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Mapping Literature on the Utilization of Project-Based Learning in Physics Education from 2018 to 2023: A Bibliometric Analysis

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Abstract
Project-based Learning (PjBL) was an active learning approach where students undertake in-depth investigations of topics or issues, aiming to produce tangible products or solutions. This literature mapping aims to offer an overview of the existing literature on project-based learning in Physics Education via bibliometric analysis. Utilizing the Scopus database, a data search was conducted, yielding 180 documents, with limitations applied based on specific criteria. Publications with the highest citation counts were identified from international journals indexed by Scopus, with a focus on quartile 3 journals. Using VOSviewer visualization, eight clusters were identified, highlighting the interconnectedness of project-based learning in physics education with courses, models, problems, and ability. Additionally, novel perspectives were explored to expand the application of PjBL in physics education. Future research opportunities lie in implementing PjBL in physics education to foster critical thinking, problem-solving abilities, creative thinking, student creativity, and metacognitive skills. Furthermore, future research endeavors could integrate PjBL with other methodologies, such as laboratory activities or STEM approaches. This analysis provides valuable insights into the current landscape of project-based learning in Physics Education and offers directions for future research endeavors.

Keywords: Project-based Learning, Physics Education, Bibliometric Analysis.

INTRODUCTION

Project-Based Learning (PBL) is an active learning approach that allows students to participate in-deep investigation into specific topics or issues through projects designed to produce concrete products or solutions (Sukackė et al., 2022). In the context of physics education, a branch of science focusing on the fundamental concepts of physics and natural phenomena, PjBL provides opportunities for students. They can not only acquire information from teachers but also actively participate in problem-solving, gathering data, analyzing information, and presenting their understanding through presentations or products they produce (Fahmi et al., 2019; Luh Andriyani & Wayan Suniasih, 2021) .

Physics education not only focuses on theoretical aspects but also involves experiments, demonstrations, and practical applications to help students understand the principles of physics in the context of everyday life (Babalola et al., 2020). Thus, the main goal of physics education is to develop a strong understanding of physics as well as practical skills in applying these concepts in various situations. In this regard, learning approaches like PjBL have great potential to help students deepen their understanding of physics concepts through hands-on experiences and direct applications in the real world (Anasi & Harjunowibowo, 2023; Malik, 2018).

Over the past six years, there has been an increased interest on the utilization of PjBL in physics education. Therefore, bibliometric analysis of related literature becomes relevant to understand publication trends, dominant research topics, and institutional contributions to the development and employment of this learning approach (Solihin et al., 2021). Such analysis can provide valuable insights into the structure and dynamics of the field of physics education, as well as help identify unmet research needs and potential collaboration opportunities.

Thus, the aim of this article is to present a comprehensive bibliometric analysis of the utilization of PjBL in physics education during the period 2018-2023, with the hope of providing guidance for researchers and practitioners in developing more effective and innovative learning approaches. Additionally, the article highlights the top five authors based on citation counts. Lastly, this article provides visualizations of the trends in project-based learning in physics education using the Scopus database and VOSviewer.

Table 1. Bibliometric analysis of prior research on project-based learning.

No	Title	Topic Discussion
1	A bibliometric and classification study of Project-based Learning in Engineering Education (Reis et al., 2017).	The study aims to conduct a comprehensive classification and bibliometric analysis of Project-based Learning (PBL) within the realm of Engineering.
2	Promising research studies between mathematics literacy and financial literacy through project-based learning (Sagita et al., 2022).	Future research potential lies in the development and integration of learning activities within an autonomous curriculum, influencing schools' capacity to utilize project-based learning, recognized as the foremost method for integrating financial literacy into mathematics education.
3	Learning in Project-Based Engineering Education: A Bibliometric Analysis (Zarate-Perez et al., 2022).	The objective of this paper is to perform a bibliometric analysis aimed at assessing the effectiveness of implementing PBL in the engineering curriculum.
4	Project-based Learning in Vocational Education: A Bibliometric Approach (Ahmad et al., 2023).	In this study, a bibliometric method is used to provide insight into the structure of the subject, social networks, research trends, and issues reflecting project-based learning in vocational education.
5	Project Based Learning (PjBL) Model in Science Learning: A Bibliometric Analysis (Misbah et al., 2024).	The aim of this study was outlined to acquire a thorough understanding of Project Based Learning (PjBL) in science education and to identify prevalent research topics in the current discourse.

METHODS

This study utilizes a bibliometric analysis step consisting of five stages, including: 1) study design; 2) data collection; 3) data analysis; 4) visualization of data; 5) interpretation analysis (Misbah et al., 2023). Data collection was conducted in December 2023, based on the criteria obtained from 180 documents. The criteria used are documents from articles and proceeding papers with the source type namely journals and proceedings, then the publication stage is final, the document is in English, the scope is in physics education, and within the 2018-2023 time period. The articles have already been analyzed from the international journal indexed by Scopus. The Scopus database was chosen because it is a source that has high credibility besides the web of science. Data from Scopus has ever been stored in RIS and CSV, moreover Mendeley Dekstop has been utilized to reorganize article metadata. Furthermore, VOSviewer software as a visualization of research trend data with the project-based learning in the range 2018-2023 has been implemented. The bibliometric stages of analysis utilized are depicted in Figure 1.

