

Project-Based Learning Evaluation trends in 21st Century Skills Development: bibliometrics and VoS Viewer

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ABSTRACT

This study aims to evaluate research trends related to Project-Based Learning (PjBL) in 21st-century skills development through a bibliometric approach. 21st-century skills, such as critical thinking, collaboration, communication, and creativity, are a major focus in modern education, and PjBL is seen as a relevant pedagogical approach to cultivating those skills. However, systematic mapping of research trends and scientific collaboration in this field is still limited. This study uses a bibliometric method by analyzing 174 articles indexed by Sinta and Scopus from 2015 to 2025, which contain keywords related to "Project-Based Learning" and "21st Century Skills". Data was analyzed using VOSviewer software to visualize collaboration networks, keywords, and the distribution of authors and institutions. The results of the analysis show that there has been a significant increase in publications related to PjBL and 21st-century skills in the last five years. The main keyword clusters found include: project-based learning, 21st century skills, collaborative learning, STEM education, and critical thinking. The United States, Indonesia, and Spain are listed as the countries with the highest contributions in publications. Bibliometric visualization also shows that the topic of PjBL in the context of 21st-century skills is increasingly shifting towards strengthening the integration of digital technology and cross-disciplinary approaches. This study provides a comprehensive overview of the direction of research development and the potential for cross-border collaboration and suggests the need for a more structured evaluative approach in the implementation of PjBL in various educational contexts.

Keywords: Learning Evaluation, Project-Based, Development, 21st Century Skills

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INTRODUCTION

In an era of globalization marked by rapid technological advances, education must adapt to prepare young people with indispensable 21st-century skills, such as critical thinking, creativity, collaboration, and communication. These skills are becoming increasingly important in the face of the world of work's complexity and ever-evolving social dynamics, where the ability to adapt and innovate is crucial to success. One innovative approach that can address this challenge is project-based learning (PjBL) (Arifin & Mu'id, 2024). PjBL offers a learning method that is more interactive and relevant to students' daily lives, where they are directly involved in the completion of real projects that demand the practical application of knowledge and skills (Satria et al., 2024). Through PjBL, students not only learn theory but also experience a holistic learning process, from planning to evaluating project results.

This approach encourages students to work in teams, collaborate and communicate effectively, thus honing their social skills. In addition, PjBL also provides opportunities for students to think critically in dealing with real problems, design creative solutions, and evaluate the impact of

these solutions (Afifah et al., 2020). However, to implement PjBL effectively, it requires support from various parties, including teachers trained in this methodology and adequate infrastructure (Wiyati, 2024). Thus, PjBL is not only an innovative learning method but also a bridge to develop 21st-century skills that are relevant to the needs of today's world (Mu'minah & Suryaningsih, 2020). Through the consistent and planned implementation of PjBL, it is expected that students can be better prepared to face future challenges and contribute positively to a global society.

Project-based learning (PjBL) is a holistic and innovative approach to education, which not only emphasizes mastery of academic material but also promotes the development of important skills such as critical thinking, problem solving, teamwork, and independence. In PjBL, students engage in a structured learning process through a series of stages, from project planning involving problem identification to the implementation of the designed solution (Wardani et al., 2025). During this process, students learn to process relevant data and information and evaluate the results of their projects (Purba et al., 2023). Thus, PjBL encourages students to be more active and responsible for their learning process (Farhin et al., 2023). In addition, PjBL also supports multidisciplinary learning by being oriented towards real products or artifacts, which means that students not only learn theoretically, but also apply their knowledge in a real-world context (Al Fithri et al., 2025). Through investigation and collaboration with classmates and mentors, students can independently construct knowledge and develop essential social skills (Devi et al., 2023). This approach creates a dynamic learning environment where students can exchange ideas and perspectives, thus enriching their learning experience (Setiyawati et al., 2024). PjBL also provides space for students to innovate and be creative in solving problems, which is very important to prepare them for future challenges (Afifah et al., 2019). Thus, PjBL serves not only as an effective learning method but also as a tool to shape the character and skills of the younger generation to be better prepared to contribute to an increasingly complex and interconnected society.

