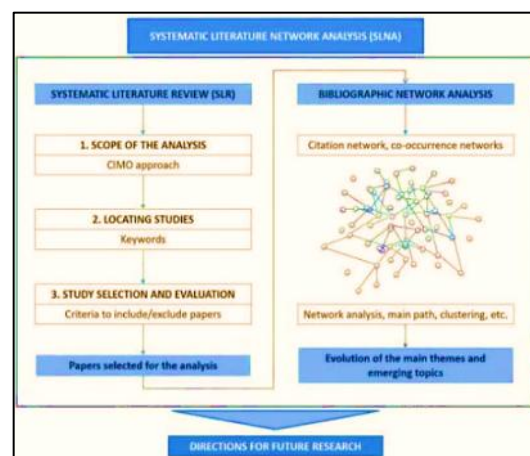

Figure 1. SLNA Methodology.

The first step of the SLNA is the conduct of the SLR. SLR is a structured method that aims to review existing studies, select and evaluate their contributions, also analyse and synthesise relevant data (Denyer & Tranfield, 2009). The SLR process consists of several steps, including: 1) Defining the scope of analysis using the CIMO (*Context, Intervention, Mechanism, and Outcome*) approach, which served to formulate the research questions and narrow the scope of the literature review; 2) identifying studies through searches using specific keyword, as well as collecting articles from database such as scopus; 3) selection and evaluation of studies by applying inclusion or exclusion criteria to the articles, including document type, language, and relevant topics. This stage produces a collection of articles that will be analysed in the next stage.

The second stage in SLNA is bibliometric analysis. At this stage, the article data is compiled in tabular form using Excel and saved in CSV format so that it can be processed using VosViewer software. This bibliometric analysis includes Citation Network and Co-ocurrence Network. Citation network utilizes the reference list of articles to show the relationship between previous research that influenced the development of a particular study. This analysis shows the citation network between researchers, while keyword analysis (co-occurrence network) is used to cluster research themes. The results of this clustering of themes show the most frequently researched or most influential topics over a period of time. From this stage, the evolution of main themes and new topics will emerge. At the end of this stage, an overview of future research directions is expected.

Article data analysed in this study were obtained from the Scopus database, which is managed by Elsevier. The serach was conducted using keywords such as "project-based learning", "mathematics education", and "secondary school students". The articles searched were from the last ten years, 2014-2024.

III. RESULT AND DISCUSSION

A. Result

1. Stage One: SLR Overview

a. Scope of the Analysis

This step is important to avoid misunderstandings in the review through clear definitions and formulation of review questions (Ali et al, 2017). To determine the scope of the SLR, the CIMO approach was used, with the following details: 1)

Context; the context of the research analysed is research in the field of mathematics education, especially on the PjBL model. 2) Intervention; the intervention analysed in the article is the Project-based learning model, especially in the field of mathematics learning in secondary schools. 3) Mechanism; according to the intervention provided, this mechanism is closely related to the learning model that is closely related in this article. 4) Outcome; the selected

b. Locating Studies

In this step, data was collected from the scopus database. The collection was done by selecting titles related to "Project-based learning". The fosuc of the search was on mathematics education or learning, and the keyword "Secondary School Students" was added. The article search was limited to the last ten years, 2014-2024.

c. Study Selection and Evaluation

In this step, a total of 1545 articles were found from the search results which were then selected by manually deleting duplicate articles and not in accordance with the type of articles in journals and proceedings and ignoring documents in the form of books and magazines, leaving 1503 articles. The final selection stage was to select articles relevant to mathematics learning at secondary school level that could be accessed, resulting in 15 articles. A number of inclusion criteria were identified to transpose the process and to evaluate the relevance of the papers to be selected as shown in Table 1.

