



## Project-Based Learning in mathematics education: A bibliometric study on 2014–2023 scopus database

Mathilda Susanti<sup>1\*</sup>, Heri Retnawati<sup>2</sup>, Eny Sulistyaningsih<sup>1</sup>, Kartianom<sup>2</sup>, Munaya Nikma Rosyada<sup>1</sup>, Gulzhaina K Kassymova<sup>3</sup>, Rimajon Sotlikova<sup>4</sup>

<sup>1</sup>Department of Mathematics Education, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

<sup>2</sup>Doctoral Program of Educational Research and Evaluation, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

<sup>3</sup>Satbayev University, 22a Satpaev str. 050013, Almaty, The Republic of Kazakhstan

<sup>4</sup>Webster University, Tashkent, 13 Navoi Avenue, Tashkent 100011, Uzbekistan

E-mail: [mathilda@uny.ac.id](mailto:mathilda@uny.ac.id)

\* Corresponding author

### ARTICLE INFO

#### Article history

Received: 8 May 2023

Revised: 25 May 2023

Accepted: 31 May 2023

#### Keywords

Project based learning, mathematics learning, bibliometric analysis, biblioshiny, VOSViewer, Scopus.

#### Scan me:



### ABSTRACT

Project-based learning is omitted by the curricula of various countries. For the future development, the extent of research related to project-based learning needs to be mapped. This literature review research does a bibliometric analysis of project-based learning research published in Scopus-indexed journals over the last ten years. There are 802 articles from the Scopus database in 2014-2023. The R package and VOSViewer tools are used to perform bibliometric analysis. The results are analyzed and interpreted, including the distribution per year, subject area, affiliation, country or region, citations, main information, treemap, authorship, most cited documents, relationships between years, dendrogram, collaboration between authors, collaboration between countries and continents, as well as the relationship between keywords in the article. The number of research increased significantly from 2014 to 2022. More than 50% of these came from social sciences field. Universitas Negeri Malang has published the most articles, while the United States is most publications country. Although the United States has the most documents, Spain is the the most cited country. The most cited document is written by Kokotsaki et al. in 2016. United States, China, Australia, France, and the United Kingdom often collaborate between countries and continents.

This is an open access article under the [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



**How to Cite:** Susanti, M., Retnawati, H., Sulistyaningsih, E., Kartianom, Rosyada, M.N., Kassymova, G.K., Sotlikova, R. (2023). Project-Based Learning in mathematics education: A bibliometric study on 2014–2023 scopus database. *Jurnal Riset Pendidikan Matematika*, 10(1) 30-49. <http://dx.doi.org/10.21831/jrpm.v10i1.55392>

## INTRODUCTION

The learning process conducted in schools plays a crucial role in student learning, especially in learning mathematics. It involves effective communication between teachers and students, involving mindsets and logic. A structured approach to learning mathematics is more effective than an unstructured one and can be tailored to students' abilities and needs. There are various learning models that can be adopted, such as the flipped classroom learning model, the auditory intellectual repetition learning model (Huda et al., 2019) realistic mathematics learning model, problem solving, inquiry, discovery learning, and project-based learning.

The learning model used in the mathematics learning process is not depend on just one type of learning model. However, a good learning process uses several learning models customized to students' needs. Project-based learning is one of the learning models that can be used in the process of learning mathematics. Project-based learning is one model that can motivate students to apply their mathematical skills and knowledge in real-life projects that combine different subject areas (Enver, 2022). However, for this model to be effective, the teacher must be a good facilitator and choose relevant topics for learning mathematics (Kubiatko & Vaculová, 2011). Through project-based learning, students become

more active in the learning process by exploring, assessing, interpreting, synthesizing, and producing various forms of learning outcomes.

Various research groups have explored the use of project-based learning models in mathematics education, resulting in mixed outcomes. Nurfitriyanti (2016) investigated the impact of project-based learning models on students' mathematical problem-solving abilities. This research showed that students who received the project-based learning method had better mathematical problem-solving abilities than those who received the expository learning method. Another study by Gerhana et al. (2017) focused on the use of the project-based learning model in trigonometry material and found that it was more effective in producing students' mathematics learning outcomes than the classical model with a scientific approach. The application of this model is also carried out on other topics in mathematics learning, as was done by Ozdemir et al. (2015) who focused on the topics of ratios, proportions, and percentages. The research results suggest that applying the classical learning process using project-based learning models can lead to better learning outcomes.