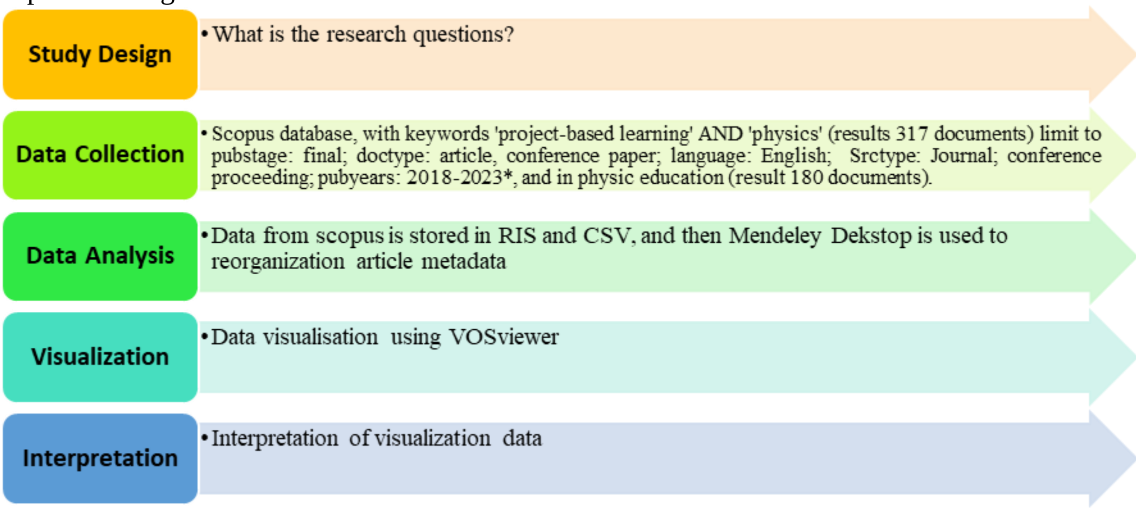

Figure 1. Research Scheme of Bibliometric Project-based Learning in Physics Education

RESULTS AND DISCUSSION

The data retrieved from the Scopus database using the keywords "Project based learning" OR "Project-based learning" AND "physics education" resulted in the number of documents published between 2018 and 2023, as depicted in Figure 2.

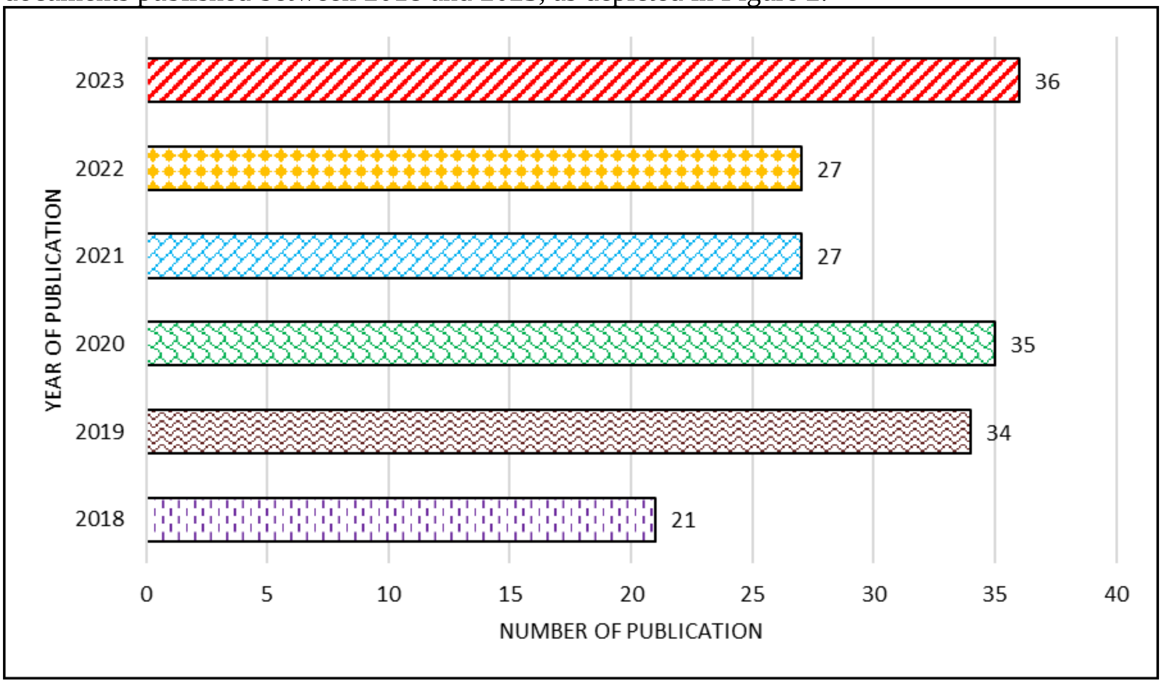

Figure 2. The Number of Project-based Learning in Physics Education Publications for 2018-2023