Table 1.
Inclusion Criteria for Selection and Evaluation

Inclusion Criteria	Description
Published in a	Peer-reviewed journals are

Inclusion Criteria	Description
peer reviewed journal	considered to be of higher quality than non-peer-reviewed articles
The selection of articles is in the last ten years (2014-2024)	The time span of the last decade can capture the latest trends, relevance and developments in the implementation of PjBL by considering technological advances, innovations in learning methods and significant changes in education policies
Selection of articles with search limitations, namely "title-abstract-keywords"	The selected articles are more accurate and efficient in supporting the research objectives
Published in English	English is the dominant language in the research field

The number of articles in each year from the last decade that met the inclusion criteria above can be seen in Figure 2.
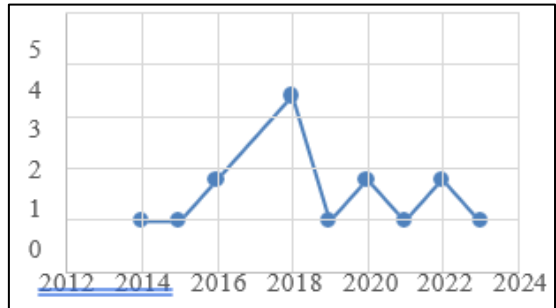

Figure 2. Number of Documents Relevant to the PjBL Topic.

Figure 2 shows the publication trend more clearly. The data shows that publications were relatively stable with a slight increase each year from 2014 – 2017. A spike was seen in 2018 driven by global education policies that support innovative learning approaches. In 2019 there was a temporary decline related to the initial impact of the Covid-19 pandemic, and the trend increased again with the adaptation of distance learning and the use of technology in PjBL. Journal metrics from the article can also be seen in the table 2.

Table 2.
Journal Metric of Eligible Articles

No	Journal	f	%	Indeks by H- Indeks/ SJR 2023	WoS H indeks/JIF for SSCI or JCI for ESCI
1	Statistics Education Research Journal	1	7.143	Q2 / SJR: 0.49	WoS : ESCI
2	International Journal of Science and Mathematics Education	1	7.143	Q1 / SJR: 1.04	WoS : SSCI
3	ERIC-Education Resources Information Center	2	14.286	-	WoS : ESCI
4	The Journal of Educational Research	1	7.143	-	WoS : ESCI
5	Journal of Pre-College Engineering Education Research (J-PEER)	1	7.143	-	WoS : ESCI
6	Education Sciences MDPI	1	7.143	Q2 / SJR : 0.67	WoS : ESCI
7	International Society of the Learning Sciences	1	7.143	-	WoS : ESCI
8	Journal of Research in Science Teaching	1	7.143	Q1 / SJR: 1.91	WoS : SSCI
9	LUMAT: International Journal on Math, Science and Technology Education	1	7.143	-	WoS : ESCI
10	International Journal of Educational Methodology	1	7.143	Q3 / SJR: 0.27	WoS : ESCI
11	ERIC-Education Resources Information Center	1	7.143	-	WoS : ESCI
12	European J	1	7.143	Q2 / SJR: 0.39	WoS : SSCI
13	Research Gate	1	7.143	Q2 / SJR: 0.63	WoS : ESCI
14	Sage Journals	1	7.143	-	WoS : SSCI

2. Second Stage: Bibliometric Analysis

a. Citation Network Analysis

Citation Network Analysis (CAN) is a method based on citations and as a consequence, this method can only be applied to connected components as seen in Figure 3.

Figure 3. Relationship between Titles in PjBL Studies.

This figure visualises the citation relationships between the articles analysed. The analysis shows that the articles with the highest citations are from 2015 and 2016, which form the basis for the most recent studies. The article by Han et al (2015) is at the centre of this network, reflecting its wide influence in the development of PjBL. The overlay network is shown in Figure 4.
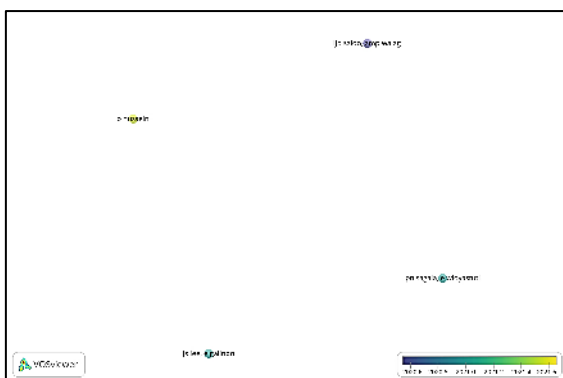

Figure 4. Overlay Network Co-occurance Author.