In addition to the studies that have been mentioned, many other studies still use project-based learning models in the mathematics learning process. Even so, the development of technology and science demands to continue to discover new things with ongoing research. Therefore, a bibliometric analysis can be useful in mapping and analyzing research carried out, as it can help identify themes and areas for further research (Tupan et al., 2018). In this study, bibliometric analysis is used to examine project-based learning research that has been carried out by many people from different countries. This approach can also help to increase accuracy and reduce researcher bias in scientific literature reviews by combining the opinions of many researchers (Zupic & Čater, 2015).

Bibliometric analysis is one method of analysis by reviewing data. Many researchers have used this analytical method to classify research results with a particular theme. In general, bibliometrics is a mathematical and statistical method used to analyze and measure the quantity and quality of books, articles, and other forms of publication using three indicators, namely quality, quantity, and structure (Durieux & Gevenois, 2010). In bibliometric analysis, data is obtained from Scopus, Google Scholar, and other databases. This data is then analyzed, mapped, and interpreted according to the research objectives. This study aims to conduct a bibliometric analysis of studies conducted and published in Scopus-indexed journals worldwide over the last ten years.

## METHOD

The bibliometric analysis was carried out using data taken from the Scopus website. The keywords used are "project-based learning", "mathematics learning", "project method", "project studies", "PBL", and "PjBL". Data was taken from 2014 to 2023, limited to references with open access status. The data are references in English, in order to facilitate the analysis and description of the bibliometric results carried out. To narrow the discussion space and focus on learning mathematics, the search is limited to the subject area "Social science". From the search, 802 metadata were obtained which were then exported from the Scopus website in the form of .csv (microsoft excel comma delimited).

The next step is to analyze the database with R package software, namely bibliometrix. The analysis covers authors, documents, conceptual structures, and intellectual structures. It will include main information, most frequent words, most relevant authors, most relevant affiliations, most cited countries, treemap, wordcloud, thematic map, thematic evolution, trend topics, topic dendrogram, and collaboration worldmap. Although it does not tell the complete results of the analysis, it is hoped that the results of this bibliometric analysis can provide an overview of mapping research for project-based learning themes in mathematics learning.

As part of the research process, the VOSViewer software was used in addition to bibliometrics. The software helps to analyze the conceptual structure and research themes, as well as the relationship between keywords/themes and recent research trends on project-based learning. The first step is to export a database similar to the initial filter, but the required file is a file with the .ris extension. The steps of analysis carried out were: (1) choosing the option to make a map based on bibliographic data, (2) entering the .ris file that was downloaded from the Scopus website, (3) choosing the type of analysis in the form of co-occurrence, unit analysis based on keywords, and counting method in the form of full counting, (4) determining the minimum number of occurrences of 10 so that terms that meet the

threshold are obtained as many as 51. The analysis will be carried out on network visualization, overlay visualization, and the resulting density visualization, based explicitly on the highlighted theme. The analysis results from VOSViewer complemented the ones generated from the bibliometrics. These results will be further explained in the Results sub-chapter and elaborated on in the Discussion sub-chapter.

## RESULT AND DISCUSSION

The data obtained in this research at the beginning will be explained about the output results or plots from Scopus. These results include documents by year, documents by subject area, documents by affiliations, documents by country or territory, and documents by year by source. While the output results from the bibliometric analysis include main information, keywords (most frequent words, treemap, word cloud), authorship (most relevant author, most relevant affiliations, most cited countries), documents (citation per year, thematic map, thematic evolution for author keywords), topic dendrogram (collaboration network for authors, collaboration world map). Furthermore, the discussion for the results of the VOSViewer analysis includes network visualization, overlay visualization, density visualization-item density, and density visualization-cluster density.

