

# Project-based Learning in Vocational Education: A Bibliometric Approach

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Received: 25 December, 2022; Revised: 08 March, 2023; Accepted: 18 May, 2023; Published: 08 August, 2023

**Abstract:** The project-based learning (PjBL) paradigm is often considered the most advanced in vocational education. The increasing use of the PjBL paradigm in vocational education is an intriguing topic of study. In line with the rapid growth of information technology, it enables PjBL in vocational education to help students develop problem-solving, critical thinking, and teamwork skills. 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. On November 27, 2022, the Scopus database was searched using project-based learning terms in the title. The second search field appears in the title, abstract, and keywords vocational education or TVET, restricted to journal articles or proceedings and in English to keep them current. This analysis revealed 60 articles in Scopus-indexed journals and proceedings between 2010 and 2022. Dwi Agus Sudjimat from Malang State University, Indonesia, was the most prolific author, having authored four articles on the subject. Indonesia is the nation investing the most in developing PjBL models. According to the thematic data, project-based learning is located in the first quadrant, has high centrality and density, and has well-developed questions related to the study topic. The results of this study show that the project-based learning model that is evolving in vocational education is likely to continue to be an important teaching approach in this field.

**Index Terms:** Bibliometric, learning model, Project-Based Learning, PjBL, Vocational Education.

## **1. Introduction**

Vocational education is a form of education that prepares students for trades, industry, and other practical

occupations. It is designed to provide students with the knowledge and skills they need to be successful in a specific industry or business [1]. The implementation of vocational training is one of the elements of the government's success in improving the quality of human resources, especially in developing skilled workers. Vocational education emphasizes not only the mastery of knowledge but also the mastery of skills [2]. The history of vocational education can be traced back to the 19th century, when the Industrial Revolution increased the number of specialized trades and industries. Many people then began acquiring vocational training through apprenticeships, where they worked with experienced artisans and learned on the job [3]. Vocational education began to be structured and institutionalized with the creation of vocational schools and programs at high schools and universities in the early 20th century. These programs were created to provide students with the necessary skills and information to excel in various jobs and industries [4].

In vocational education, a learning system refers to the techniques and resources used to teach and assess the skills and information required for a specific job or career. Hands-on training, experiential learning, classroom instruction, and instructional resources such as textbooks, films, and simulations can be included. A vocational education learning system aims to provide students with the skills and information they need to be successful in their chosen career, be it a skill such as carpentry or electrical work or an industry such as healthcare or business [5]. While this term refers to the learning model, it also refers to the methodology or method used to teach and assess the skills and information required for a specific job or career.

Whether the learning model is most appropriate for vocational education has long been debated. It is crucial for vocational programs to select the learning model that best suits the goals and needs of their students, as well as the specific careers or professions for which they are being trained. On the other hand, the project-based learning (PjBL) approach is considered the most developed. Students in this model work on real-life projects that challenge them to use the information and skills they have learned throughout the curriculum [6]. This paradigm is seen as a 21st-century vocational education method capable of applying an active learning model. Project-based learning plays a significant role in supporting the reform of professional computer education and has an excellent practical impact on developing innovative skills in students' vital teaching tools [5].

The term PjBL (project-based learning) is used in this study to emphasize the focus on vocational education. For example, the PjBL learning model is applied in vocational high schools in Indonesia, resulting in more active and creative students. This research uses the term "project-based blended learning," which combines the project-based learning model with blended learning [7]. In another study, the term PjBL was also used to find out whether students in higher education vocational cosmetology programs were interested in using Google Classroom with a project-based learning approach in their courses [8]. Likewise, Jang Seung-hwan, from Duksung Women's University, Seoul, Korea, used the term PjBL in his research related to the implementation of PjBL models in vocational education and workforce development in various countries [9].

PjBL is more commonly associated with vocational education, where the focus is on developing technical skills and practical knowledge that can be applied in a specific trade or industry. Additionally, the use of PjBL in this study helps to distinguish it from other forms of project-based learning, such as engineering design projects, community-based projects, and service-learning projects, which may have different goals and outcomes. By using the term PjBL, this study emphasizes the specific application of project-based learning in vocational education, highlighting the unique challenges and opportunities that arise in this context. Both PjBL and PBL involve students working on projects, PjBL emphasizes the development of technical skills and practical knowledge in a specific trade or industry, while PBL focuses on developing critical thinking and problem-solving skills through the process of working on a complex problem or challenge. On this basis, the term PjBL is used because it is more in line with the philosophy of vocational education.

The rationale for this study is to analyze the use of project-based learning (PjBL) in vocational education comprehensively. The increasing implementation of the PjBL model in vocational education is an intriguing research topic as it aligns with the rapid development of information technology [10]. It is in line with the rapid development of information technology, which enables PjBL in vocational education to help students develop problem-solving, critical thinking, and collaboration skills. While providing them with the opportunity to practice the technical skills learned and apply them in a practical context of media media-based learning.

Based on relevant articles, this research work intends to analyze the use of the PjBL model in vocational education comprehensively. In this study, a bibliometric approach is used to provide insight into the structure of the subject, social networks, research trends, and themes. This study aims to review the literature and identify the most important nations, authors, contexts, and sources for project-based learning models in vocational education. The conceptual framework for this review is based on the principles of project-based learning and vocational education. The framework will be used to categorize and analyze the publications, authors, and themes identified in the bibliometric analysis. The framework will enable the analysis of the literature based on these key concepts, identify research gaps, and provide a comprehensive overview of the use of the PjBL model in vocational education. Additionally, this study intends to identify research streams and topics by searching the Scopus database for publications from 2010 to 2022.