Figure 2 illustrates the fluctuation in the number of publications related to this topic, particularly evident from 2018 to 2023. The highest number of publications occurred in 2023, attributed to the culmination of research conducted in previous years. Conversely, there was a decline in publications in 2021, primarily due to the disruptions caused by the COVID-19 pandemic, which impeded the completion of numerous studies, consequently impacting publication rates during those years. This is in line with research on critical thinking skills (Arici & Cengiz, 2023) and creative thinking skills (Saefudin et al., 2023) .

The information provided presents the top five authors ranked by the number of citations in the field of Project-based learning in physics education, as displayed in Table 2.

Table 2. Top Five Authors Based on The Number of Citations on The Topic of Project-based Learning in Physics Education

No	**Authors**	**Cited**	**Tittle**	**Source**	**Quartile & SJR**
1	(Mutakinati et al., 2018)	86	Analysis of students' critical thinking skill of middle school through stem education project-based learning	Jurnal Pendidikan IPA Indonesia	Q3 0.36
2	(Baran, 2018)	38	Learning physics through project-based learning game techniques	International Journal of Instruction	Q2 0.61
3	(Santyasa et al., 2020)	32	Project based learning and academic procrastination of students in learning physics	International Journal of Instruction	Q2 0.61
4	(Samsudin, 2020)	20	The effect of STEM project based learning on self-efficacy among high-school physics students	Journal of Turkish Science Education	Q2 0.44
5	(Schneider et al., 2022)	14	Improving Science Achievement—Is It Possible? Evaluating the Efficacy of a High School Chemistry and Physics Project-Based Learning Intervention	Educational Researcher	Q1 3.3

Table 2 shows that the author's widely cited article on project-based learning was published by a Scopus indexed international journal with quartile 3 (Mutakinati et al., 2018). The article garners the highest number of citations due to its substantial contribution to comprehending and improving middle school students' critical thinking abilities via STEM project-based learning. Furthermore, it addresses a gap in the literature concerning the application of the PjBL method in STEM education at the middle school tier.

VOS viewer can provide bibliometric analysis mapping with three different visualizations, namely network visualization listed in Figure 3. There are 90 identifiable items of 8 clusters characterized by different colors namely red, green, blue, yellow, purple, light blue, brown, and rose taupe.

Based on Figure 3, show that four terms appear more frequently: course (134 times), model (123 times), and problem (109 times). Course item has largest labels than other items. The distance between a PjBL item and another item determines whether they are closely related. Figure 3 shows that PjBL is closely related to courses, models, problems and ability. PjBL items have a wide range of the following items: metacognitive skills, gifted child, practical activity, laboratory, optics and energy. The distance between the two items is an opportunity for further research.

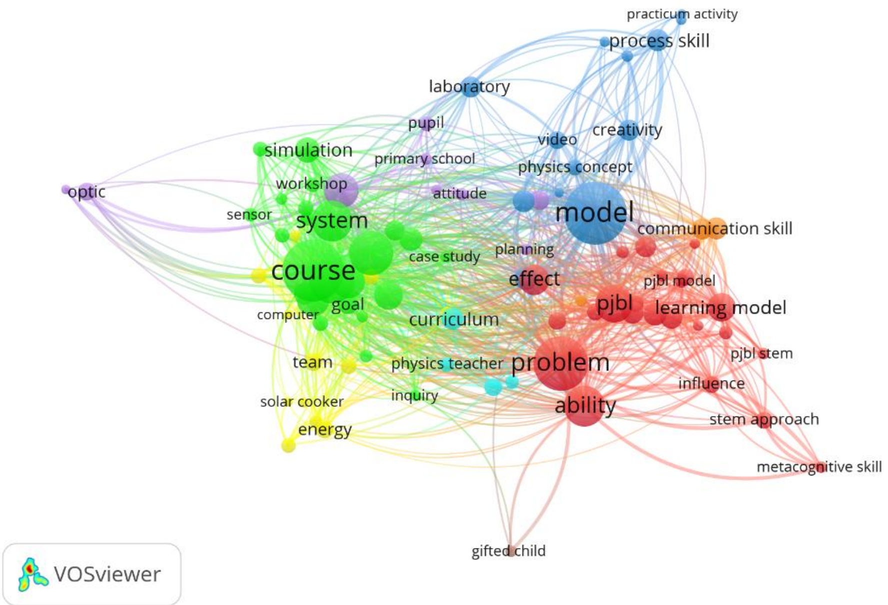

Figure 3. The Network Visualization of Project-based Learning in Physics Education.

