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Bibliometric Analysis of Trends Project Based Learning (PjBL) Integrated STEM For Twenty First Century Skills Enhancement in Physics Learning

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ABSTRACT (10 PT)

Twenty first century skills are very important skills in learning because these skills are able to prepare individuals to face challenges and opportunities in the future masses. This study aims to analyze the trend of project-based learning (PjBL) integrated in Science, Technology, Engineering, and Mathematics (STEM) to improve twenty first century skills in Physics learning. The method used is bibliometric analysis method. A total of 127 articles were collected through the Publish or Perish (PoP) application based on relevant keywords in Google Scholar indexed journals. The article was processed using the VOSviewer application. VOSviewer mapping results were analyzed and described. The results of this study are that in the last five years (2020 - 2024), STEM-integrated PjBL has become one of the trends in Physics learning in schools. This can be seen from the many articles found about STEM-integrated PjBL. However, research related to STEM-integrated PjBL to improve twenty first century skills in Physics learning still needs to be done.

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INTRODUCTION

Twenty first century skills are very important skills in learning because these skills are able to prepare individuals to face challenges and opportunities in the future masses. According to Perez (2022), twenty first century skills include: (1) learning skills (creativity and innovation, critical thinking, and problem solving; communication and collaboration); (2) literacy skills (information literacy; media literacy; ICT literacy), and (3) life skills (flexibility and adaptability; initiative and self-direction; social and intercultural skills; productivity and accountability; leadership and responsibility). By mastering these skills, students are not only able to solve complex problems, but are also able to adapt quickly to change and are able to work effectively in teams. This is in line with the opinion of Aulia, et al. (2024) who stated that twenty first century skills need to be honed in Education so that students can adapt to changing times and make it easier for them later in the world of work. Therefore, the integration of twenty first century skills in the education curriculum is a strategic move to

create a generation that is ready to face the future with confidence and competence.

Physics learning plays an important role in developing twenty first century skills, because in the process of learning Physics, students do not only learn theory, but students are also trained to conduct experiments, analyze data, and draw conclusions. To develop twenty first century skills in Physics learning, an appropriate learning model is needed and is able to respond to the needs of the times. This is in line with the opinion of Perez (2022) which states that one of the Education components needed in the twenty first century framework is the learning method. The learning model used must be able to integrate creativity, technology, collaboration, and active problem solving. In addition, it is also able to encourage student-centered learning. Thus, students not only master academic knowledge, but also master essential skills to face future challenges.

One of the learning models that is expected to develop twenty first century skills in students is Project Based Learning (PjBL) Integrated STEM. According to Nair (2020); Lee (2019), Dag & Durdu (2017); Barlenti et al (2017); Mursid et al (2022); and Rais et al (2021), PjBL is student centered learning so that PjBL helps students to be able to find creative ideas and solve problems related to their social life. Project-Based Learning (PBL) is a learning model that puts students at the center of the learning process by involving them in real-world projects that are relevant and challenging, this Project-Based Learning (PjBL) learning model emphasizes hands-on experience, active student engagement, and the application of knowledge in real-world contexts (Yani, et al: 2024). This is in line with the opinion of Bell (2010) and Kokotsaki et al (2016) who state that project-based learning (PjBL) is a constructivist learning strategy in which students actively participate in problem-solving activities; the assumption is that students learn best when they are given the opportunity to solve real problems. The steps of PjBL learning according to N.M.Y. Suranti (2017) are: (1) Starting with essential questions; (2) Planning project work rules; (3) Making a schedule of activities; (4) Monitoring the progress of student projects; (5) Assessment of student work; (6) Evaluation of student learning experiences. This is in line with Solihin's (2021) opinion, Project Based Learning (PjBL) is innovative learning that encourages students to investigate, work collaboratively in researching and creating projects that apply their knowledge in discovering new things, are proficient in the use of technology, and are able to solve problems.