## 2. Method

Bibliometrics is a statistical method for collecting and evaluating written knowledge from scientists in books, journals, and other publications [11]. Bibliometric analysis can be broadly classified into descriptive analysis, which focuses on identifying underlying patterns in knowledge generation [12]. It also applies scientific mapping and network analysis methods to demonstrate knowledge-based relationship patterns [13]. In particular, bibliometric studies show recent advances in various areas, as they can provide important information, such as the most popular keywords and authors and the most frequently addressed topics [14].

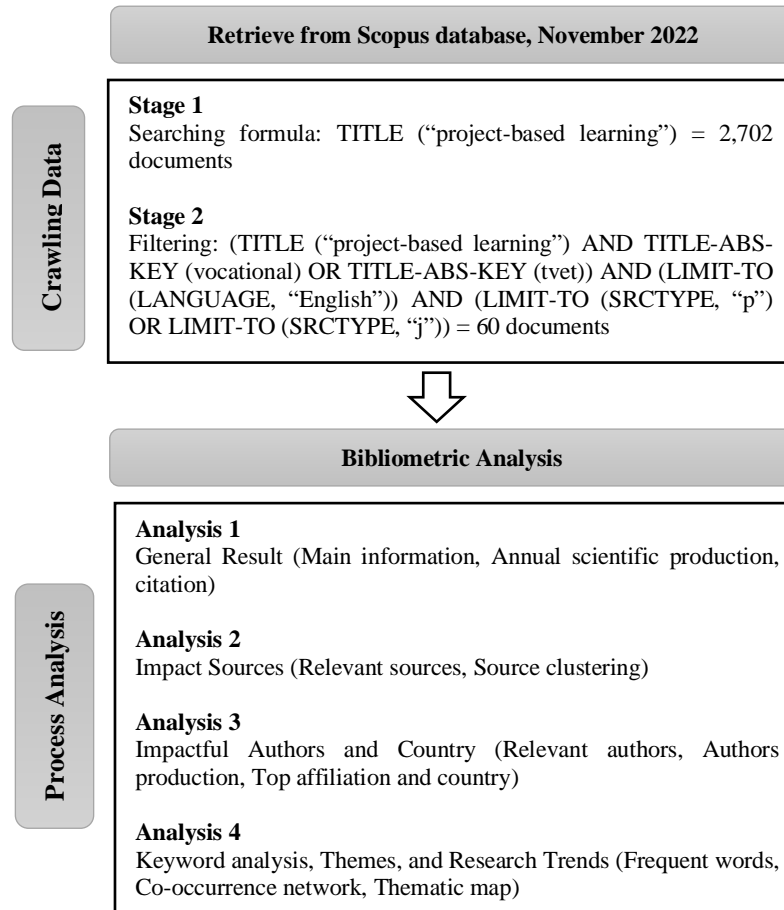


Fig. 1. Bibliometric procedure in Project-Based Learning in vocational

This study used Scopus, a recognized database index that provides complete research results and information. The search was conducted on the Scopus database on November 27, 2022, using the search terms (TITLE ("project-based learning") AND TITLE-ABS-KEY (vocational) OR TITLE-ABS-KEY (tvvet)) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "p") OR LIMIT-TO (SRCTYPE, "j")). The search string consists of compound terms concatenated with the AND and OR operators. The first search field contains project-based learning terms to search in the title. The term vocational or TVET appears in the second search field's title, abstract, and keywords. As a result, all publications on project-based learning at vocational schools were discovered, as shown in Figure 1. We limited our study to journal articles or proceedings in English to keep it relevant.

Consequently, a linked paper entitled "Creative project-based learning approach to promote the creativity of professional high school students" was discovered in December 2022 in the International Journal of Evaluation and Research in Education [15]. According to Usmeldi and Risda Amini, creative project-based learning methods can encourage students' inventiveness concerning products and work attitudes. Other research by Seung-Hwan Jang, in his article titled "Case analysis of overseas countries in project-based learning for vocational education and human resources development", published in April 2022 in the International Journal of Emerging Technology and Advanced Engineering, describes project-based learning as an educational method that can effectively develop future skills, such as 4C or 21<sup>st</sup>-century skills needed in vocational training.

This study used Bibliometrix, created by Aria and Cuccurullo and coded in the R programming language, to conduct quantitative research in bibliometrics [16]. It contains essential statistical and scientific mapping analysis

methods, as indicated in Figure 1 above. The VOSviewer software was used to map the collection of articles [17]. VOS works to display literary data and can visualize written material in picture maps [18].

### 3. Result, Analysis, and Discussion

#### 3.1 General Result

In the first part of this chapter, we deal with the annual scientific output of publications on project-based learning in vocational education and training. From 2010 to 2022, we discovered 60 publications in Scopus-indexed journals and proceedings. Sixty percent are conference papers, and forty percent are journal articles. The modest annual growth rate of 17.6% suggests that this topic is of no interest to researchers. Figure 2 shows the annual number of publications and total citations per year.



Fig. 2. Articles published by year, 2010-2022 (n=60) and mean total citation per year

The article by Utku Kose from Afyon Kocatepe University, Distance Education Vocational School, Turkey, was first published in 2010 and presented at the 2nd World Conference on Educational Sciences, WCES-2010. He developed a web-based method that allows students to learn web design and programming by creating a website using sophisticated tools [19]. The following year, Hsu Yu-Ping presented Technology-Integrated Project-Based Learning in the Classroom at the International Conference on Technology for Education (IASTED) in December 2011 in Dallas, Texas, United States [20]. In particular, this research focuses on developing technology-integrated project-based learning as a resource for technical and professional teachers in higher education.

According to other work by Al-Sarawi et al. (2011), project-based learning is an innovative teaching style that has proven itself in vocational schools [21]. They ensure the explicit development of these skills as part of their course delivery using the educator-developed Research Skills Development (RSD) framework. This research was presented in Bursa, Turkey, during the 7th International Conference on Electrical Engineering and Electronics (ELECO 2011). In 2011, only these two articles were published.