The success of project-based learning (PjBL) is greatly influenced by an appropriate and effective evaluation system of the learning process. Evaluation not only serves to measure the achievement of learning objectives, but also to assess the development of 21st-century skills expected of students, such as critical thinking, collaboration, and creativity (Gunartha, 2024). By conducting a comprehensive evaluation, teachers can understand student progress both individually and in groups, as well as identify areas that require improvement or reinforcement. However, the implementation of project-based evaluation still faces several significant challenges (Ni'mah et al., 2025). One of the main obstacles is the lack of clear and structured guidance for teachers in designing and implementing evaluations that follow the characteristics of PjBL (Irawan et al., 2023). Without adequate guidance, teachers may struggle to determine success indicators and appropriate assessment methods, which may ultimately affect the quality of learning (Efendi & Sholeh, 2023). In addition, limited supporting resources, such as appropriate evaluation tools and sufficient time to conduct a thorough assessment, are also inhibiting factors. Many teachers feel burdened by the demands of a busy curriculum, making it difficult to give full attention to evaluating the PjBL process (Rahmawati, 2023). Therefore, educational institutions need to provide training for teachers on evaluation strategies in PjBL and develop the necessary resources to support the process (Sari et al., 2024). By improving the evaluation system and providing adequate support to teachers, it is hoped that PjBL can be implemented more effectively, so that students can experience the maximum benefits of this learning approach and be ready to face future challenges.

Through bibliometric analysis and the use of the VoS Viewer tool, this study aims to identify trends in the evaluation of project-based learning (PjBL) in the context of 21st-century skills

development over the period 2015-2025. By exploring publication patterns, collaboration between researchers, as well as key topics of interest in the PjBL literature, this study provides a comprehensive insight into the development and application of PjBL methods in education. This analysis will not only reveal the frequency of publications and collaboration networks among researchers but will also highlight critical issues and emerging innovations in PjBL evaluation practices (Izzara et al., 2024). The results of this study are expected to contribute significantly to the development of more effective and relevant evaluation strategies, so as to improve the quality of education and prepare students with the necessary skills to face challenges in the modern era. Thus, this research not only serves as a source of information for academics and educational practitioners but also as a basis for formulating better educational policies in the implementation of PjBL at various levels of education. Through this data-driven approach, it is expected to create a learning environment that is more responsive and adaptive to the needs of students and society.

MATERIALS AND METHODS

Type and Design

Using the keywords Evaluation, Project-Based Learning, and 21st century skills based on journal titles, article data from publications available in Publish or Perish (PoP 8) was filtered. Only works that were utilized from 2015 to 2025, or the last ten years (Gunawan et al., 2023). The study was based on data from articles published in a Google Scholar search. It is open source because Google Scholar searches are based on published data. Then, using Publish or Perish 8 (PoP 8) reference management, collect or obtain research data (Pranata, 2024) . PoP 8 is used to conduct a literature review on the topic discussed in the study (Fikri 2023). The steps in entering it can be seen in the process carried out using the Publish or Perish software (Mudaningrat et al., 2023). The research procedure for bibliometric analysis involves several steps: (i) using PoP 8 software, to collect publication data in the first stage; (ii) processing bibliometric data by entering it in CSV form and converting it into Excel worksheets; (iii) using VoSViewer software to map and perform computational analysis of bibliometric data on third stage; and (iv) perform bibliometric data analysis using vosviewer-assisted publications or data from Google Scholar obtained in January 2024 from literature reviews published between 2015 and 2025. The research is then exported into two file types: Research Information System format (.Ris) and Comma-Separated Values (*.csv). VOSviewer is also used to visualize and assess trends through the use of bibliometric maps. The database comes from articles mapped from various sources (Bagaskara et al., 2024). VoSViewer is used in three ways for publication mapping: network visualization, density visualization, and network-based overlay visualization (shared citations) between existing items (Karimi et al. 2021). Bibliometric maps are viewed based on the frequency of keywords, which are then processed into analytical data to determine the novelty factor of the research topic to be carried out (Klarin, 2024). That's the main advantage of using VoSViewer to view data and statistics from sorting while testing data analysis using bibliometrics and mapping. data under the theme or topic of the searched keyword is taken by processing the search results data from PoP8 and Publish or Perish as a search engine based on the keywords entered.

Data and Data Sources

Data

In this study, the research data utilized consists of descriptive quantitative bibliometric data focusing on project-based learning (PjBL) evaluation trends within the context of 21st-century learning. The data was collected using Publish or Perish version 8 (PoP 8) software, which retrieves and analyzes

academic publication metadata from various scholarly databases such as Google Scholar and Scopus. The descriptive bibliometric approach was employed to identify general characteristics of the existing literature, including publication volume by year, citation frequency, author distribution, and the most frequently occurring keywords related to PjBL and 21st-century skills. This quantitative analysis aims to provide an objective overview of the evolving research landscape, highlight patterns in scholarly productivity, and map dominant topics within the field. Through this method, the study offers a systematic understanding of the extent to which evaluation in PjBL has been explored with 21st-century skill development, while also identifying under-researched areas that present valuable opportunities for future academic inquiry and practical implementation.

Table 1. The number of citations per year from the trend of project-based learning evaluation in 21st-century learning.