In its development, PjBL can be integrated with the STEM (Science Technology Engineering and Mathematics) approach. STEM has been integrated into various learning models, such as inquiry-based learning (Levin & Tsybulsky, 2017), problem-based learning (LaForce et al., 2017), cooperative learning (Aslan-Tutaket al., 2017), and project-based learning (Capraro & Slough, 2013, p. 1). This is in line with the opinion of Erdogan et al (2016) who stated that, in encouraging the ability to design and work on projects, learners must master integrated skills, which include Science, Technology, Engineering, and Mathematics (STEM) simultaneously. According to Altakhyneh & Abumusa, 2020; Retnowati et al., 2020, STEM education aims to encourage learners to have science and technology literacy that is seen from reading, writing, observing, and conducting scientific research. This shows that PjBL is very suitable to be integrated with STEM.

Based on the description above, the author conducted research with the title "Bibliometric Analysis of STEM-Integrated Project Based Learning (PjBL) Trends for Improving twenty first Century Skills in Physics Learning". The purpose of this study is to identify and analyze research trends in the field of Education, especially STEM-integrated PjBL to improve twenty first century skills in physics learning through bibliometric analysis. According to Cavas (2015), organizing and assessing research trends can help us identify interesting trends from the past as well as become a milestone for future research directions.

METHODS

This type of research is library research using bibliometric analysis. According to Ayudha (2021), bibliometric analysis is carried out by looking at the distribution of publications to evaluate the contribution of articles to the advancement of knowledge from various literatures using a statistical approach and can provide a broader understanding of all disciplines. According to Yani (2024), bibliometric analysis allows researchers to evaluate research trends, scientist productivity, collaboration between institutions, and the impact of scientific publications.

This research data collection technique uses secondary data. The research data is in the form of research articles related to STEM-integrated Project Based Learning (PjBL) to improve twenty first century skills. Data collection was carried out using the Publish or Perish application with the keywords "PjBL STEM, twenty first century skills, physics" and the limitation of the search time range for the publication year of the last 5 years, namely between 2020 and 2024. After obtaining 200 articles according to the keywords, the data was then selected with article restrictions in the form of Article, Journal, so that 127 articles were obtained to be analyzed. The article data is exported in RIS format and will be processed using the VOSviwer application. The VOSviwer application is a software that has the ability to visualize and explore the results of bibliometric studies. The following are the data collection and processing steps that have been carried out:

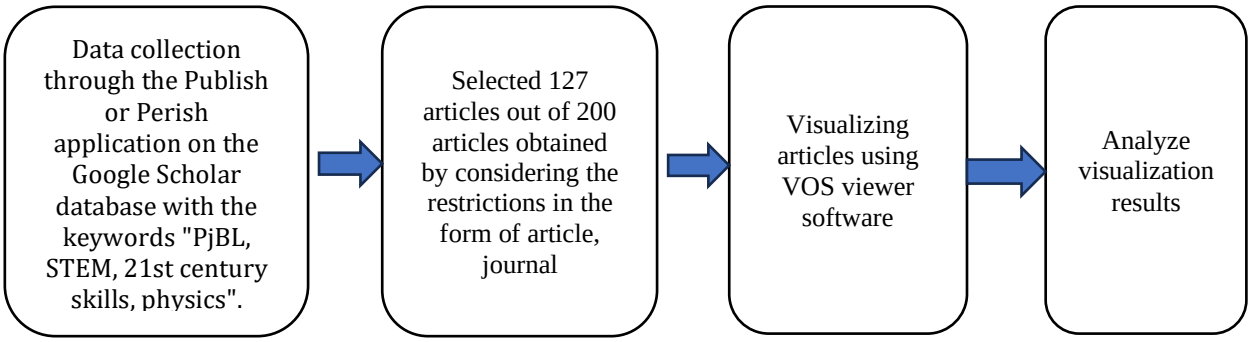

Figure 1. Data Collection and Processing Methode

Figure 1 shows the steps in this research. The first step: collecting data through the Publish or Perish application on the Google Scholar database with the keywords "PjBL, STEM, twenty first century skills, physics". The criteria for articles used in this study are: 1) containing the terms PjBL STEM, twenty first century skills, and physics in the title or abstract, 2) is a research article, and 3) articles published in Sinta or Scopus indexed journals. From the first step, 200 articles related to the keywords were obtained. The second step, selecting 200 articles that have been collected, the selection results obtained 127 articles by considering limitations in the form of articles, journals. The third step is to process the data using the VOS viewer application. According to Yani (2024) data processing through the VOSviewer application can be done in a way: First install the VOSviewer application for free from the VOSviewer web. Next, select the Create menu in the action panel column, then click Create a map based on text data. Set the data source to "read data from reference management files". Then enter the file in RIS format. Finally, select the selected terms, select words that are relevant and irrelevant to the research. The search results in Publish or Perish are saved in RIS format before being imported into VOS Viewer. Files were imported into VOS Viewer, and the color, shape, and size of the display were adjusted before saving in PNG format. The fourth step was to analyze the visualization results from VOSviewer.

RESULTS AND DISCUSSION

Results

The results of literature screening using the Publish or Perish application on the Google Scholar database in the range of 2020 to 2024, found 127 articles on STEM-integrated Project Based Learning (PjBL) to improve twenty first century skills. Total citations 1760 and citations/year 440.00. Table 1, shows some examples of the top articles/publications with the highest number of citations, obtained from the Publish or Perish results used in this study.

Table 1. Top Articles/Publications with the Highest Number of Citations

No.	Citation	Authors	Title	Year
1.	198	K Halim Simatupang, MA Fauzi	The Effect Of Project Based Learning Model With Stem Approach To Students'critical Thingking Skill On Human Excretion	2023
2.	196	R Kurniasari, S Ridho	Analysis of the STEM-based blended project based learning model to improve students' science literacy	2023
3.	194	A Ilhami, T Mahendra	Learning With An Integrated Stem Project Based Learning Model To Improve Students'creative Thinking Abilities	2024
4.	190	BBVÃ Alejandro, FV Mendoza, RGÃF Fredi	Project-Based Learning in the Perception of Stem Subjects and the Improvement of Hard and Soft Skills in University Students	2022
5.	189	OP Angelina, M Maryani	Implementation of stem project-based learning (pjbl) student worksheet through the "otok-otok" boat game on engineering thinking skills	2023
6.	188	C Rochman, D Mulhayatiah, I Sari	Science process skills through PjBL-STEM on global warming concept	2022
7.	185	IM Astra, K Kartini	E-learning based on PjBL integrated to STEM using microsoft sway on parabol motion materials to improve critical thinking ability of high school class X students	2023
8.	183	A Nurramadhani, I Permana	Students generated question quality through STEM based project learning in science activity	2020
9.	161	FW Ginting, IR Lukman, R Andriani, S Tiarani	Analysis of Science Process Skills and Scientific Attitudes of Students in STEM Integrated Project-Based Learning	2022
10.	160	A Al Fatihah, Y Yennita	Application of the PjBL-STEM Model to Improve Science Literacy of Class XI SMAN Plus Student	2023

Table 1. is the sample data of articles used in the study, articles that have been analyzed using bibliometric analysis. The data displayed in Table 1. is data from the ten articles with the

highest citations from 2020 to 2024. The citation value is in the range of 160 - 198. The highest citation was obtained in 2023 with the title "The Effect of Project-Based Learning Model with STEM Approach on Critical Thinking Ability of Class X Students of SMA Negeri 10 Padang". High citation refers to the number or frequency of references or citations received by a scientific work or publication from other authors or research. This indicates that the work is recognized and considered relevant by the academic or professional community in a particular field. The higher the citations of a work, the greater its influence or contribution to the development of science or research in that field. High citations are also often considered an indicator of quality and credibility, as frequently cited works usually include important findings or methodologies that can be applied in future research.