Each cluster shows the development of project-based learning in physics education that can be observed in Table 3.

Table 3. Research Development of Each Cluster

No	Cluster	Number of Item	Keywords
1	Red	24	Ability, collaboration, creative thinking, creative thinking skill, critical thinking, critical thinking skill, effect, impact, influence, learning model, lecture, metacognitive skill, pjbl (project-based learning), pjbl model, pjbl stem, portfolio assessment, problem, solution, stem approach, stem pjbl, student worksheet, student problem, teaching material, worksheet
2	Green	24	Case study, challenge, competition, course, education, electronic, engineering student, environment, experience, goal, inquiry, motivation, program, programming, robotic, sensor, simulation, simulator, system, teamwork, undergraduate student, understanding, university, workshop
3	Blue	13	Creativity, interview, laboratory, laboratory learning, misconception, model, physics concept, physics teacher candidate, practicum activity, process skill, product, tracker, video
4	Yellow	12	Computer, energy, engineering design product, instruction,

No	Cluster	Number of Item	Keywords
			intervention, lesson plan, performance, reflection, solar cooker, team, turbine, water
5	Purple	9	Attitude, evaluation, experiment, optic, photoelectric effect, planning, primary school, pupil, science education
6	Light Blue	4	Curriculum, ict (Information and Communication Technology), physics teacher, pre service physics teacher
7	Brown	3	Communication, communication skill, prospective physics teacher
8	Rose Taupe	1	Gifted child

Figure 3 and Table 3 show that project-based learning has been a keyword in the Scopus database for the last six years, and it is in cluster 1. In cluster 1 which is colored red, this cluster depicts various aspects related to PjBL in physics education, including creative ability, critical thinking skills, creative thinking skills, and students' metacognitive abilities (Fiteriani et al., 2021; Muliyati et al., 2023). Additionally, the cluster also highlights the STEM approach in PjBL, the use of student worksheets, portfolio assessment, and the influence and impact of implementing PjBL models in physics education (Astra et al., 2019).

In cluster 2, this cluster encompasses a wide array of elements relevant to PjBL and physics education, including case studies, challenges, competitions, courses, and workshops (Gonzalez et al., 2019; Persano Adorno et al., 2023). Project-based learning also incorporates themes such as motivation, teamwork, and goal-setting (Rissanen et al., 2023), which are integral to the PjBL approach (Čavić et al., 2022). Moreover, it delves into topics like engineering students' experiences, understanding of systems, and the application of simulation and robotics, showcasing the interdisciplinary nature of PjBL in enhancing learning outcomes in physics education (Campos, 2023).

In cluster 3, The cluster highlighted in blue, underscores the intersection of PjBL and physics education by emphasizing key components such as creativity, laboratory learning, and process skills (Oh et al., 2020). It sheds light on the significance of hands-on practicum activities, the role of physics teachers as candidates in fostering student understanding, and addressing misconceptions in physics concepts (Romero-Vera et al., 2023). Additionally, it explores the use of models, videos, and trackers as tools to facilitate the PjBL process, indicating a holistic approach to integrating practical experiences and conceptual understanding within physics education.

In cluster 4, this cluster highlights the fusion of PjBL and physics education through a focus on various elements such as computer modeling, energy concepts, and engineering design products (Bering et al., 2022; Bischof et al., 2021). It explores the integration of instruction and intervention strategies within lesson plans to enhance student performance and foster reflective learning practices (April Yanti, 2019). Additionally, it delves into specific projects like solar cooker and turbine design, emphasizing teamwork and hands-on exploration of physics principles. Overall, this cluster showcases how PjBL can be effectively employed to engage students in real-world applications of physics concepts while promoting collaborative problem-solving and innovative solutions in energy and engineering domains.

In cluster 5, This cluster highlights the relevance of PjBL in physics education by addressing key aspects such as attitude, evaluation, and planning within the context of science education, particularly at the primary school level (Abra Olivato & Castro Silva, 2023). It emphasizes the integration of experimental approaches and hands-on activities to explore topics like optics and the photoelectric effect, fostering a deeper understanding of physics concepts among pupils (Efwinda & Mannan, 2020). Additionally, it underscores the importance of cultivating positive attitudes towards science and promoting critical evaluation skills through engaging, inquiry-based learning experiences (Calalb, 2023). Overall, this cluster underscores the potential of PjBL to enhance science education outcomes by encouraging active participation, experimentation, and reflective practice.