Year	Number of Citations
2015	39
2016	37
2017	94
2018	90
2019	85
2020	78
2021	212
2022	79
2023	59
2024	16
2025	0
Total Number Of Citations Per Year	789
Average Citations per Year	71,73

The quantitative data used for data analysis in this study includes the aforementioned bibliometric indicators presented in the form of descriptive data. This research is classified as quantitative due to its reliance on measurable and numerical data, which allows for systematic analysis and objective interpretation of patterns and trends in scholarly publications. By quantifying elements such as publication counts, citation frequencies, author contributions, and keyword occurrences, the study is able to offer empirical evidence that supports the mapping of the intellectual structure and research development surrounding project-based learning evaluation in the context of 21st-century skills. The descriptive nature of the data facilitates a comprehensive overview without manipulation of variables, focusing instead on portraying the scope, distribution, and frequency of existing research outputs. As such, the use of quantitative bibliometric analysis not only strengthens the methodological rigor of the study but also contributes to a deeper understanding of the knowledge landscape and emerging gaps that merit further scholarly exploration.

Source Data

This research data source is used as a basis for identifying project-based learning evaluation trends in the development of 21st-century skills. Data obtained from the search using PoP 8, which aims to

collect articles from leading scientific publications through the Google Scholar database. Thus, it can be concluded that this data source is part of a project-based learning evaluation research pattern in developing 21st-century skills in elementary school studies. A total of 174 articles from the leading international conference and scientific journals have been collected, including basic education, social science, and cultural topics. In addition, situation data is used to produce up to 789 annual data points from related research. This research also collects quantitative data, such as the number of articles published per year, the number of studies on project-based learning evaluation trends in the development of 21st-century skills, as well as the number of writers involved (Duckett, 2021). Bibliographic data search is limited by four criteria: (1) only certain types of journals selected; (2) the word 'learning evaluation', 'based on project', as the title or keyword included in the pop application; (3) keyword '21st century skills development in the search column; and (4) total citations in the journal published between 2015 as many as 39 citations, 2016 as many as 37, 2017 as many as 94, 2018 as many as 85, 2019, 2020 (78 data), 2021 (212 data), 2022 (79 data), 2023 (59 data), 2024 (36 data) and finally data citations up to 2025 as 0. Data collection in this study.

Data collection technique

The data in this analysis is filtered using Google Scholar as the baseline data to acquire data based on trustworthy research findings relevant to the ongoing research. The data collection method utilized in the bibliometric analysis of this study is Pop 8 (Publish or Perish). The method that employs the POP 8 application seeks to observe the findings of the study that was carried out. Furthermore, there are numerous approaches to data collecting with Bibliometric Analysis to investigate the trends in the assessment of project-based learning in the development of 21st-century skills. Upon obtaining all of the acquired data, the vosviewer is utilized to arrange the data to obtain further information.

Data analysis

To identify patterns in the Project-Based Learning Evaluation Trends in 21st Century Skills Development using a bibliometric database. The analysis can be performed following the three steps listed below for research data collection: Using citations from research on Google Scholars, (i) searching for publication data on the topic searched using POP 8 software; (ii) processing bibliometric data in Microsoft Excel to find relevant articles, including authors, titles, year publications, and other details; and (iii) Analyze the mapping of bibliometric data in publications. The articles that follow that, depending on the title of the journal, data from publications available in Pop 8 are filtered using. The keywords 'Learning Evaluation', 'Project-based', '21st Century Skills Development', only works published in the previous ten years, from 2015 to 2025, are used, and all data were obtained in April of that year.

RESULTS

The application of a semantic search database combined with reference management resulted in 174 articles of data that met the research requirements when used for data search. Title, year, journal name, publisher, citation count, article link, and associated URL are among the metadata for the articles collected from the literature review. Only the number, author name, paper title, year of publication, citations, and references are included in the data table and cannot be changed. In Table 1, the published data were collected in Excel and presented in a table using the PoP 8 analysis exemplified. There were 25 articles in the sample data that met the criteria of matching the topics in this study. This study resulted in a total of 789 citations for all articles used, 78.90 citations per year, 4.53 citations per article, and an average of 71.73 authors per article. the table below displays the data:

Table 2. Trends Project-Based Learning Evaluation Trends In 21st Century Skills Development