### Plots originated from scopus website

The first graph of the SCOPUS results shows documents by year (see Figure 1). The time span used in this research is from 2014-2023. Based on the graph, it can be seen that there is an increasing trend in 2014-2020 but it decrease in the number of documents in 2021 and will increase significantly again in 2022 as well as achieving the highest number of documents in that time span, reaching nearly 200 documents. The graph shows a decline in 2023. This is because 2023 is still at the beginning of the year and the hope is that it will increase again later than 2022 until the end of 2023. When viewed as a whole in that time span, it can be seen that the number of documents has increased significantly from 2014 until 2022 which is almost 10 times.

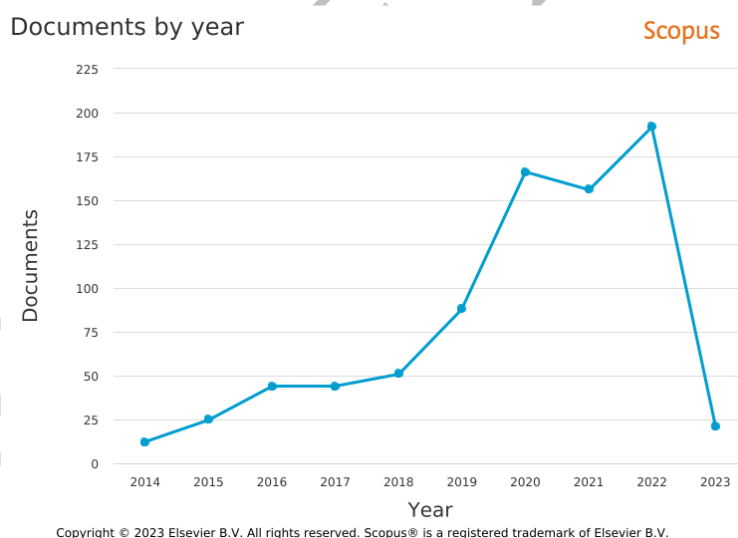
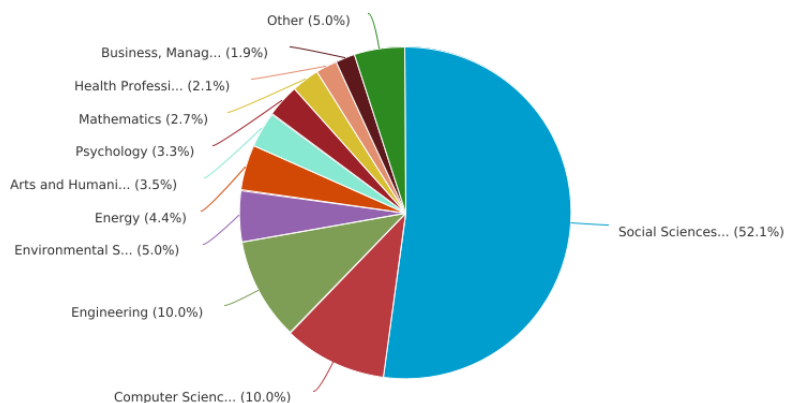


Figure 1. Documents by year

The second result from SCOPUS illustrates documents by subject area (see Figure 2). The result shows that more than 50% are documents about social science as much as 52.1%. While the second highest number is from the subject of engineering and computer science, each of which is 10%. Subject with the least number of documents from business and management. Other fields that are not far apart are environmental science, energy, arts & humanities, psychology, mathematics, health professions, and others (5%).

Documents by subject area

Scopus



Copyright © 2023 Elsevier B.V. All rights reserved. Scopus® is a registered trademark of Elsevier B.V.