The overlay network illustrates the evolution of PjBL research themes. Authors with recent research (2021 – 2024) have focused more on the integration of digital technologies, such as the use of online learning platforms and computer-based simulations to support PjBL. This research also notes the increasing attention to the application of PjBL in distance learning environments. This can be seen from the bibliometric analysis conducted on the citation score analysis as presented in Table 3.

Table 3.
Analysis of Citations of PjBL Articles in the Field of Mathematics Education

No	Author	Article Title	Source	Year	Citacy
1	Conti K.C.; de Carvalho D.L.	Statistical literacy: Developing a youth and adult education statistical project	Statistics Education Research Journal	2014	1
2	Han S.; Capraro R.; Capraro M.M.	How Science, Technology, Engineering, And Mathematics (STEM) Project-Based Learning (PBL) Affects High, Middle, And Low Achievers Differently: The Impact Of Students Factors On Achievement	International Journal Science	2015	292
3	Holmes	Exploring the effects of project-based learning in secondary mathematics education	ERIC-Education Resources Information Center	2016	78
4	Capraro R.M.; Capraro M.M.; Scheurich J.J.; Jones Morgan Huggins, K.S.; Corlu M.S.; Younes R.; Han S.	Impact of sustained professional development in STEM on outcome measures in a diverse urban district	The Journal of Educational Research	2016	33

No	Author	Article Title	Source	Year	Citacy
5	Siswono T.Y.E.; Hartono S.; Kohar A.W.	Effectiveness of project- based learning in statistics for lower secondary schools	ERIC- Education Resources Information Center	2018	16
6	Bowen B.; Peterson B.	Exploring authenticity through an engineering-based context in a project-based learning mathematics activity	Journal of Pre- College Engineering Education Research PEER)	2018	8
7	Viro Joutsenlahti J.	The starT project competition from the perspective of mathematics and academic literacy	Education Sciences MDPI	2018	4
8	Banks T.; Searcy J.; Wallace, S; Peppler, K.; Sedas M.	Design math: Middle-school youth making math by building yurts	International Society of the Learning Sciences	2018	2
9	Craig, T.T.; Marshall J.	Effect of project-based learning on high school students' state-mandated, standardized math and science exam performance	Journal Research in Science Teaching	2019	27
10	Viro Joutsenlahti J.	Learning mathematics by project work in secondary school	LUMAT: International Journal on Math, Science and Technology Education	2020	3
11	Collazo	The Impact of Project Creation on Learning Mathematics in a Transdisciplinary Setting	International Journal Educational Method	2020	1
12	Mailizar;	Examining students' intention to use augmented reality in a project-based geometry learning environment	ERIC- Education Resources Information Center	2021	18
13	Sari R.M.M.; Priatna	Implementing Project-Based Blended Learning Model Using Cognitive Conflict Strategy to Enhance Students' Mathematical Spatial Literacy	European Journal of Educational Research	2022	2
14	Vidic D.	Trends in sing Student- Centred Approaches in Mathematics and its Connection with Science, Technology, and Engineering	Research Gate	2022	0
15	Kemp S.	A design course for every student	Sage Journals	2023	0

Table 3 shows that there are 15 articles that examine PjBL in the mathematics learning process in secondary schools in several countries. Based on table 3, it can be seen that the article by Han et al. (2015) on how science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: the impact of student factors on achievement has the most citations. Then, followed by the article by Holmes & Hwang (2016), on exploring the effects of project-based learning in secondary mathematics education, and the article by Capraro et al. (2016), on impact of sustained professional development in STEM on outcome measures in a diverse urban district. So, it can be said that the three studies provide the greatest contribution to further research on PjBL in the mathematics learning process in secondary schools. According to (Dawson & Joksimovic, 2014), citations can be used to assess the relevance of a publication,

although frequently cited articles do not necessarily represent all research. Zhao & Strotman (2015) stated that citations can be considered to reflect the extent to which the cited article influences new research.