Before 2019, research on the PjBL model could have been more interesting. No relevant research was discovered in 2013 or 2014 either. Due to the development of the PjBL model in traditional education in these years, vocational education research was not yet intensive. In 2019, the number of publications more than tripled compared to the previous year, peaking in 2020 and then declining in 2021 and 2022. It was attributed to the epidemic encouraging researchers to publish more frequently.

For example, a six-citation article that received much attention in 2019 looks at the impact of problem-solving skills-based approaches to learning on learning outcomes. It was developed by Retno N.H.D. et al. (2019) at the 3rd International Conference on Science and Science Education, IConSSE 2019, Salatiga, Indonesia. They claim that project-based learning approaches could be used as an alternative for teachers to conduct their learning, foster an active learning environment, and improve students' skills. Other research by Edy et al., highlighted the impact of project-based learning on online learning in VET at the 4th International Conference on VET, ICOVET 2020, in 2019 [22]. Analysis

of learning during the COVID-19 pandemic revealed variations and improvements in student learning outcomes. With seven citations this year, this piece has garnered much attention.

Table 1. Articles by subject area (Scopus)

Subject Area	Articles (%)	Most cited articles (DOI)
Social Sciences	24 (20.9%)	10.1016/j.sbspro.2010.03.168
Engineering	22 (19.1%)	10.1109/ACCESS.2020.2992092
Physics and Astronomy	22 (19.1%)	10.1088/1742-6596/1307/1/012009
Computer Science	14 (12.2%)	10.1109/ACCESS.2020.2992092
Business, Management and Accounting	7 (6.1%)	-
Materials Science	5 (4.3%)	10.1109/ACCESS.2020.2992092
Mathematics	5 (4.3%)	10.1109/ICOVET50258.2020.9230137
Arts and Humanities	4 (3.5%)	-
Decision Sciences	4 (3.5%)	10.1109/ICOVET50258.2020.9230137
Energy	2 (1.7%)	10.1109/ICASET.2019.8714463
Other	6 (5.2%)	10.1016/j.sbspro.2010.03.168

The Scopus database classified the subject in Table 1. The top 3 disciplines are social sciences (20.9%), engineering (19.1%), and physics and astronomy (19.1%). The publication of Utku Kose from Afyon Kocatepe University is an essential publication in the field of science, with 23 citations [19]. As mentioned, his study was the first to appear in the 2010 Scopus database. It was published in *Procedia: Social and Behavioral Sciences*. He has developed a web-based system for students to learn web design and programming.

Meanwhile, Dogara et al. (2020) cited PjBL ten times in their study to establish a conceptual PjBL framework for soft skills integration among college students. They pointed out that the government should provide appropriate facilities for PjBL activities to improve soft skill integration. The factors identified by PjBL should be incorporated into soft skills teaching and learning in technical institutes to successfully integrate soft skills into students lives. Publications by Retno et al. (2019) have attracted considerable attention in physics and astronomy, having been cited six times. This paper, published in the *Journal of Physics: Conference Series*, reviews the impact of physics problem-solving skills through project-based learning on college students.

There may still be gaps in research on project-based learning methods in vocational education after 13 years. Research on PjBL in vocational education can be costly and time-consuming for several reasons, such as those listed above. Funding sources are required to conduct a meaningful study of the effectiveness of this vocational education paradigm. Another reason is that PjBL is very tough on vocational education from a pragmatic point of view. For example, regulating some factors that might affect student learning in a project-based context is possible. In the future, however, more relevant research will be carried out regarding the possible use of PjBL in professional settings, especially concerning technological advances.

### 3.2 Impact Sources

Document analysis analyzes the intellectual structure of a knowledge topic by determining the amount and authority of the referenced literature. Table 2 shows the ten most cited articles according to Scopus citation data.

Table 2. Top ten most cite documents in PjBL vocational education

Reference	DOI	Source	Global Citation	TC per Year
Habók et al. (2016)[23]	10.1186/s40064-016-1725-4	SpringerPlus	39	5.57
Utku Köse (2010)[24]	10.1016/j.sbspro.2010.03.168	Procedia - Social and Behavioral Sciences	23	1.76
Dogara et al. (2020)[25]	10.1109/ACCESS.2020.2992092	IEEE Access	10	3.33
Ardi Marwan (2015)[26]	-	Turkish Online Journal of Educational Technology	9	1.12
Edy et al. (2020)[27]	10.1109/ICOVET50258.2020.9230137	4th International Conference on Vocational Education and Training, ICOVET 2020	7	2.33
Jalinus et al. (2020)[28]	-	International Journal of Innovation, Creativity and Change	6	2
Retno N.H.D et al. (2019)[29]	10.1088/1742-6596/1307/1/012009	3rd International Conference on Science and Science Education, IConSSE 2019	6	1.25
Viswambaran et al. (2019)[30]	10.1109/ICASET.2019.8714463	2019 Advances in Science and Engineering Technology International Conferences, ASET 2019	6	1.50
Maulana et al. (2019)[31]	10.3991/ijet.v14i15.10305	International Journal of Emerging Technologies in Learning	6	1.50
Leksono Edy et al. (2020)[32]	10.1109/ICOVET50258.2020.9229921	4th International Conference on Vocational Education and Training, ICOVET 2020	5	1.66



In particular, Habok et al. (2016), Utku Kose (2010), and Dogara et al. (2020) each received a total of 72 citations in Scopus and were rated as the three most cited articles. The study by Habok et al. (2016) examines teachers' perspectives on the methods, roles, and effectiveness of project-based learning [23]. The research is based on accurate primary and vocational secondary school data. Most educators preferred project-based methods, and oral assessment was one of the main methods to actively involve students in the assessment process. Utku Kose (2010) describes a web-based system designed and built to support project-based learning activities in vocational schools, offering a web design and programming course [24]. According to the results, the students received a well-designed web-based system and a strategy used for project-based learning activities. Students' overall academic performance has the potential to improve significantly when they use the method.