No	Author	Title	Year
1	M. Moliner, T. Guraya, P. Lopez-Crespo, M. Royo, J. Gámez-Pérez, M. Segarra, L. Cabedo	Acquisition of transversal skills through PBL: a study of the perceptions of the students and teachers in materials science courses in engineering	2015
2	Widya Kartika	Penerapan Model Project Based Learning Untuk Meningkatkan Communication Skills Pada Mata Kuliah Pengembangan Sumber Daya Manusia	2016
3	Jackie W. W. Chan, Vicky C. Tam, Sandy S. Li, J. Pow	The development of an assignment coding guide for evaluating ICT-usage in a 21st Century primary school in Hong Kong	2016
4	P. Brady, John C. Chen, Danielle Champney	Future K-12 Teacher Candidates Take on Engineering Challenges in a Project-Based Learning Course	2016
5	Joseph A. Harsh, John J. Esteb, A. Maltese	Evaluating the development of chemistry undergraduate researchers' scientific thinking skills using performance-data: first findings from the performance assessment of undergraduate research (PURE) instrument	2017
6	Nitce Isa Medina Machmudi Isa, M. Abdullah	Implementasi Pendidikan Berasaskan Hasil (PBH) melalui Pembelajaran Berasaskan Projek (PBPi) untuk Menilai Pencapaian Domain Kognitif Berdasarkan Topik Ekosistem Terancam	2017
7	Sharifah Sariah Syed Hassan, Mohaida Mohin	Curriculum and instructions: towards 21st century teaching and learning	2017
8	W. D. Dwiyogo	Developing a Blended Learning-Based Method for Problem-Solving in Capability Learning.	2018
9	Sunni H. Newton, Meltem Alemdar, Roxanne A. Moore, Christopher J. Cappelli	An Investigation of Students' Experiences in a K-12 Invention Program (Evaluation)	2018
10	Nittayaporn Kinboon	Enhancing Grade 10 Students' Achievement and the 21st Century Learning Skills by Using Information Based on STEM Education	2019
11	Susilowati, I. Wilujeng, P. W. Hastuti	Development the Sciences Outdoor Learning to Improve Knowledge Competences and Problem Solving Skills of Junior High School Students	2019
12	Elsa Santaolalla, Belén Urosa, Olga Martín, Ana Verde, T. Díaz	Interdisciplinarity in Teacher Education: Evaluation of the Effectiveness of an Educational Innovation Project	2020
13	Erdisna, Ganefri, Ridwan, Raimon Efendi	Developing of Entrepreneur Digitals Learning Model in the Industrial Revolution 4.0 to Improve 21st Century skills	2020
14	P. Nilsook, Pinanta Chatwattana, Thapanee Seechaliao	The Project-based Learning Management Process for Vocational and Technical Education	2021
15	Tahani Salman Alrajeh	Project-based Learning to Enhance Pre-service Teachers' Teaching Skills in Science Education	2021
16	C. Beinert, N. Øverby, Frøydis Nordgård Vik	Project LifeLab Food and Health – Innovative Teaching for the Future: Development of Student Active Learning Tasks for Home Economics Education in the 21st Century	2021
17	Nurul Hazwani Ariffin, Anis Nazihah Mat Daud, Nur Raihana Mohd Razak, Norazilawati Abdullah, Nurhafizah Hasim	Development of Project-based Learning Module for Ecosystem Balance Theme of Year One Science	2022
18	Hisyam Ihsan	Assessment and Learning Mathematics Integrated 21st Century Competency-Computational Thinking Skills in Junior High School: Partly Detailed and Completed Intervention Stage	2022
19	Liu Jie, Thapana Choicharoen, Suwana Juithong	Effect of Learning Management Using Project-Based Learning on Graphic Design Ability of Sophomore Students at Suzhou Institute of Art and Design, the People's Republic of China	2023
20	R. Setyawati, Binod Prasad, Agnita Siska Kathmandu University,	Construct the Validity of STEM and Project-based Critical Thinking Skills Test Instruments Using the Rasch Model	2023

	Nepalramasdyahsari, Sindi Nur Aini			
21	Rahadian	Sujud, Yuli Rahmawati, Ade Dwi Utami	Development of Science Literacy Through Group Choice STEM-PjBL Projects Integrated with Matter State Changes	2024
22	Muhammad Agil Masruri, Agus Efendi, Sri Sumaryati		Innovative Project-Based Learning Video Tutorial Media: Development and Its Effect on Students Collaborative Skills	2024
23	Citra Dewi, Diani Syahfitri, Hery Setiyatna		Evaluation of the Implementation of Project-Based Curriculum for the Development of 21st Century Skills in Students	2025
24	Shinta Permata Sari, Dian Nugraheni*, E. Hamimi, Novida Pratiwi, Habiddin Habiddin		Development of Project Based Learning STEAM based Water Purifier Educational Kit on Water Pollution to Train Critical Thinking Skills	2025
25	Najdah Sanusi, Hafizhah Zulkifli, Mohd Isa Hamzah		Challenges, opportunities, and effects of alternative assessment approaches in teaching practices: a systematic literature review	2025
26	Faizul Bayani, J. Rokhmat, A. Hakim, A. Sukarso		Research Trends in Analytical Thinking Skills for Science Education: Insights, Pedagogical Approaches, and Future Directions	2025