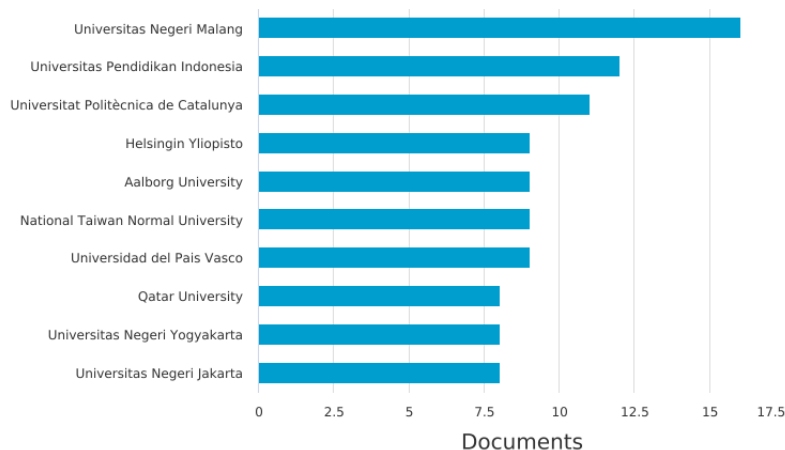
Figure 2. Documents by subject area

The third result from SCOPUS describes documents by affiliation (see Figure 3). There are 10 universities that have the highest number of documents. The first rank is Universitas Negeri Malang which has more than 15 documents. Second position is from the Universitas Pendidikan Indonesia with more than 10 documents. The third position is Universitat Politècnica de Catalunya with more than 10 documents but still far behind from the Universitas Pendidikan Indonesia. Meanwhile, Helsingin Yliopisto, Aalborg University, and National Taiwan Normal University have the same number of documents, namely less than 10. The eighth to tenth places are Qatar University, Universitas Negeri Yogyakarta, and Universitas Negeri Jakarta.

Documents by affiliation

Scopus

Compare the document counts for up to 15 affiliations.



Copyright © 2023 Elsevier B.V. All rights reserved. Scopus® is a registered trademark of Elsevier B.V.

Figure 3. Documents by affiliation

The fourth plot of SCOPUS describes documents by country or territory (see Figure 4). The graph shows the 10 countries that have the highest number of documents in accordance with the analysis in this study. The gap between the first and last position is very noticeable. The two are separated by nearly 100 documents. The highest number of documents is the United States with more than 120 documents. Furthermore, Indonesia with more than 100 documents. In third place is Spain with more than 80 documents. Next, there is the United Kingdom, Malaysia and China in third to fifth positions. Australia and Taiwan with almost the same number of documents are in seventh and eighth positions. The ninth is Turkey and the last is Portugal.

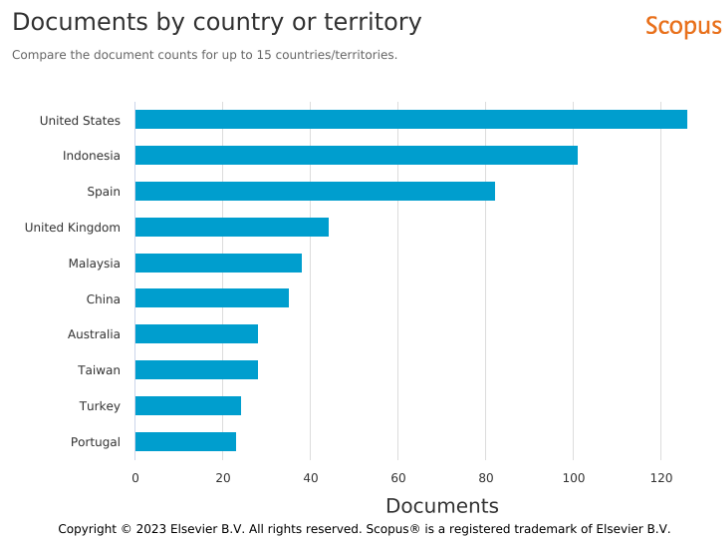


Figure 4. Documents by country or territory

The fifth graph from SCOPUS shows documents per year by source (see Figure 5). The graph shows that there are four sources, namely Education Science, Interdisciplinary Journal of Problem Based Learning, Sustainability Switzerland, and International Journal of Instruction. The first four years from 2015-2019, the sources were not very prominent. Even for Sitzerland Sustainability and Education Science only appeared in 2017. However, Sustainability Switzerland immediately increased significantly and consistently until 2021 and then continued until 2022. Likewise for Education Science which continued to increase although not as significantly as Sustainability Switzerland. The increase will last until 2022. The opposite has happened in the Interdisciplinary Journal of Problem Based Learning and the International Journal of Instruction. They are relatively consistent with the number of documents not more than 5 documents per year from 2015-2022. Interdisciplinary Journal of Problem Based Learning has unstable in the number of journals every year. Even though 2023 is still underway, it is already starting to be seen that Sustainability Switzerland and Education Science are still outperforming the other two sources. Interdisciplinary Journal of Problem Based Learning does not yet have data on the number of documents in early 2023.