b. Co-occurrence network

Network analysis uses the total number of words to identify influential words in the title, and each word is only counted once, regardless of how often the word appears in the same article (Xia, et al., 2021).
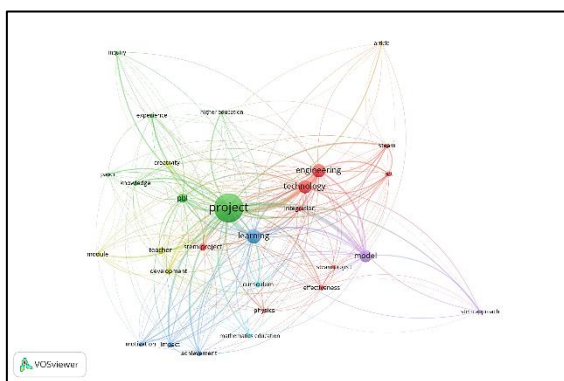

Figure 5. Network Visualization PjBL (Co- Citation) Title and Abstract

Based on Figure 5, it can be seen that the relationship between the title and abstract on the PjBL topic. This network visualization analysis shows that there are seven clusters that appear, such as: (1) red cluster; art, effectiveness, engineering, integration, physics, steam, steam project, stem project, technology. (2) green cluster; experience, higher education, inquiry, knowledge, paper, PBL, project. (3) briu cluster; achievement, impact, learning, motivation. (4) yellow cluster; creativity, development, module, teacher. (5) purple cluster; model, stem approach. (6) tosca blue cluster; curriculum, mathematics. (7) orange cluster; article.

B. Discussion

The analysis shows that research on PjBL has not fully integrated the lastest supporting theories, especially those related to technology-based learning and global contexts. For example, Bowen & Peterson (2018) research shows the potential of STEM integration in PjBL, but its implementation in mathematics education is still limited. The study results also indicated the need for a more holistic approach to support student engagement in various cultural contexts.

In terms of the state of the art, PjBL research in mathematics education focuses on the effectiveness of this method in improving students' conceptual understanding and the application of mathematics in real life. One important finding is the shift in research focus from developing an isolated PjBL model to combining this approach with technology and other disciplines, such as Science, Technology, Engineering, and Mathematics (STEM). Recent studies such as those conducted by (Holmes & Hwang, 2016; Baran & Maskan, 2010; Baran et al., 2021; Zen & Ariani, 2022; Wang & Li 2024), highlight the impact of PjBL on student achievement in STEM and how this approach can be integrated with the use of digital technologies to enrich the learning experience.

In addition, important research areas in this decade also include the use of PjBL to address emerging educational issues, such as disparities in academic achievement and differences in student skills. Several studies highlight how PjBL can be adapted to various educational contexts, including distance learning that has grown during the

Covid-19 pandemic. For example: several studies have shown that with the pandemic, there has been an increased need for project-based learning methods that utilize digital platforms, in order to maintain student engagement in the learning process even through virtual media.

The results of data processing also show that the evolution of PjBL in mathematics education is moving towards a more inclusive and holistic direction. This method is not only applied to improve cognitive learning outcomes, but also builds students' social and emotional abilities. Recent studies emphasize that project-based learning has the potential to address the problem of disparities in student abilities by providing a more collaborative and contextual learning environment. Furthermore, the integration of PjBL with digital-based educational technology has become an increasingly relevant trend, especially in the context of post-pandemic education. Therefore, the trend and development of PjBL research in secondary school mathematics education over the past ten years indicate that this method will continue to develop, especially with the integration of technology and a broader interdisciplinary approach.

IV. CONCLUSION

Systematic literature network analysis (SLNA) has been conducted and found 15 eligible articles. The results of the analysis show that the trend of using PjBL has increased in the last ten years (2014-2024), with increasingly diverse and effective applications in various educational contexts. The state-of-the-art research shows PjBL as a method that supports the development of 21st century skills, especially in critical and collaborative thinking, as well as its integration with modern technology. The evolution of PjBL also shows the importance of research that focuses on developing inclusive and contextual approaches, so that it has a significant impact on increasing student engagement and understanding, while offering new directions for future research.