The data displayed shows the number of samples that have a significant relationship between the desired topic or data with literature search results using the Publish or Perish (PoP) version 8 device integrated with the Google Scholar search engine. The results obtained indicate that there is a match between the keywords used in the search process and the bibliographic data generated by the system. This shows that the quality and accuracy in the selection of keywords is an important foundation in determining the validity and relevance of the collected literature. Furthermore, this linkage reflects the extent to which the search syntax and parameters incorporated into PoP 8 are capable of filtering and presenting data that is precisely targeted for the benefit of literature review or bibliometric analysis. The validity of the data obtained is also further strengthened through the suitability of the topic, study domain, and citation level of each article found. Therefore, the use of PoP 8 is not only as a reference search tool, but also as a strategic support in mapping research trends, measuring scientific impact, and identifying research gaps in certain fields. To expand the scope of the analysis, these results can be further integrated with data visualization applications such as VOSviewer or Biblioshiny to explore the intellectual structure and collaborative networks within the field of study. Thus, the process of collecting and validating data is not only quantitative, but also contributes qualitatively in shaping the theoretical framework and the direction of research development in the future.

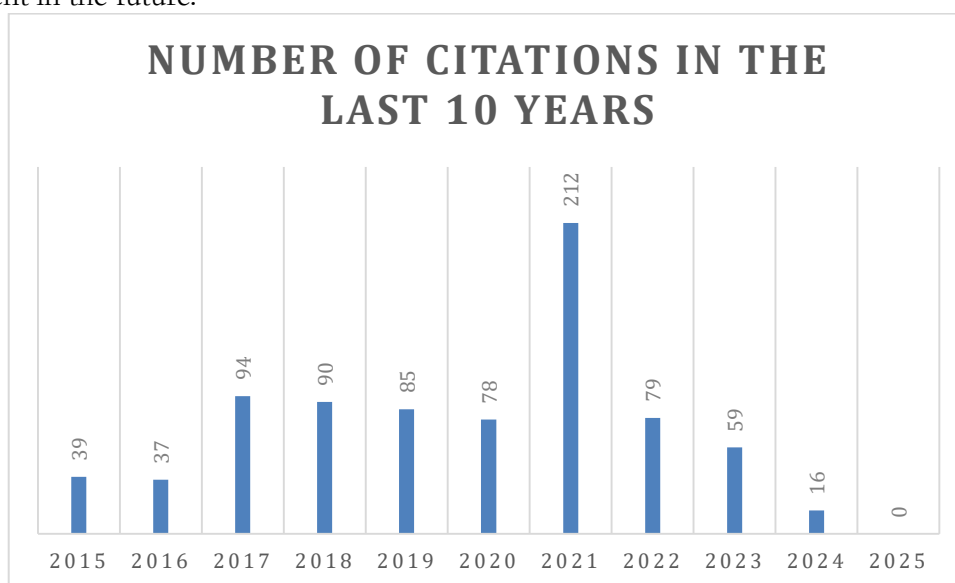


Figure 1. Citation data from the last 10 years of project-based learning evaluation trends in the context of 21st-century skills development

Furthermore, based on research data from 2015 to 2025 regarding trends in the evaluation of project-based learning in the context of developing 21st-century skills. Based on the data shown in Figure 1, 789 citations have been successfully collected through the PoP 8 application. In 2015, there were 39 citations of articles, and this decreased in 2016 to 37 citations of published articles. There was an increase in publication citations starting in 2017, with a total of 94 citations of related article publications. In 2018, it again experienced a significant decline to 90 and then decreased again in 2019 to 85 article citations. Research citations in 2020 experienced a very significant decline, a very significant decline, namely only 78 citations. Publication of articles in 2021 again experienced an increase in citations of 212. In 2022, it again experienced a very significant decline of 79 citations. In 2023, there was another very significant decline, which only reached 59 citations. Furthermore, there was a very, very significant decline to 16 citations in 2024, then a free fall of 0 citations in that span until it impacted in 2025. The latest figure from when this analysis was conducted (Haddow, 2009). The citations in 2025 were 0 citations. From the data analysis, it appears that the research is related to the research (Vandever, 2020). The trend of evaluating project-based learning in the context of developing 21st-century skills is still very rare. done and still needs to continue to be researched