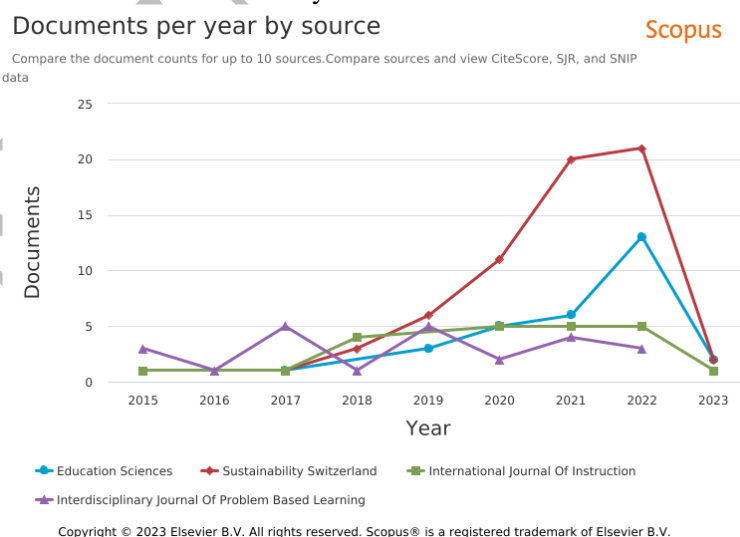


Figure 5. Documents per year by source

The following figure (Figure 6) is the main information from the database that we input into the bibliometric software. The database contains as many as 802 documents from 322 sources related to project-based learning. Another indicator is the annual growth rate which states information about the growth of many documents over the previous year which was recorded at 8.5%. For information about the authors, there were 2,374 authors involved in the study, with 109 authors writing their own



documents. 12.97% of the collaboration involved international/country writers. Keywords that are related to project-based learning are 2,417 keywords/themes. Other information that can be known is the average citations for each document, which is 7,468 citations for each document.



Figure 6. Main information

### Keywords

In this section, we will discuss the top 10 most frequent words, treemap, and wordcloud. The keywords used in this analysis are author keywords, where these keywords are the words the author has chosen and feel are appropriate to describe project-based learning. First, we will discuss the 10 most frequent words (see Figure 7). It can be seen that the keyword "project-based learning" appears the most, namely 320 times. The second most is "project based learning", it is assumed that the keyword is the same as the first most only without the hyphen (-). Other writing of project-based learning is also mentioned with the abbreviation (pbl), and appears 52 times. "Higher education" is the third most frequent keyword, with 41 occurrences. Besides higher education, "Engineering education" is also related to the theme of project-based learning and is included in the top 5 most frequent words. The "active learning" method seems to be one of the themes/keywords that appear a lot along with project-based learning, with 25 appearing in the database. Finally, "stem" and "stem education" are the authors' keywords that appear frequently, respectively, 22 and 21 times.