Dogara et al. (2020) establish a conceptual PjBL framework for integrating soft skills in technical college students when they are in third place [25]. According to the results of the study, the PjBL preparation (planning), application, obligation, and evaluation approach has a positive influence on the development of soft skills among students at universities of applied sciences. They found that encouraging project-based learning has a significant but negative association with soft skill integration among students in higher education.

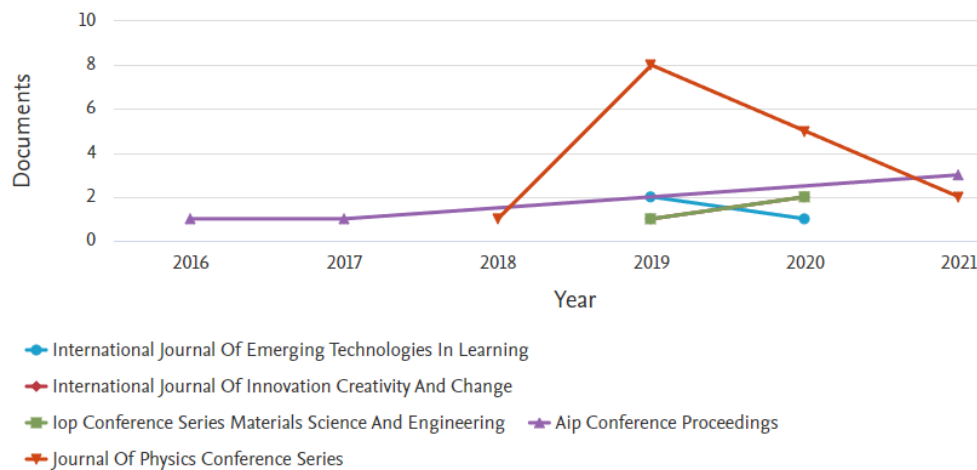


Fig. 3. Top five most source in PjBL vocational education research

The year 2010 marked the beginning of research on the use of PjBL in vocational education. The development of this study, on the other hand, only started in 2016, when UNESCO published its Strategy for Vocational Education and Training (2016-2021) [33]. Education, training, and skill development in various professional fields, production services, and lifestyles are included in vocational education. For this reason, vocational education has evolved into Technical and Vocational Education and Training (TVET), which includes various work-related programs.

The vast majority of sources relevant to this research are in the form of conference proceedings. As mentioned, conference papers account for about sixty percent of all work done on PjBL related to vocational education. According to the data, since 2018, the Journal of Physics Conference Series has been the most productive venue, where 16 documents have been produced as conference papers. The article that has had the most significant impact is that of Retno N.H.D. and his colleagues, and presented at the 3rd International Conference on Science and Science Education held in 2019 in Salatiga, Central Java, Indonesia [34]. They spoke about the impact that being able to solve physics problems with PjBL can have on the overall learning outcomes of students at vocational high schools in Surakarta, Indonesia. As a result, there is an interaction effect between learning techniques and problem-solving ability regarding cognitive learning outcomes. They suggested that project-based learning approaches could be used as an option for trainers to conduct their learning in an active learning environment. This research has been cited six times in Scopus and published in the Journal of Physics: Conference Series, Volume 1307.

PjBL in Indonesian vocational high schools formed part of the topics that Sudjimat et al. (2018) investigated for their research on the Mechanical Engineering Study Program in Malang. The findings indicate that vocational teachers have applied PjBL in terms of planning, the actual execution of learning, and the assessment of that learning. Because the teachers have not incorporated the industry in the creation of the projects, and because the projects themselves are rather straightforward, the end results of the projects cannot be used or sold. At the 1st International Conference on Vocational Education and Technology, which took place in Bali, Indonesia, in 2018, this study was presented and published in the Journal of Physics: Conference Series Open Access Volume 1165.

The second-place source for this study was also an article from a conference that appeared in AIP Conference Proceedings. On the other hand, only five publications were identified here, in contrast to the Journal of Physics: Conference Series, which published sixteen articles. The publication by Rahmawati et al. (2021), presented at the 2nd Science and Mathematics International Conference: Transforming Research and Education of Science and Mathematics in the Digital Age, SMIC 2020, describes the STEM approach to developing critical thinking skills at vocational high schools in the province of Banten in Indonesia through the use of project-based learning [35]. The results indicate that

implementing projects in pre-existing educational settings positively impacts student engagement, motivation, teamwork, and creativity.

A total of three articles were published in the *International Journal of Emerging Technologies in Learning* and the *International Journal of Innovation, Creativity, and Change*, both of which are in the top 5. Although they do not contain conference papers, these two journals only appeared in 2019-2020. Outside of that year, there were no articles that were related to this study. Publications regarding developing project-based learning tools for local network device installation, Maulana et al. (2019) wrote an article published in Volume 14 of the *International Journal of Emerging Technologies in Learning* [36]. The conclusion that can be drawn from this research is that the value is 85.75%. It is very beneficial to learn to install local area network equipment using this model and use it as a reference model for other topics. This article has been cited six times in Scopus, making it the publication that contributed the most.

Jalinus et al. (2020), in the *International Journal of Innovation, Creativity, and Change*, Volume 11, compared project-based learning models to direct instruction of welding skills and collaborative skills among vocational students [28]. This study shows that due to the different competency ratios of hard skills and soft skills that students possess in a project-based learning model, implementing different learning models is very well suited to 21st-century learning that prioritizes student learning outcomes over soft skills. Scopus referenced this article six times.