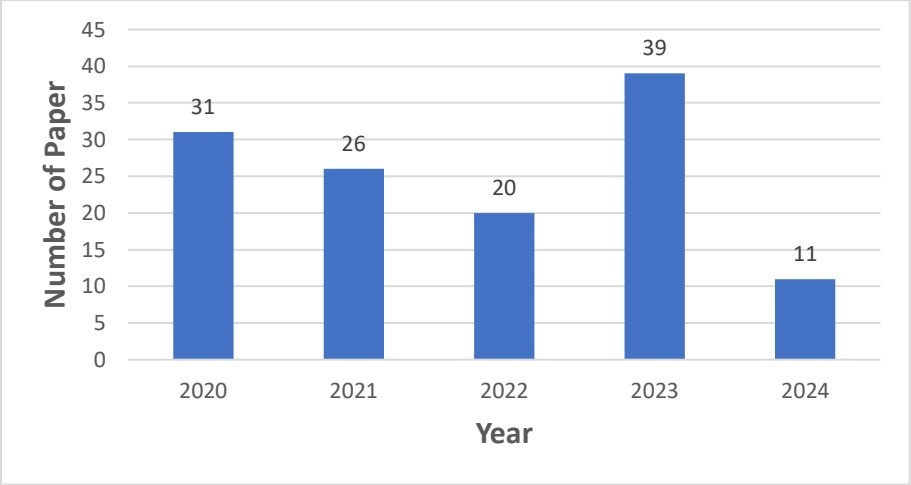

Figure 2. Publication Data of STEM-integrated Project Based Learning to improve twenty first century skills in Physics learning 2020-2024

Figure 2 shows the development of research with the research topic Project Based Learning integrated with STEM to improve twenty first century skills in Physics learning in Googe Scholar or Scopus indexed journals in 2020, 2021, 2022, 2023, and 2024. In 2020, there were 31 articles that discussed PjBL STEM to improve twenty first century skills in Physics learning. Experienced a decrease from 2020 to 2022. However, in 2023 there was a very significant increase of 39 articles, and again decreased in 2024, where only 11 articles examined PjBL STEM to improve twenty first century skills in learning Physics (data taken until June 2024). This explanation shows that Project Based Learning integrated with STEM to improve 21st century skills in Physics learning still has the potential for further research. The results of research on STEM-integrated Project Based Learning to improve twenty first century skills in Physics learning were obtained from keyword analysis of 127 research articles using VOSviewer software. The results are in the form of visualization analysis mapped into three parts, namely Network Visualization, Overlay Visualization, and Density Visualization.

Discussion

Networking Visualization

In the network visualization, items are represented by their label and by default also by a circle. The size of the label and the circle of an item is determined by the weight of the item. The higher the weight of an item, the larger the label and the circle of the item. For some items the label may not be displayed. This is done in order to avoid overlapping labels. The color of

an item is determined by the cluster to which the item belongs. Lines between items represent links. By default, at most 1000 lines are displayed, representing the 1000 strongest links between items (Eck, Nees Jan Van and Ludo Waltman: 2023). The networking visualization results of this research can be seen in Figure 3.