In cluster 6, This cluster highlights the intersection of PjBL, physics education, and teacher training, focusing on curriculum development and the integration of Information and Communication Technology (ICT) tools (Zhang et al., 2023). It explores how PjBL can be incorporated into the training of pre-service physics teachers, emphasizing the use of innovative instructional strategies to enhance their pedagogical skills (Muliyati et al., 2020). Additionally, it underscores the role of physics teachers in implementing PjBL approaches within the classroom, utilizing ICT resources to facilitate active learning and student engagement (Singh et al., 2019). Overall, this cluster underscores the importance of equipping educators with the necessary tools and training to effectively implement PjBL methodologies and enhance physics education outcomes.

In cluster 7, This cluster highlights the significance of communication skills in the context of PjBL and physics education, particularly among prospective physics teachers (Cuenca-Gotor et al., 2022). It explores how PjBL can be utilized to develop and enhance communication skills essential for effective teaching and interaction with students. By engaging in collaborative projects and presenting findings, prospective physics teachers can refine their ability to communicate complex physics concepts in a clear and accessible manner (Kovalenko et al., 2021). Additionally, this cluster underscores the importance of integrating communication skill development within teacher training programs to better prepare educators for implementing PjBL methodologies and fostering meaningful learning experiences in physics education.

In cluster 8, PjBL in physics education only associates with gifted child (Abidin et al., 2021). VOS viewer can provide bibliometric analysis mapping with three different visualizations, namely overlay visualization listed in Figure 4.

Figure 4
The Overlay Visualization of PjBL in Physics Education

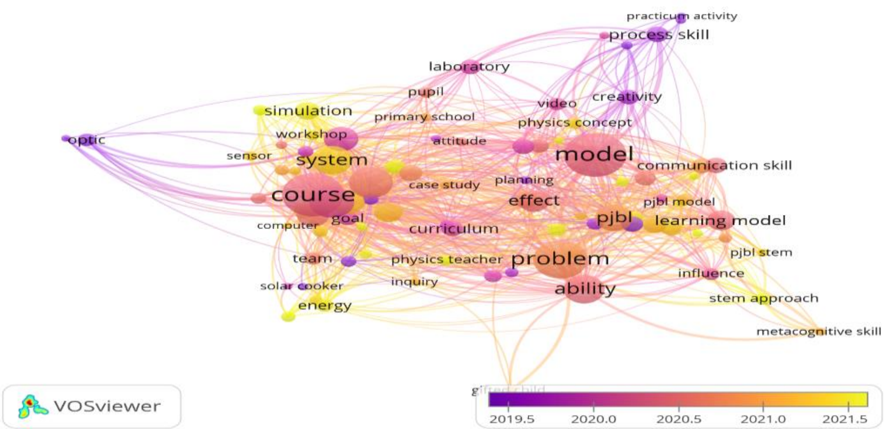

Figure 4 shows that the majority of research on PjBL was conducted in 2019 and 2023, supported by the research trend depicted in Figure 2. The intensity of the yellow color and the width of the word label circles indicate the frequency of occurrence of these terms (Kijkasiwat et al., 2022; Mardian et al., 2023). Over the past two years, research on PjBL has frequently been associated with terms such as PjBL, course, model, problem, and ability (Dewi et al., 2022; Yanti & Kuswanto, 2019). Many researchers have examined the implementation of PjBL in university, particularly within the course (Rissanen et al., 2023). This has prompted researchers to further explore the perspectives of physics teachers regarding the use of PjBL in physics education.

This research is intriguing and provides valuable contributions to further study. There are two important findings from this research that need to be highlighted. Firstly, the majority of research on PjBL in physics education was conducted in 2023. The second finding relates to future research potential. The visualization results using VOSviewer indicate that there are still many opportunities to develop the use of PjBL in physics education. This can be observed from Figures 3 and 4, where gaps in PjBL, simulation, physics teachers, creative thinking, critical thinking, problem-solving, metacognitive skills, practicum activities, optics, and energy have rarely been studied in 2018-2023. These findings also confirm the effectiveness of bibliometric analysis in investigating and describing the current literature, which can be used to determine whether further research is needed, as suggested by other articles (da Silva et al., 2018; Inamdar et al., 2020).

CONCLUSION

There have been more articles published on this subject, particularly in 2018–2023. The author with the greatest citations was then published in an international journal that was quartile 3 indexed by Scopus. Eight clusters were identified based on visualization with VOSviewer, and highlighting the interconnectedness of project-based learning in physics education with courses, models, problems, and ability. Additionally, novel perspectives were explored to expand the application of PjBL in physics education. Future research opportunities lie in implementing PjBL in physics education to foster critical thinking, problem-solving abilities, creative thinking, student creativity, and metacognitive skills. Furthermore, future research endeavors could integrate PjBL with other methodologies, such as laboratory activities or STEM approaches. This analysis provides valuable insights into the current landscape of project-based learning in Physics Education and offers directions for future research endeavors.