### 3.3 Impactful Authors and Country

Project-based learning is a type of education that focuses on hands-on, experiential learning[37,38]. Students in this form of learning are given a problem or challenge that they need to address to work together to find a solution[39]. John Dewey, recognized as the father of experiential learning[40,41], and Milton Chen[42], known for his work on the importance of students taking an active role in their learning, are two authors who have made significant contributions to project-based learning.

Table 3. Top five most productive authors in PjBL vocational education research

Authors	Affiliation	Country	Number Article	Most Cited Article (DOI)
Dwi Agus Sudjimat	Universitas Negeri Malang	Indonesia	4	10.29333/IJL.2021.14111A
Gimba Dogara	Kaduna State College of Nursing and Midwifery	Nigeria	3	10.1109/ACCESS.2020.2992092
Yusri Kamin	Universiti Teknologi Malaysia	Malaysia	3	10.1109/ACCESS.2020.2992092
Syahril	Universitas Negeri Padang	Indonesia	3	-
A.Ana	Universitas Pendidikan Indonesia	Indonesia	2	10.30880/jtet.2020.12.02.006

The five most prolific authors addressing the adoption of PjBL in vocational education are listed in Table 3 above. Very intriguing; Indonesian authors are the most active in this field. Dwi Agus Sudjimat from Malang State University was the most prolific author, having authored four papers on the subject. Sujimat et al. (2020) found that vocational school teachers prepare projects ranging from simple to complex workpieces in their study of applying the project-based learning paradigm in the vocational high school [43]. Ten 21st-century workforce characteristics were identified and incorporated into the execution of the model. Scopus has referenced this article four times.

Gimba Dogara of Kaduna State College of Education in Nigeria and Yusri Kamin of Universiti Teknologi Malaysia are the second and third most prolific contributors, respectively, with three Scopus writings. Their collaboration on establishing the PjBL framework for integrating soft skill in college students was cited ten times on Scopus [44]. This study found that project-based learning support has a strong but unfavorable association with soft skill integration among college students. According to Dogara et al. (2020), the government should provide appropriate facilities for appropriate PjBL activities to enhance soft skills integration.

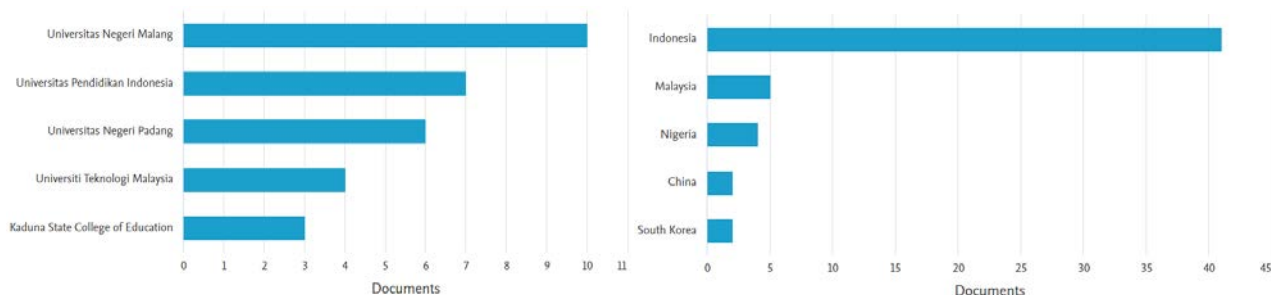


Fig. 4. Top five affiliations and countries in PjBL vocational education research

This study shows that Indonesia is the country that invests the most in the development of PjBL models, be it in vocational schools or universities. According to the Scopus database, the top five affiliations on this subject come from Indonesia. Universitas Negeri Malang, Universitas Pendidikan Indonesia, and Universitas Negeri Padang published ten, seven, and six articles in Scopus, respectively (Figure 4). The most exciting article by these three members is the article by Edy et al. (2020), discussing the impact of project-based learning on online learning in VET during a pandemic [45].

Online learning with project-based learning is a step toward solving the practical knowledge problem. This article was presented at the 4th International Conference on Vocational Education and Training, ICOVET 2020, and has been cited seven times on Scopus.

As a result, it was evident that Indonesia has played an essential role in research connected to the PjBL model in vocational education. Figure 4 demonstrates that, of the 60 papers identified in the Scopus database connected to this research, Indonesia is the most prolific nation with 41 publications, followed by Malaysia with 5, Nigeria with 4, and China and South Korea with 2. Vocational education seems to be an essential tool to educate students for the workforce and to assist in fulfilling the needs of the country's increasing economy in Indonesia. In recent years, the Indonesian government has made efforts to strengthen and expand vocational education, mainly via collaborations with companies and industries to give students appropriate training and employment possibilities [46].

### 3.4 Keyword Analysis, Themes, and Research Trends

Keyword analysis is a well-known bibliometric research tool [47]. Researchers use this strategy to find trends and patterns in research by analyzing the keywords or phrases used in a group of publications. This can be achieved by calculating how often a given keyword appears in publications and comparing it to other keywords to see which ones are used more frequently. Keyword analysis can provide essential insights into the research environment of a subject. These data can be used to guide future studies and identify gaps in the literature [48, 49]. We perform a keyword analysis of the 60 papers found in this part, including common terms, word clouds, and topic trends. Bibiloshiny is used for process analysis and VOSviewer for visualization.