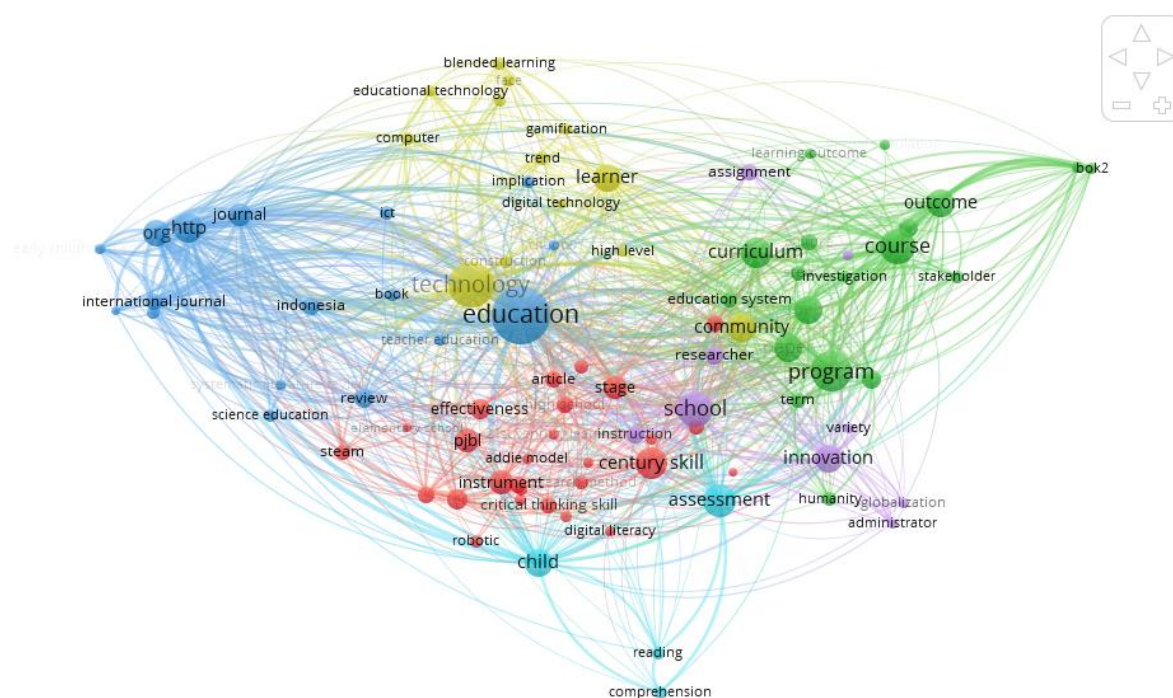


Figure 2. Network Visualization dari Project Based Learning Evaluation trends in 21st Century Skills Development

The figure shows a bibliometric network visualization using VOSviewer software, which maps the relationships between keywords in scientific articles. These networks are formed based on the co-occurrence of terms in a particular data set, such as journal articles or scientific publications. The network visualization generated through bibliometric data processing using VOSviewer software displays the structure of the relationship between terms or keywords that appear in academic literature. In the visualization, 89 items or nodes represent the main terms that often appear in related scientific publications. Each node is linked to other nodes based on the frequency of co-occurrence, which are then grouped into six different clusters. Each cluster is marked with a different color, representing groups of topics that are closely related to each other. The existence of

these six clusters indicates thematic differentiation in the literature, with each cluster focusing on a particular issue or concept within the education and technology domain.

Furthermore, the total link strength recorded at 77,268 reflects the level of intensity of connectivity between items in the overall bibliometric network analyzed. This number is not just a quantitative representation, but a crucial indicator of the density and strength of semantic relations among the keywords, authors, or documents involved. This high value indicates that the literature analyzed has a high level of thematic cohesion-that is, it shows the harmony of ideas, the focus of studies that support each other, and the integration of topics that form a dense and structured knowledge ecosystem. This visualization, obtained through tools such as VOSviewer, not only presents a map of dominant topics in a scientific field, but also reveals the complexity and depth of conceptual relationships between elements of knowledge. By looking at closely connected nodes and clusters formed, researchers can understand the direction of development of academic discourse, find meeting points between disciplines, and identify areas of study that are still fragmented or even unexplored. In the context of scientific development, this finding is of great value because it provides a comprehensive overview of the intellectual structure of the field of study from the center of research attention to the network of interrelations between themes. Thus, visualization based on total link strength not only serves as a navigation tool in literature mapping, but also as a strategic compass in designing the direction of future research that is more integrated and impactful