REFERENCES

Abidin, Z., Herman, T., Jupri, A., & Farokhah, L. 2021. Gifted Children's Mathematical Reasoning Abilities on Problem-Based Learning and Project-Based Learning Literacy. *Journal of Physics: Conference Series*, *1720*(1). https://doi.org/10.1088/1742-6596/1720/1/012018

Abra Olivato, J., & Castro Silva, J. 2023. Interdisciplinary teaching practices in STEAM education in Brazil. *London Review of Education*, *21*(1). https://doi.org/10.14324/LRE.21.1.38

Ahmad, S. T., Watrianthos, R., Samala, A. D., Muskhir, M., & Dogara, G. 2023. Project-based Learning in Vocational Education: A Bibliometric Approach. *International Journal of Modern Education and Computer Science*, *15*(4), 43–56. https://doi.org/10.5815/ijmecs.2023.04.04

Anasi, W. A., & Harjunowibowo, D. 2023. *Project Based Learning in Physics Teaching: Bibliometric Analysis and Research Trends in Last Ten Years* (Issue Icliqe). Atlantis Press SARL. https://doi.org/10.2991/978-2-38476-114-2_28

April Yanti, F. 2019. Learning design: Reflective video as self-control in project learning for physics teacher candidates. *Journal of Physics: Conference Series*, *1153*(1). https://doi.org/10.1088/1742-6596/1153/1/012118

Arici, F., & Cengiz, E. 2023. An Examination of Articles on Critical Thinking in Science Education: An Analysis Using Bibliometric Mapping. *Eğitim Bilim ve Araştırma Dergisi*, *4*(2), 539–567. https://doi.org/10.54637/ebad.1362232

Astra, I. M., Rosita, E. I., & Raihanati, R. 2019. Effect of project based learning model assisted by student worksheet on critical thinking abilities of high school students. *AIP Conference Proceedings*, *2169*. https://doi.org/10.1063/1.5132637

Babalola, F. E., Lambourne, R. J., & Swithenby, S. J. 2020. The Real Aims that Shape the Teaching of Practical Physics in Sub-Saharan Africa. *International Journal of Science and Mathematics Education*, *18*(2), 259–278. https://doi.org/10.1007/s10763-019-09962-7

Baran, M. 2018. Learning physics through project-based learning game techniques. *International Journal of Instruction*, *11*(2), 221–234. https://doi.org/10.12973/iji.2018.11215a

Bering, E. A., Khan, S., Moges, M., Jacobs, L. T., Hampton, D., Mölders, N., Thorsen, D., Gamblin, R. B., Greer, M., Greer, P., Gunawan, B., Hernandez, E., Humble, E., Lehnen, J., Nguyencuu, A., Piña, M., Porat, I., Prince, J. R., Pessoa, A. G., … Ulinski, A. (022. Student Space Missions - Report on our 2022 Undergraduate Auroral Observing Campaign. *Proceedings of the International Astronautical Congress, IAC*, *2022-Septe*.

Bischof, G., Eckstein, L., Gahleitner, B., Gasparic, M., Reisenberger, M., Savoric, S., Steinmann, C. J., & Tretton, A. 2021. Simulation of Multiple-Degree-of-Freedom Oscillatory Systems within an Undergraduate Project-based Learning Environment. *ASEE Annual Conference and Exposition, Conference Proceedings*.

Calalb, M. 2023. The Constructivist Principle of Learning by Being in Physics Teaching. *Athens Journal of Education*, *10*(1), 139–152. https://doi.org/10.30958/aje.10-1-8

Campos, F. M. 2023. Ardosia: Simulating Circuits and Robotic Systems in a Single Learning Platform. *IEEE Transactions on Learning Technologies*, *16*(2), 166–177. https://doi.org/10.1109/TLT.2023.3243688

Čavić, M. R., Stanisavljević, J. D., Bogdanović, I. Z., Skuban, S. J., & Pavkov-Hrvojević, M. V. 2022. Project-Based Learning of Diffusion and Osmosis: Opinions of Students of Physics and Technology at University of Novi Sad. *SAGE Open*, *12*(1). https://doi.org/10.1177/21582440211069147

Cuenca-Gotor, V. P., Salinas-Marín, I., Giménez-Valentín, M. H., Castro-Palacio, J. C., Sans-Tresserras, J. A., Ferrando-Martín, V., Sánchez-Ruiz, L. M., & Monsoriu-Serra, J. A. 2022. Project-based learning using scientific poster as a tool for learning and acquisition of skills in physics subjects of engineering bachelor's degrees. *SEFI 2022 - 50th Annual Conference of the European Society for Engineering Education, Proceedings*, 1113–1121. https://doi.org/10.5821/conference-9788412322262.1138

da Silva, F. F., Filser, L. D., Juliani, F., & de Oliveira, O. J. 2018. Where to direct research in lean six sigma?: Bibliometric analysis, scientific gaps and trends on literature. *International Journal of Lean Six Sigma*, *9*(3), 324–350. https://doi.org/10.1108/IJLSS-05-2017-0052