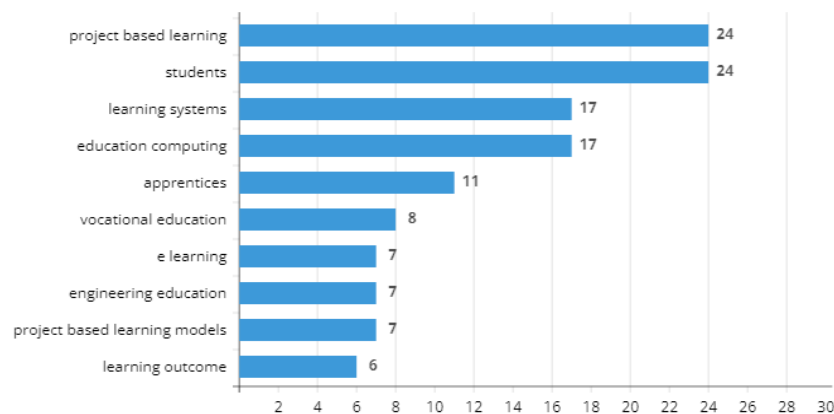


Fig. 5. Top ten words in PjBL vocational education research

We find the terms that occur most frequently on a topic with the keyword plus [50]. Keywords plus are terms or phrases that often appear in an article's references but not in the article's title. Keyword Plus is considered more trusted for author keyword searches because it expands the capacity of citation searches by searching across disciplines for all publications that citation references have in common [51].

Table 5 shows the keyword plus based on the number of terms in the top ten most used words. Students and project-based learning are the most common (24 times). Learning systems were named 17 times, educational computers 15 times, and apprentices 11 times. Vocational training is now the sixth most common, with 11 instances. It is fascinating to see the term apprentice appear in this study. This is likely because apprentices can gain hands-on experience and learn from someone with the skills and understanding of the subject. As can be seen, research on the PjBL model in vocational education relies heavily on the use of technology and computer tools in the classroom. This could improve the PjBL learning system at vocational schools.

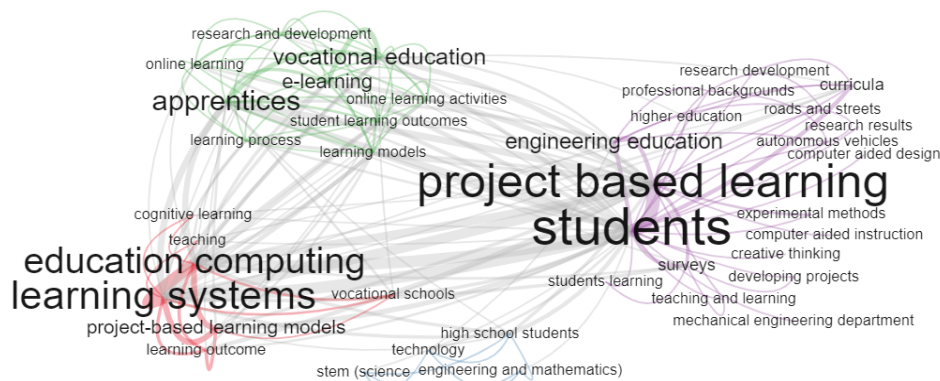


Fig. 6. Co-occurrence Network in PjBL vocational education research



Figure 6 depicts the co-occurrence network at 50 nodes based on 60 reviewed publications on the subject. Each entity is represented as a node in a co-occurrence network. The connections between the nodes indicate the interactions between the entities. Four significant clusters are interconnected. By evaluating these links, we can find patterns and trends in the data and gain insights into the research environment.

The core of Cluster 1 is "Learning Systems" and "Education Computing," which is red. In contrast, learning systems are computing systems that use artificial intelligence (AI) and other sophisticated technologies to enable computers to learn and improve their performance on a specific task without being explicitly programmed [52]. Education computing, on the other hand, is a branch of technology that focuses on using computers and software to support and enhance teaching and learning. In educational computing, learning systems can be used to support and improve the learning process [53]. For instance, a learning system could customize each student's learning experience by offering personalized feedback and suggestions based on their specific needs and progress. For example, Ting-Ting Wu of the National Yunlin University of Science and Technology in Taiwan has developed a mobile assistant learning system to help nursing students prepare health education materials [54]. The results show that the system and the learning technique can improve learning effectiveness and efficiency, and students and teachers are enthusiastic about it.

Cluster 2 in blue has the fewest nodes and focuses on high school students and STEM (science, technology, engineering, and math). This cluster suggests that PjBL impacts high school students, mainly those studying STEM. Project-based learning and STEM are related because project-based learning is a teaching style that can be used to teach STEM subjects. However, Chang et al. (2022) noted that integrating STEM into PjBL is still challenging and that its pedagogical values have not been demonstrated [55]. This combination provides students with favorable educational qualities (such as learning acquisition, achievement, and cognition) while presenting learning challenges.

The most frequently identified terms were apprentices, vocational training, and e-learning in cluster 3 (green). Vocational education and apprenticeships are closely linked. Apprenticeship is a type of vocational training in which people learn a trade through a mixture of classroom instruction and on-the-job training under the guidance of a trained person. According to Deutscher et al. (2018), post-VET apprenticeship performance is typically linked to program efficiency. It suggests that vocational education has a significant impact on the development of learners' professional knowledge and skills [56].

It can also be observed that in this cluster, vocational education is linked to e-learning. Online learning, often called e-learning or distance learning, can be used to provide professional education. Individuals can acquire the skills and information needed for a specific job or career from the comfort of their own home or any other location with an Internet connection through online vocational training programs [57]. Online learning has become more difficult for vocational education institutions that rely on hands-on classes during the epidemic. In order to ensure that students can still access the lessons, teachers and institutions must provide a variety of learning formats and digital platforms.