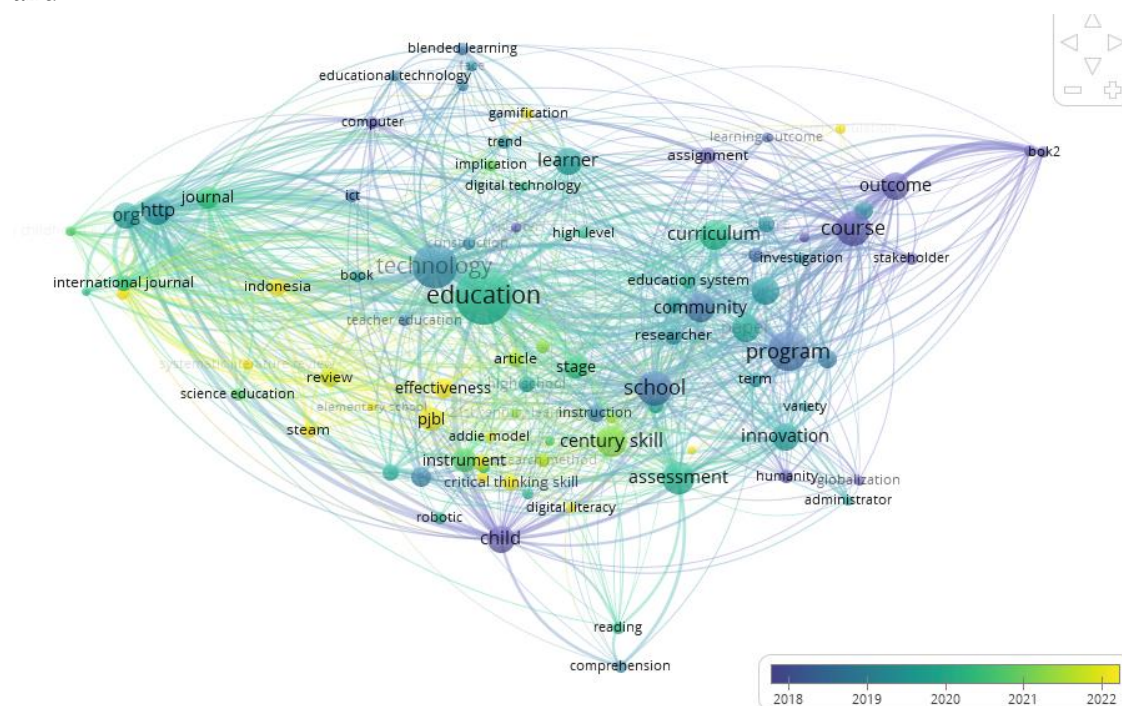


Figure 3. Visualisasi overlay dari Project-Based Learning Evaluation trends in 21st Century Skills Development

Based on the results of bibliometric visualization using VoSViewer, it can be concluded that the educational research trends of the 21st century show a strong tendency towards the integration of learning technology and innovation. Keywords such as education, technology, program, learner, and curriculum occupy a central position in the network, indicating that these themes are the main focus in the literature during the period 2018 to 2022. There are a number of interrelated thematic clusters, including educational technology clusters (such as education technology, digital literacy, and gamification), active learning approaches (such as project-based learning and blended learning), and curriculum and assessment clusters (such as curriculum, assessment, and 21st century skills). Colors

in visualization indicate temporal development, where terms such as gamification, digital literacy, outcomes, and 21st-century skills tend to be more up-to-date (2021-2022), indicating a shift in research focus towards strengthening digital literacy and innovative learning methods. In addition, the Association of keywords such as stakeholder, administrator, and community indicates increased attention to the governance dimension and the role of various actors in the education system. This visualization also shows the integration of global and local perspectives, as seen from the emergence of the term Indonesia and international journal. As such, the findings reflect a new direction in educational research that emphasizes multidisciplinary collaboration, the application of technology, and the development of 21st century skills relevant to the challenges of the Times.

Figure 4. Density visualization Project-Based Learning Evaluation trends in 21st Century Skills Development

DISCUSSION

received consistent attention from academics, especially in the framework of 21st-century skills development. In this density visualization, bright yellow indicates areas with a high concentration of research, while faded or dark yellow that blends into the background indicates areas with low levels of research. In addition, larger keyword circle sizes indicate a higher frequency of occurrence in the literature, as described by van Eck et al (2010) and (Gan et al., 2022). Based on these findings, it can be concluded that evaluating project-based learning in the context of 21st-century skills is a relatively underdeveloped area of study. This scarcity is precisely the main strength in showing the novelty value of this research, which can then become the basis for further development and application in contemporary educational studies (Pranata & Syamsijulianto, 2025). Therefore, it is important to formulate a solid conceptual and methodological framework to fill the void of such studies, so that the results of the research not only provide theoretical contributions but also relevant practical implications in designing project-based learning evaluations that are adaptive to the demands of 21st-century skills.