This research has revealed the increasing trend and diversification of PjBL implementation in the past ten years as well as its role in the development of 21st century skills, such as critical thinking, collaboration and technology integration. However, further research is still neede to explore how PjBL can be applied more effectively in a variety of different educational contexts, for example in underserved neighbourhoods or on more specific subject. Future researchers are also advised to explore the use of specific technologies that are proven to support PjBL, as well as develop more inclusive and contextualized approaches to increase student engagement and understanding. In addition, PjBL approaches should also be more inclusive, taking into account the needs of students from different social and cultural backgrounds. Cross-disciplinary studies are needed to understand how PjBL can be applied to distance or hybrid education contexts.

(BPPT) of the Ministry of Education, Culture, Research and Technology and the Education Fund Management Institute (LPDP), whose assistance and funding are greatly appreciated.

REFERENCES

Ali, A., Mahfouz, A., & Arisha, A. (2017). Analysing Supply Chain Resilience: Integrating the Constructs in a Concept Mapping Framework via a Systematic Literature Review. *Supply Chain Management: An International Journal, 22*(1). https://doi.org/10.1108/SCM-06-2016-0197

Baran, M. & Maskan, A. (2010). The Effect of Project-Based Learning on PreService Physics Teachers' Electrostatic Achievements. *Cypriot Journal of Educational Sciences, 5*, 243-257.

Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The influence of project-based STEM (PjbL-STEM) applications on the development of 21st century skills. *Journal of Turkish Science Education*, *18*(4), 798-815.

Bowen, B., & Peterson, B. (2018). Exploring authenticity through an engineering-based context in a project-based learning mathematics activity. *Journal of Pre-College Engineering Education Research*, *9*(1). https://doi.org/10.7771/2157-9288.1073

Carmichael, C., Callingham, R., Hay, I., & Watson, J. (2010). Statistical Literacy in the Middle School: The Relationship betweenIinterest, Self-Efficacy and Prior Mathematics Achievement.

Australian Journal of Educational and Developmental Psychology, *10*, 83–93.

Craig, T. T., & Marshall, J. 2019. Effect of Project-based Learning on High School Students' State-Mandated, Standardized Math and Science Exam Performance. *Journal of Research in Science Teaching, 56*(10), 1461–1488. https://doi.org/10.1002/tea.21582

Dawson, S., Gasevic, D., Siemens, G., & Joksiomovic, S. (2014, March). Current State and Future Trends: A Citation Network Analysis of The Learning Analytics Field. *In Procceedings of the Fourth International Conference on Learning Analytics and Knowledge* (pp. 2331-240).

Effendi, M., Khoiruli Ummah, S., & Cahyono, H. (2023). Teacher Perspective and Performance in Curriculum Prototype Implementation through the Development of Innovative Project-Based Learning Modules. *Mosharafa: Jurnal Pendidikan Matematika*, *12*(1), 47-58. https://doi.org/10.31980/mosharafa.v12i1.751

Hasna, N., Sagita, L., & Utami, N. W. (2024). Pengembangan LKS Model PjBL untuk Memfasilitasi Kemampuan Pemecahan Masalah Matematis. *Plusminus: Jurnal Pendidikan Matematika*, *4*(1), 137-150. https://doi.org/10.31980/plusminus.v4i1.1572

Holmes, V. L., & Hwang, Y. (2016). Exploring the Effects of Project-based Learning in Secondary Mathematics Education. *Journal of Educational Research*, *109*(5), 449–463. https://doi.org/10.1080/00220671.2014.979911

Ismail, S., Jusuf, N. F. A., Zakaria, P., Achmad, N., & Rif'at, N. (2024). Effect of Project-Based Learning Model on Students' Higher-Order Thinking Skills. *Mosharafa: Jurnal Pendidikan Matematika*, *13*(1), 187-198. https://doi.org/10.31980/mosharafa.v13i1.1986

Kartikasari, N., Rahman, S., & Ahyan, S. (2023). Model Project-Based Learning untuk Meningkatkan Aktivitas dan Hasil Belajar Siswa Melalui Kegiatan Lesson Study. *Plusminus: Jurnal Pendidikan Matematika*, *3*(2), 289-298. https://doi.org/10.31980/plusminus.v3i2.1344

Mahasneh, A.M. and Alwan, A.F. (2018). The Effect of Project-Based Learning on Student Teacher Self-Efficacy and Achievement. *International Journal of Instruction, 11*, 511-524. https://doi.org/10.12973/iji.2018.11335a

Muchlis, E. E., Priatna, N., Herman, T., & Juandi, D. (2023). Geogebra-Assisted Inductive Reasoning in Project-Based Learning Through a Web-Based System. *Journal of Engineering Science and Technology*, *18*, 224–238.