Finally, the most relevant terms in this bibliometric study are "project-based learning" and "students" in the final purple cluster. PjBL is considered a successful way to engage students in learning because it allows them to explore topics that are relevant and meaningful to them. It also encourages students to take responsibility for their learning and to be more actively involved in the learning process. PjBL engages students in an ongoing, in-depth exploration of a complicated subject or problem and provides them with an opportunity to apply their knowledge and skills to develop a product or presentation demonstrating their understanding of the subject. Carole Ayoub Moubareck from Zayed University in Dubai, United Arab Emirates, conducted the latest study on the impact of project-based learning on Emirati undergraduate students [58]. As a result, the PjBL approach had a more significant impact on teaching students about environmental sustainability than standard lectures. The experiment successfully increased the students' composting knowledge and their desire to continue composting at home.

The results of the co-occurrence network analysis of project-based learning in vocational education show that the two approaches differ. The main difference between project-based learning and vocational education is the emphasis on teaching. PjBL focuses on helping students develop skills and knowledge through real-world projects, while vocational education focuses on training students for specific jobs or skills. Consequently, research on these two methods is divided into two clusters. However, both ways can help youth learn and prepare for the future. The PjBL implementation can be a helpful tool for professional education, as technological advances help students apply what they learn to real-world projects, develop problem-solving and collaborative skills, and see the connection between their studies and their future employment.

To deepen the analysis of the application of PjBL in vocational education, we used keywords based on Elsevier's Fingerprint in SciVal to capture the trend of PjBL research in Scopus in this period [59]. Text mining by Elsevier's fingerprinting engine found document titles, abstracts, and author keywords. A list of common keywords was created by comparing keywords with one thesaurus covering all fields. Keyphrases are checked against a unified thesaurus spanning all major disciplines to produce a list of standardized vital phrases. The results of an examination of keyphrases for the five most important keywords are depicted in Fig. 7, with blue representing project-based learning, purple representing vocation, a red triangle representing vocational education, yellow representing education computing, and a red box representing the learning model. These five keyphrases are the most common in this analysis each year.

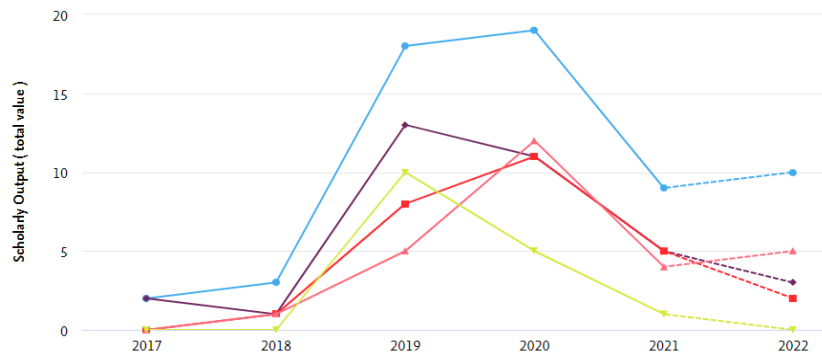


Fig. 7. Keyphrases Related PjBL Vocational Education Research

The five-year graph shows the same pattern across the five keywords. Figure 7 shows that research on PjBL has begun to grow since 2018, along with research in vocational education, educational computing, and learning models. Researchers have recognized the potential of PjBL to enhance the development of technical skills and practical knowledge in vocational education, as well as encourage collaboration and teamwork among students. Several studies have investigated the effectiveness of PjBL in vocational education, especially in fields such as engineering, computer science, and health. A creative project-based learning model that is valid, practical, and effective is proven to improve vocational students' competence in mastering electricity [60]. In another study in China, vocational college teachers guided students to use a single-chip microcomputer as the core control module of an electric vehicle model through project-based learning to optimize electric vehicle design [61].

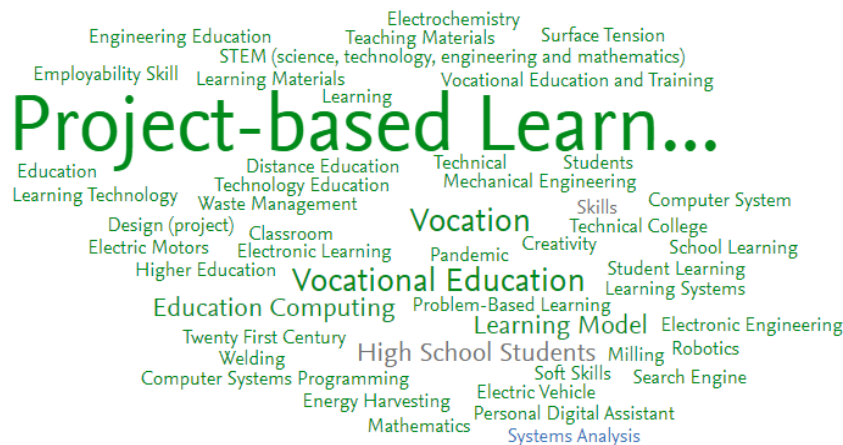


Fig. 8. Wordcloud Related PjBL Vocational Education Research

Based on the keyphrases generated, Figure 8 shows the wordcloud of the entire set of keyphrases so that the interrelated research themes can be identified. It can be seen that project-based learning is highly related to vocational education and related majors. The wordcloud also shows that educational computing is quite prominent, along with vocational education or learning models. Educational computing involves the use of various technologies such as computers, software, and the internet to support teaching and learning, while PjBL is an active learning approach that involves students working on real-life projects that challenge them to use the knowledge and skills they have acquired throughout the curriculum. The integration of PjBL and educational computing aims to enhance the benefits of both approaches to improve learning outcomes and student engagement in the learning process. The use of educational computing in PjBL can facilitate the development of students' technical skills, encourage collaboration and teamwork, and give them practical experience in the use of various technologies.