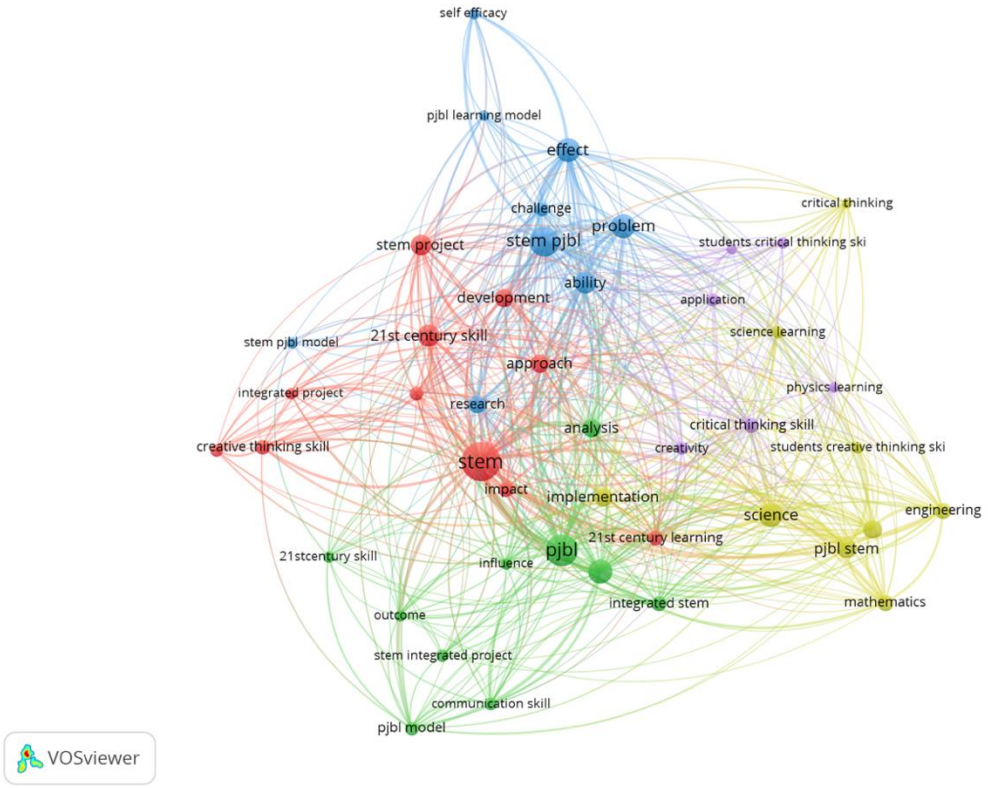

Figure 3. Network Visualization of STEM-Integrated Project Based Learning to Improve Twenty First Century Skills in Physics learning

Based on Network Visualization mapping using VOSviewer software, several relationship parameters between variables can be found. Figure 3 shows the mapping of article keyword similarity results, obtained 5 groups (clusters) according to their respective colors, with 45 keyword terms related to STEM-integrated Project Based Learning to improve twenty first century skills in Physics learning. From the results obtained, the larger the circle on a keyword indicates that the keyword is widely used by article authors and has a strong relationship with other keywords. The distance between two journals in the visualization approximately indicates the relatedness of the journals in terms of co-citation links. In general, the closer two journals are located to each other, the stronger their relatedness. The strongest co-citation links between journals are also represented by lines (Eck, Nees Jan Van and Ludo Waltman: 2023). Figure 3, has the 5 largest circles for each cluster namely STEM, PjBL, STEM PjBL, science, and critical thinking skills which shows that there is a relationship between PjBL and STEM, in other words that STEM-integrated PjBL is one of the learning models that is widely implemented in physics learning. In the STEM cluster PjBL is seen to be related to twenty first century skills, self-efficacy, creative thinking skills, and critical thinking skills, this means that STEM PjBL has been implemented to develop twenty first century skills.

Overlay Visualization

The overlay visualization is identical to the network visualization except that items are colored differently. There are two ways in which items can be colored in the overlay

visualization. If items have scores, the color of an item is determined by the score of the item, where by default colors range from blue (lowest score) to green to yellow (highest score). On the other hand, if items have user-defined colors (specified using the red, green, and blue columns in a VOSviewer map file, the color of an item is determined by the user-defined color of the item. If items have neither scores nor user-defined colors, the overlay visualization is not available (Eck, Nees Jan Van and Ludo Waltman: 2023). The overlay visualization results of this research can be seen in Figure 4.