Muslim, A. P. (2016). Penerapan TAPPS disertai Hypnoteaching (Hypno-TAPPS) dalam Meningkatkan Disposisi. *JUDIKA: Jurnal Pendidikan Unsika, 4*(1). https://doi.org/10.35706/judika.v4i1.232

Muslim, A. P. (2020). Penerapan Pembelajaran Remedial untuk Meningkatkan Hasil Belajar Matematika Siswa Kelas VIII SMPN 2 Panti Kabupaten Pasaman Tahun Pelajaran 2015/2016. *Jurnal Lemma. 6*(2). 65-68. https://doi.org/10.22202/jl.2020.v6i2.4107

Nurhikmayati, I., & Sunendar, A. (2020). Pengembangan project-based learning berbasis kearifan lokal berorientasi pada kemampuan berpikir kreatif dan kemandirian belajar. *Mosharafa: Jurnal Pendidikan Matematika*, *9*(1), 1-12. https://doi.org/10.31980/mosharafa.v9i1.587

Wang, B., & Li, P. P. (2024). Digital creativity in STEM education: the impact of digital tools and pedagogical learning models on the students' creative thinking skills development. *Interactive Learning Environments*, *32*(6), 2633-2646.

Xia, H., Tan, S., Huang, S., Gan, P., Zhong, C., Lu, M, … & Tang, X. (2021). Scoping Review and Bibliometric Analysis of the Most Influential Publications in Achalasia Research from 1995 to 2020. *Biomed Research International, 1*, 8836395. https://doi.org/10.1155/2021/8836395

Yulia, P., & Nasution, E. Y. P. (2024). Geometry and Islamic Values: Validity of Teaching Materials Based on Modified Project-Based Learning Model. *Mosharafa: Jurnal Pendidikan Matematika*, *13*(1), 113-124. https://doi.org/10.31980/mosharafa.v13i1.1980

Zen, Z., & Ariani, F. (2022). Academic achievement: the effect of project-based online learning method and student engagement. *Heliyon*, *8*(11).

Zhao, D., & Strotman, A. (2015). *Analysis and Visualization of Citation Networks*. Morgan & Claypool Publishers.

AUTHOR'S BIOGRAPHY

Audra Pramitha Muslim, M.Pd.

Born in Padang, on 25 August 1988. Faculty member at Sainstek UPGRISBA. Completed undergraduate studies in Mathematics Education at Universitas Negeri Padang, Padang, in 2010; Completed graduate studies in Mathematics Education at Universitas Pendidikan Indonesia, Bandung, in 2014.

Prof. Dr. H. Darhim, M.Si.

Born in Ciamis, on 03 March 1955. Faculty member at FPMIPA UPI Bandung. Completed undergraduate studies in Mathematics Education at IKIP Bandung, Bandung, in 1981; Completed graduate studies in Mathematics at UGM, Yogyakarta, in 1993; and completed doctoral studies in Mathematics Education at Universitas Pendidikan Indonesia, Bandung, in 2004.

Prof. Dr. H. Tatang Herman, M.Ed.

Born in Garut, on 11 October 1962. Faculty member at FPMIPA UPI Bandung. Completed undergraduate studies in Mathematics Education at IKIP Bandung, Bandung, in 1989; Completed graduate studies in Mathematics education at Deakin University, Australia, in 1996; and completed doctoral studies in Mathematics Education at Universitas Pendidikan Indonesia, Bandung, in 2006.

Prof. Al Jupri, S.Pd., M.Sc., Ph.D.

Born in Serang, on 10 Mei 1982. Faculty member at FPMIPA UPI Bandung. Completed undergraduate studies in Mathematics Education at Universitas Pendidikan Indonesia, Bandung, in 2004; Completed graduate studies in Mathematics education at Utrecht University, The Netherlands, in 2008 and completed doctoral studies in Mathematics and Algebra Education at Utrecht University, The Netherlands, in 2015.