Based on the visualization results, it appears that the relationship between topics is still very minimal, which opens up great opportunities for new research. One promising area is the evaluation of project-based learning in the context of developing 21st-century skills, especially in the context of education related to the evaluation of learning related to 21st-century skills (Syamsijulianto, 2022). The network visualization also shows that there are other research potentials that have not been widely explored, such as learning evaluation in the context of 21st-century skills and its integration in project-based learning. The light blue color that appears in the digital cluster density indicates the possibility that this approach could make learning more enjoyable. In addition, 21st-century skills also have the potential to be integrated into project-based learning, especially if it is related to the context of education in elementary schools. However, the visualization also shows that research on the evaluation of project-based learning is still very limited, as seen from the low density of color (Pranata, 2024; Pranata et al., 2023; Pranata & Syamsijulianto, 2024, 2025; Syamsijulianto et al., 2024). Thus, there is a great opportunity to develop further studies in the areas of learning evaluation, project-based learning, and the integration of 21st-century skills in primary schools.

Findings from the bibliometric analysis indicate a significant increase in the number of publications related to Project-Based Learning (PjBL) and 21st century skills development over the past two decades. This shows that the world of education globally is increasingly paying attention to project-based learning strategies as an effective approach in equipping students with relevant competencies to face the challenges of the times. The PjBL approach is seen as able to integrate various aspects of contextual learning, such as collaboration, creativity, and authentic problem-solving, that are the main characteristics of 21st-century skills (Ananiadou & Claro, 2009; Chu et al., 2016; Nordin et al., 2022).

Data visualization using VOSviewer software shows the formation of several dominant thematic clusters that are closely interconnected, including "collaborative learning", "critical thinking", "technology integration", and "self-directed learning". The interconnectedness between these keywords is strengthened by the high value of the total link strength, which reflects conceptual coherence and consistent research direction. The cluster shows that PjBL is not only a pedagogic method, but also a space for the integration of various dimensions of the 4C skills Critical Thinking, Creativity, Collaboration, and Communication, which are the foundation of 21st-century education (Chu et al., 2016; Kids, 2019). These findings show that research in this field further strengthens PjBL's position as a bridge for holistic competency development.

Tren bibliometric trends also note a shift in research focus from the application of the PjBL method towards evaluating its effectiveness and impact on 21st-century skill development. In the last five years, there has been great interest in the development of authentic assessment instruments, portfolio assessments, and the use of technologies such as learning analytics and AI-based assessments to measure learning outcomes more accurately and in real-time (Bris et al., 2021; Elliot et al., 2017; “The Wiley Handbook of Problem-Based Learning,” 2019). This reflects the need for an evaluation system that assesses not only the outcome but also the complex and multidimensional learning process. In this context, digital portfolios and technology-integrated projects are becoming powerful alternatives to replace traditional evaluations that tend to be unable to capture the dynamics of transdisciplinary skills.

Nevertheless, some challenges are still a concern. Several studies have identified gaps between the concept of 21st century skills carried out in theory and the implementation of assessments in the field. For example, the evaluation of social-emotional skills, metacognition, and reflective thinking skills still receives less attention in the design of PjBL assessment instruments (Pramesti et al., 2022; Uus et al., 2022). Therefore, it is important to develop a holistic and integrative evaluation framework that is able to represent learning outcomes in cognitive, affective, and psychomotor aspects in a balanced manner.

Overall, the results of this study provide a clear map for policymakers, educators, and researchers to see the dynamics of global trends in the 21st century skill-oriented evaluation of PjBL. In addition, through bibliometric mapping and visual analysis based on VOSviewer, this study opens up opportunities for cross-border and institutional research collaboration, as well as provides strategic direction in designing education policies, curriculum development, and project-based assessment innovations that are more contextual and responsive to the needs of the 21st century.

CONCLUSIONS

This study provides a comprehensive bibliometric analysis of research trends on *Project-Based Learning (PjBL)* evaluation in the context of 21st-century skills development by employing VOSviewer for network, overlay, and density visualizations. The findings reveal a limited yet emerging body of literature, characterized by fragmented publication patterns and prolonged periods of dormancy, indicating that scholarly attention to the evaluation dimension of PjBL remains insufficiently explored. The visualization results highlight a lack of consistent and systematic focus on evaluative frameworks, despite the increasing relevance of PjBL as a pedagogical approach aligned with critical competencies of the 21st century, such as critical thinking, collaboration, creativity, and digital literacy. Notably, the scarcity of existing studies highlights the novelty and significance of this research, indicating a critical gap in the literature that warrants a deeper theoretical articulation and empirical investigation. Therefore, this study lays a foundational pathway for future research to develop robust and contextually responsive evaluation models for PjBL, ultimately contributing to the advancement of effective, skill-oriented education in contemporary learning environments.

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