Dewi, W. S., Febryan, H., & Sari, S. Y. 2022. Need analysis of project-based learning model and portfolio assessment in physics learning. *Journal of Physics: Conference Series*, *2309*(1). https://doi.org/10.1088/1742-6596/2309/1/012086

Efwinda, S., & Mannan, M. N. 2020. Pedagogical Content Knowledge Ability in Reflecting Project-Based Learning on Physics Concepts. *Proceedings of the 7th Mathematics, Science, and Computer Science Education International Seminar, MSCEIS 2019*. https://doi.org/10.4108/eai.12-10-2019.2296475

Fahmi, F., Setiadi, I., Elmawati, D., & Sunardi, S. 2019. Discovery Learning Method for Training Critical Thinking Skills of Students. *European Journal of Education Studies*, *6*(3), 342–351. https://doi.org/10.5281/zenodo.3345924

Fiteriani, I., Diani, R., Hamidah, A., & Anwar, C. 2021. Project-based learning through STEM approach: Is it effective to improve students' creative problem-solving ability and metacognitive skills in physics learning? *IOP Conference Series: Earth and Environmental Science*, *1796*(1). https://doi.org/10.1088/1742-6596/1796/1/012058

Gonzalez, O. M., Gonzalez, M., Vega, F. B., Samaniego, G. R., & Kurita, J. H. 2019. ARAPY Project: High altitude balloons payload design as a tool to reduce the access gap in bring steam education to rural Paraguay. *Proceedings of the International Astronautical Congress, IAC*, *2019-Octob*.

Inamdar, Z., Raut, R., Narwane, V. S., Gardas, B., Narkhede, B., & Sagnak, M. 2020. A systematic literature review with bibliometric analysis of big data analytics adoption from period 2014 to 2018. *Journal of Enterprise Information Management*, *34*(1), 101–139. https://doi.org/10.1108/JEIM-09-2019-0267

Kijkasiwat, P., Almustafa, H., & Phuensane, P. 2022. Initial coin offerings for business: a systematic literature review and bibliometric analysis. In *SN Business & Economics* (Vol. 3, Issue 1). Springer International Publishing. https://doi.org/10.1007/s43546-022-00386-0

Kovalenko, I., Balta, E. C., Qamsane, Y., Koman, P. D., Zhu, X., Lin, Y., Tilbury, D. M., Mao, Z. M., & Barton, K. 2021. Developing the workforce for next-generation smart manufacturing systems: A multidisciplinary research team approach. *Smart and Sustainable Manufacturing Systems*, *5*(2), 4–24. https://doi.org/10.1520/SSMS20200009

Luh Andriyani, N., & Wayan Suniasih, N. 2021. Development of Learning Videos Based on Problem-Solving Characteristics of Animals and Their Habitats Contain in Ipa Subjects on 6th-Grade. *Journal of Education Technology*, *1*(1), 37–47.

Malik, R. S. 2018. Educational Challenges in 21St Century and Sustainable Development. *Journal of Sustainable Development Education and Research*, *2*(1), 9. https://doi.org/10.17509/jsder.v2i1.12266

Mardian, V., Utama, J. A., & Suwarma, I. R. 2023. Bibliometric Map of STEM-Physics Research Evolution. *Berkala Ilmiah Pendidikan Fisika*, *11*(2), 262. https://doi.org/10.20527/bipf.v11i2.16284

Misbah, M., Hakam, A. B., Qamariah, Umar, F., Harto, M., & Muhammad, N. 2024. Project Based Learning (PjBL) Model in Science Learning: A Bibliometric Analysis. *E3S Web of Conferences*, *482*, 04031. https://doi.org/10.1051/e3sconf/202448204031

Misbah, M., Hamidah, I., Sriyati, S., & Samsudin, A. 2023. *Research Trend of Dynamic Fluid in Learning : A Bibliometric Analysis*. *9*(2), 263–272.

Muliyati, D., Bakri, F., Siswoyo, S., Ambarwulan, D., Septyaningrum, L. D., Budi, A. S., & Fitriani, W. 2020. The implementation of project-based learning to enhance the technological-content-knowledge for pre-service physics teacher in ICT courses. *Journal of Physics: Conference Series*, *1521*(2). https://doi.org/10.1088/1742-6596/1521/2/022023

Muliyati, D., Prastiawan, F., & Mutoharoh, M. 2023. Development of STEM project-based learning student worksheet for Physics learning on renewable energy topic. *Journal of*