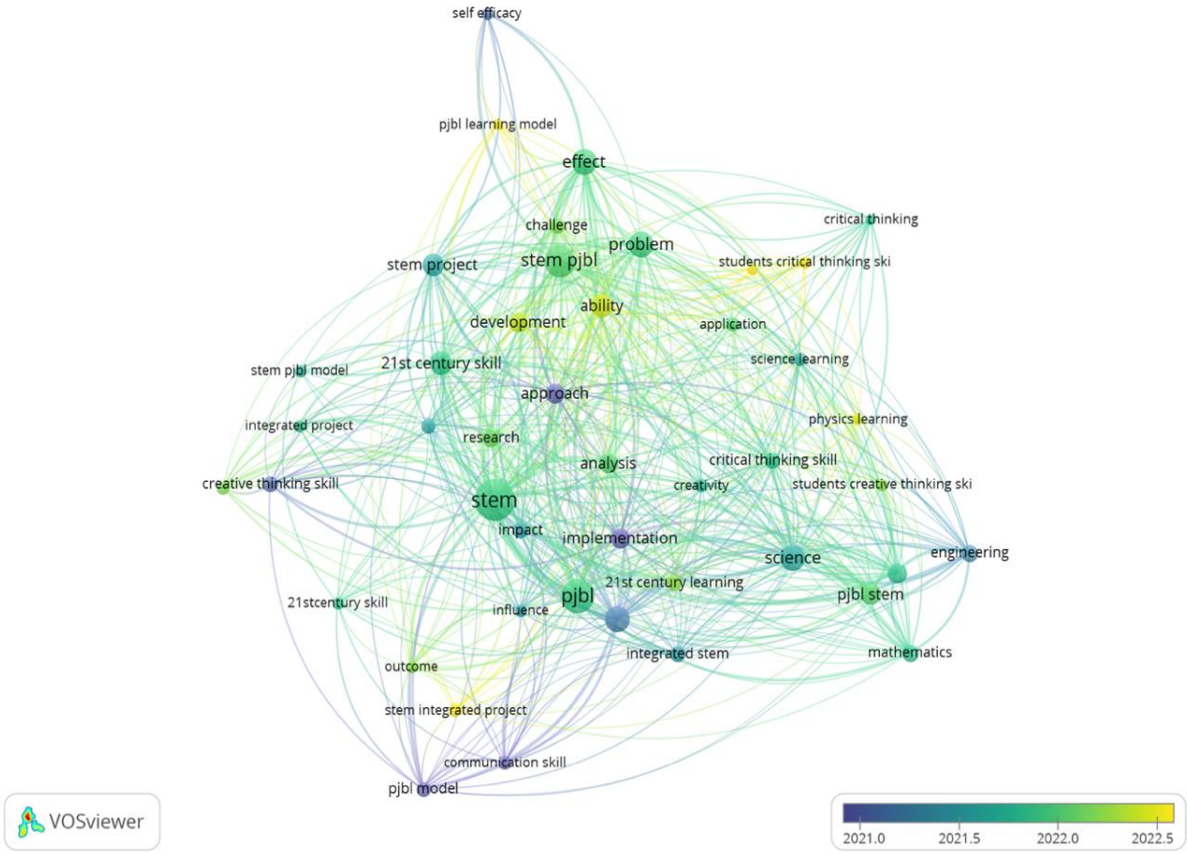

Figure 4. Overlay Visualization of STEM-integrated Project Based Learning to Improve Twenty First Century Skills in Physics learning.

Overlay visualization serves to map the evolution and development of research over time in an intuitive and informative way. We can see how research trends change and how scientific topics are related to each other. Based on Figure 4, there is a spectrum of dark colors and light colors. According to Yu, et al (2020) and Durieux & Gevenois (2010), the darker the color displayed, this indicates that the research using the term has been done for a long time and the lighter the color displayed, the research using the term is new. Based on Figure 4, it can be seen that the current trending research is related to STEM PjBL related to sudents critical thinking skills in physics learning, while research that is no longer trending is about the implementation of the PjBL model.

Density Visualization

Density visualization in bibliometric analysis allows us to understand the distribution of data density within a research network. This density visualization depicts the relative concentration of research activity or the frequency of occurrence of certain entities within a given scientific field. This technique is very useful in identifying research hotspots, namely

areas that have high research activity and have great potential for further development (Yani, 2024). The density visualization results of this study can be seen in Figure 5.