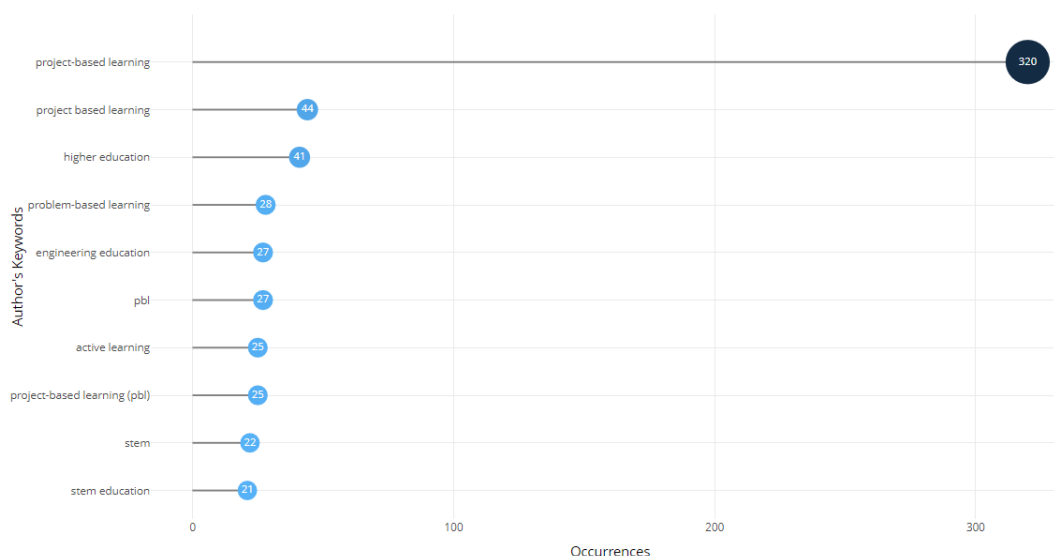


Figure 7. Most frequent words

Next, we will discuss about TreeMap. The treemap (see Figure 8) provides information about the 50 author keywords, how many times they appear in the data, and the percentage of occurrences of these keywords compared to all keywords. The bigger the size of the box, the bigger the part of the keyword is of the whole and vice versa. The use of a color palette with various colors makes it easier for readers to observe parts of keywords, so that they can see which keywords appear more often than other keywords. From the following treemap, the keyword "project-based learning" occupies 34% of the

entire nested rectangle, marked in blue on the left. Other keywords share a percentage of 1% to 5%, far compared to the keyword "project-based learning".



Figure 8. Treemap

Different author keyword presentations can be written with Word Cloud (see Figure 9). Font size and word thickness represent the frequency of occurrence of these keywords in the database. As seen in the following word cloud (according to the previous charts), the largest written "project-based learning" indicates that the keyword is the keyword that appears the most in the database. Next is "higher education", "engineering education", "problem-based learning", and "active learning". those keywords are closely related to project-based learning in mathematics education. Interesting keywords obtained in the word cloud include "covid-19", "online learning", "flipped classroom", "blended learning", "e-learning", "stem", "stem education", "science education", "high school", "collaboration", "collaborative learning" and "experiential learning".



Figure 9. Word cloud

### Authorship

The following data (see Table 1) describes the most relevant authors. Based on the results obtained, it is known that there are several authors of documents on project-based learning that are most suitable for the keywords that are often searched. Sequentially from the most suitable are Du, Xiangyun

and Kolmos, A J from Denmark, Loun, S J from Taiwan, Wang, J from China, Capraro, RM from United States, Lavonen from South Africa, Malik, M who coming from the United Kongdom, Wang, S from China, and then there is Admiraal, WF from Norway. Each author has a Scopus ID which can show their respective identities in the authorship of Scopus indexed articles.

Table 1. Most relevant authors and their respective countries

R	Author	Scopus ID	Country/Region
1	Du, Xiangyun	35333877900	Denmark
2	Kolmos, A J	6507218136	Denmark
3	Lou, S J	13805119700	Taiwan
4	Wang, J	57945210700	China
5	Capraro, R M	6603490655	United States
6	Lavonen, J	55894399700	South Africa
7	Malik, M	52163858900	United Kingdom
8	Wang, S	57223295389	China
9	Admiraal, W F	55499681000	Norway

Furthermore, data from the nine most relevant authors in the search for project-based learning articles obtained detailed data on the number of each document (Figure 10). Du X is the most relevant with a total of six documents. Then there are Kolmos A, Lou S J and Wang J, that each of whom has five documents. They are in second to fourth rank. In the fifth to eighth, there are four documents each, namely Capraro RM, Lavonen J, Malik M, and Wang S. while in the last two or in the ninth and tenth, there are Admirals W and Baran M, each of which has three documents.