Physics: Conference Series, *2596*(1). https://doi.org/10.1088/1742-6596/2596/1/012078
Mutakinati, L., Anwari, I., & Yoshisuke, K. 2018. Analysis of students' critical thinking skill of middle school through stem education project-based learning. *Jurnal Pendidikan IPA Indonesia*, *7*(1), 54–65. https://doi.org/10.15294/jpii.v7i1.10495
Oh, B. K., Kunimune, J. H., Spicher, J., Anfenson, L., & Christianson, R. 2020. (Student paper) undergraduate demonstration of a hall effect thruster: Self directed learning in an advanced project context. *ASEE Annual Conference and Exposition, Conference Proceedings*, *2020-June*.
Persano Adorno, D., Scardulla, F., D'Acquisto, L., & Pizzolato, N. 2023. Design of an open-lab activity for engineering students: A case study. *International Journal of Mechanical Engineering Education*, *51*(1), 47–65. https://doi.org/10.1177/03064190221143318
Reis, A. C. B., Barbalho, S. C. M., & Zanette, A. C. D. 2017. A bibliometric and classification study of Project-based Learning in Engineering Education. *Production*, *27*(Special Issue), 1–16. https://doi.org/10.1590/0103-6513.225816
Rissanen, A., Hoang, J. G., & Spila, M. 2023. First-year interdisciplinary science experience enhances science belongingness and scientific literacy skills. *Journal of Applied Research in Higher Education*, *15*(5), 1561–1586. https://doi.org/10.1108/JARHE-09-2020-0313
Romero-Vera, A., Roblero, J., Mosquera, J., Gutiérrez, E., & Pazmino, A. 2023. Teaching Thermodynamics and Basic Electronics for Engineering Students Through A Real-Life Project: Building A Thermal Box. *Proceedings - 2023 7th International Conference on Computer, Software and Modeling, ICCSM 2023*, 16–19. https://doi.org/10.1109/ICCSM60247.2023.00012
Saefudin, A. A., Wijaya, A., & Dwiningrum, S. I. A. 2023. Mapping research trends in mathematical creativity in mathematical instructional practices: A bibliometric analysis. *Journal of Pedagogical Research*, *7*(4), 439–458. https://doi.org/10.33902/JPR.202322691
Sagita, L., Putri, R. I. I., Zulkardi, & Prahmana, R. C. I. 2022. Promising research studies between mathematics literacy and financial literacy through project-based learning. *Journal on Mathematics Education*, *13*(4), 753–772. https://doi.org/10.22342/jme.v13i4.pp753-772
Samsudin, M. A. 2020. The effect of STEM project based learning on self-efficacy among high-school physics students. *Journal of Turkish Science Education*, *17*(1), 94–108. https://doi.org/10.36681/tused.2020.15
Santyasa, I. W., Rapi, N. K., & Sara, I. W. W. 2020. Project based learning and academic procrastination of students in learning physics. *International Journal of Instruction*, *13*(1), 489–508. https://doi.org/10.29333/iji.2020.13132a
Schneider, B., Krajcik, J., Lavonen, J., Salmela-Aro, K., Klager, C., Bradford, L., Chen, I.-C., Baker, Q., Touitou, I., Peek-Brown, D., Dezendorf, R. M., Maestrales, S., & Bartz, K. 2022. Improving Science Achievement—Is It Possible? Evaluating the Efficacy of a High School Chemistry and Physics Project-Based Learning Intervention. *Educational Researcher*, *51*(2), 109–121. https://doi.org/10.3102/0013189X211067742
Singh, M. N. K., Sun, Q., & Weber, C. 2019. Evaluating the use of a personalized learning management system to increase student enrollment in high school physics (evaluation, diversity). *ASEE Annual Conference and Exposition, Conference Proceedings*.
Solihin, A., Wibowo, F. C., & Astra, I. M. 2021. Review of trends project based learning (PjBL) integrated STEM in physics learning. *Journal of Physics: Conference Series*, *2019*(1). https://doi.org/10.1088/1742-6596/2019/1/012031
Sukackė, V., Guerra, A. O. P. de C., Ellinger, D., Carlos, V., Petronienė, S., Gaižiūnienė, L., Blanch, S., Marbà-Tallada, A., & Brose, A. 2022. Towards Active Evidence-Based Learning in Engineering Education: A Systematic Literature Review of PBL, PjBL, and

CBL. *Sustainability (Switzerland)*, *14*(21). https://doi.org/10.3390/su142113955

Yanti, F. A., & Kuswanto, H. 2019. Development of cooperative research project based learning models to improve research and communication skills for prospective physics teachers in Indonesia. *International Journal of Engineering and Advanced Technology*, *8*(5), 740–746. https://doi.org/10.35940/ijeat.E1105.0585C19

Zarate-Perez, E., Cornejo-Carbajal, C., Grados, J., Gutierrez-Tirado, R., Astocondor-Villar, J., Tejada-Cabanillas, A., & Grados-Espinoza, A. 2022. Learning in Project-Based Engineering Education: A Bibliometric Analysis; [Aprendizaje Basado en Proyectos de Educación en ingeniería: Un Análisis Bibliométrico]. *Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology*, *2022-July*, 1–10.

Zhang, R., Shi, J., & Zhang, J. 2023. Research on the Quality of Collaboration in Project-Based Learning Based on Group Awareness. *Sustainability (Switzerland)*, *15*(15). https://doi.org/10.3390/su151511901