To complement this research, we used thematic maps to look at current emerging trends. Thematic maps evaluated with Biblioshiny emphasize project-based learning as a learning system that evolves in vocational education. As shown in Figure 9, the thematic map breaks down the identified themes into strategic charts based on density (y-axis) and centrality (x-axis). The centrality of the chosen theme defines its importance, while the density represents its development. Issues appearing in the lower left corner are either evolving or declining. The fundamental or transversal themes are those that appear in the lower right corner of the thematic map. These topics have low density but high centrality. Many studies have been conducted on these subjects. The upper left half has high density but lower centering. These themes are well-developed yet separate. The upper right corner denotes dense and central. The topics in this section are developed and basic motor themes.

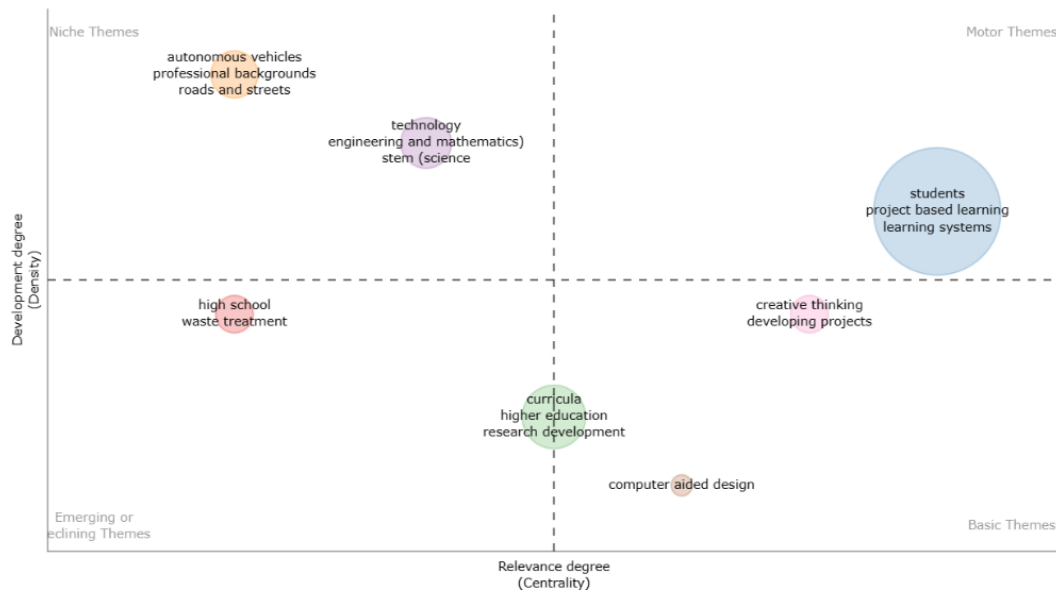


Fig. 9. Thematic map in PjBL vocational education research

These results indicate that project-based learning is in the first quadrant (Q1, motor theme, top right), has high centrality and density, and has well-developed themes important to the subject of study. It makes PjBL very useful in vocational education as it allows students to apply what they have learned in the classroom to real-life circumstances, which can help them see the relevance and value of their education. Students can be supported to develop the skills needed for professional success, such as problem-solving, collaboration, and communication. PjBL research will grow in a variety of courses in the future as it can become a powerful tool for vocational education teaching and learning, enabling students to build the skills and knowledge they need to thrive in their chosen profession.

#### 4. Conclusion

This study extends the previous reviews on PjBL by utilizing a bibliometric approach to comprehensively analyze the use of the PjBL model in vocational education. The bibliometric approach provides insight into the structure of the subject, social networks, research trends, and themes. By searching the Scopus database for publications from 2010 to 2022, this study aims to identify the most important nations, authors, contexts, and sources for project-based learning models in vocational education, as well as research streams and topics. This analysis revealed 60 articles in Scopus-indexed journals and proceedings between 2010 and 2022. 60% of the articles are conference papers, while 40% are journal articles.

The low annual growth rate of 17.6% indicates that scientists are not interested in this area. Utku Kose of Afyon Kocatepe University Distance Learning Vocational School in Turkey wrote the paper, which was first published in 2010. Before 2019, PjBL modeling research may have been more intriguing. No relevant research was identified in 2013 and 2014. Compared to the previous year, the number of publications quadrupled in 2019, peaking in 2020 and declining in 2021 and 2022. Habok et al. (2016), Utku Kose (2010), and Dogara et al. (2020) were cited a total of 72 times in Scopus, making them the three most cited articles. The most fruitful medium was the Journal of Physics Conference Series, where 16 papers were produced as conference papers. Authors from Indonesia are most active in this area. Dwi Agus Sudjimat from Malang State University was the most prolific author, with four articles on the subject. According to the results of this research, Indonesia is the country that invests the most in the development of PjBL models, be it in vocational schools or universities.

According to the Scopus database, Indonesia has the top five affiliations on the subject. The results of the co-occurrence network analysis of project-based learning in vocational education show that the two methods differ. The focus on teaching distinguishes project-based learning from vocational education. According to thematic data, project-based learning is in the first quadrant, has high centrality and density, and has well-developed topics relevant to the study topic. Based on the keyphrases generated, it appears that educational computing is quite prominent, along with vocational education or learning models. This study provides insights into the current state of PjBL in vocational education and highlights the potential of education computing to enhance student learning outcomes. Furthermore, the review suggests that the use of technology, such as computer-based learning, can enhance the effectiveness of PjBL in vocational education.

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**How to cite this paper:** Selamat Triono Ahmad, Ronal Watrianthos, Agariadne Dwinggo Samala, Mukhlidi Muskhir, Gimba Dogara, "Project-based Learning in Vocational Education: A Bibliometric Approach", *International Journal of Modern Education and Computer Science(IJMECS)*, Vol.15, No.4, pp. 43-56, 2023. DOI:10.5815/ijmecs.2023.04.04