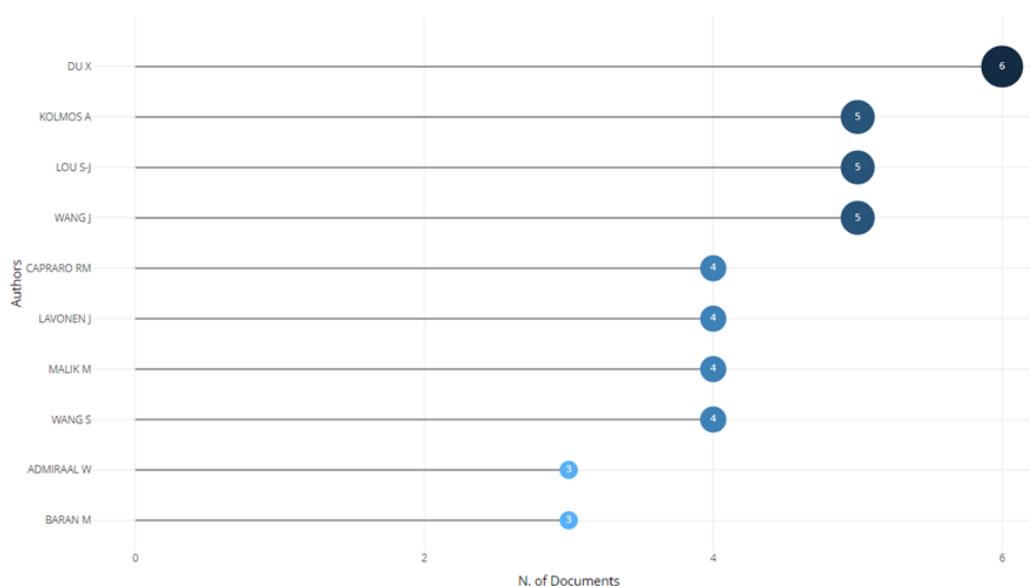


Figure 10. Most relevant authors based on their total documents

The results obtained based on the most relevant affiliations show that the Universitas Negeri Malang outperforms other affiliations with a total of 28 articles (see Figure 11). Furthermore, there is Universitas Pendidikan Indonesia which has 20 articles. The third place is Universiti Malaysia Kelantan with a total of 19 articles. Aalborg University and the University of Helsinki are in fourth and fifth positions with 18 relevant articles each. The sixth position is occupied by Qatar University with a total of 17 relevant articles. Furthermore, there is the Universitas Negeri Jakarta with 16 articles. In eighth place that has 15 articles relevant to prjvect-based learning is National Taiwan Normal University. Ninth and tenth positions with 13 relevant articles respectively are Michigan University and Universitas Negeri Padang.