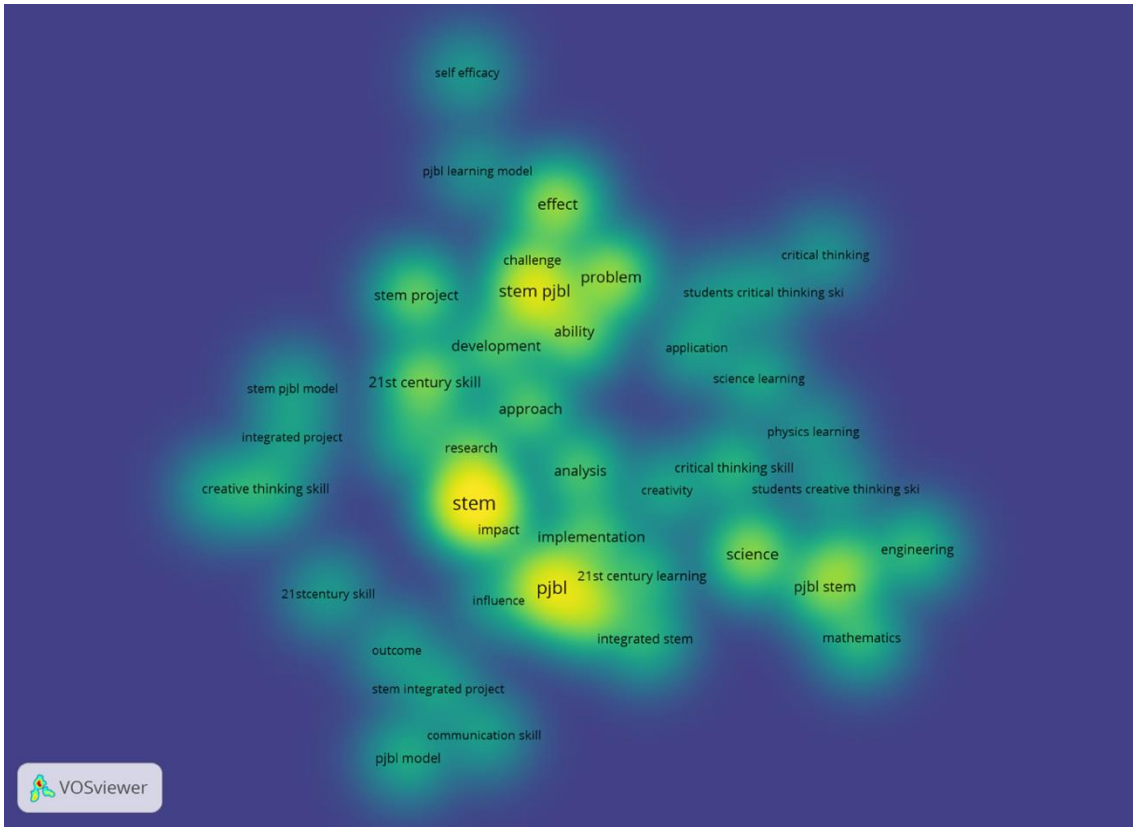

Figure 5. Density Visualization of STEM-integrated Project Based Learning to Improve Twenty First Century Skills in Physics learning.

Density visualization serves to find out how often research using the term is researched. According to Blacer-Bacolod (2022), terms that have a bright and bright background color indicate that the term's research has often been researched, while terms that have a blurred background indicate that the term needs further research. Based on Figure 5, it can be seen that research related to STEM and PjBL has often been done, while research related to STEM-integrated PjBL to improve twenty first century skills in Physics learning still needs further research.

CONCLUSION

Based on the research that has been carried out starting from data collection using the Publish or Perish application, data processing, conducting bibliometric mapping with VOSviewer software, conducting analysis and description, it can be concluded that in the last five years (2020 - 2024), STEM-integrated PjBL has become one of the trends in Physics learning in schools. This can be seen from the many articles found about PjBL integrated with STEM. However, research related to STEM-integrated PjBL to improve twenty first century skills in Physics learning still needs to be done. In the range of 2020 - 2022, related research has decreased. However, in 2023 it experienced a very significant increase and decreased again in 2024. This can be seen from the mapping results with VOSviewer in the Density visualization section (Figure 5). Based on the results of Network Visualization mapping, it is found that STEM integrated PjBL is one of the learning models that is widely implemented in physics learning. In the STEM PjBL cluster, it can be seen that it is related to twenty first century skills,

self-efficacy, creative thinking skills, and critical thinking skills, this means that STEM PjBL has been implemented to develop twenty first century skills. Based on the results of the overlay visualization, it is found that the research that is currently trending is related to STEM PjBL related to students' critical thinking skills in physics learning, while research that is no longer trending is about the application of the PjBL model.

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