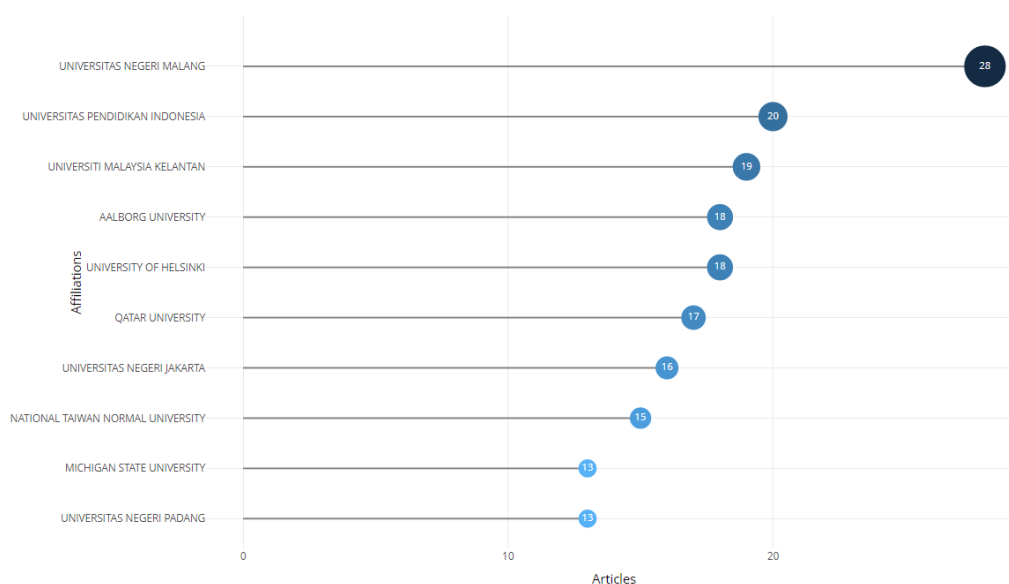


Figure 11. Most relevant affiliations

Other data obtained is about the most cited countries (on Figure 12). The following data describes the order of the most cited countries. The most cited is Spain with 587 citations. Next there is the USA with 475 citations and the United Kingdom with 467 citations. In fourth place is China which has 290 citations, followed by Indonesia with 261 citations in fifth place. The Netherlands has 192 citations in sixth. Furthermore, there are 179 citations from Finland in seventh place. Hong Kong, Portugal, and Canada are eighth, ninth, and tenth with 149, 133, and 116 citations respectively.

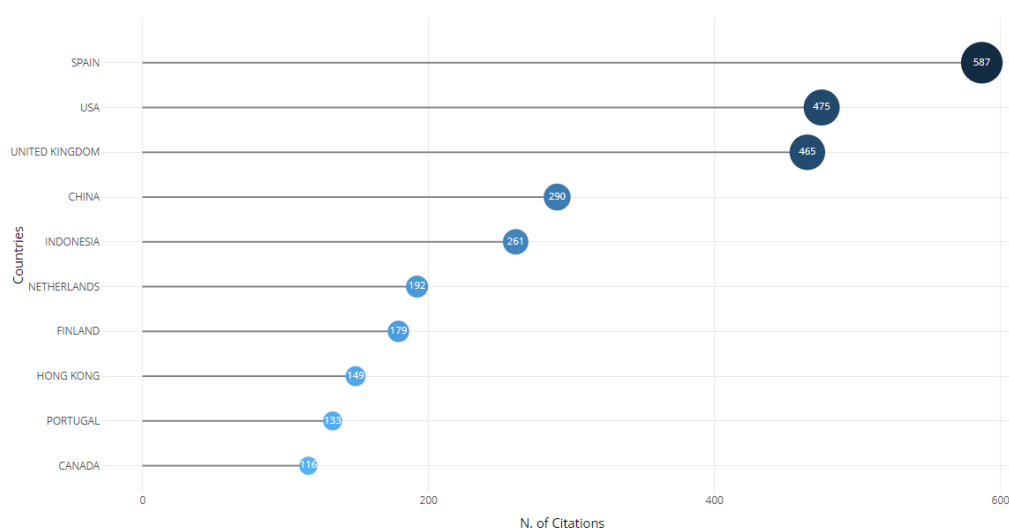


Figure 12. Most cited countries

### Documents

The following data describes the most global cited documents (see Table 2). There are ten documents which are cited as the most cited documents in the world. Most cited documents are "Project-based learning: A review of the literature" by Kokotsaki, D; Menzies, V; Wiggins, A in 2016 as many as 41.38 citations/year. Furthermore, in 2016 there was an article by Sáez-López, J; Román-González, M; Vázquez-Cano, E with the title "Visual programming languages integrated across the curriculum in elementary school: A two-year case study using "Scratch" in five schools" with 33.75 c/y. In 2020 there are also articles by Guo, P; Saab, N.; Post, LS; Admiraal, W with 33.50 c/y entitled "A review of project-based learning in higher education: Student outcomes and measures". In fourth place is an article entitled "STEM learning through engineering design: Impact on middle secondary students' interest towards STEM" by Mohd Shahali, E H; Halim, L; Apostle, MS; Osman, K; Zulkifeli, MA who cited 13.71.

Article entitled “21st century skills development through inquiry-based learning” by Chu, S K W; Reynolds, R.B.; Tavares, NJ; Notary, M; Lee, C W Y in 2017 fifth position with 11.88 c/y. The next is articles written by Zhang, Z; Hansen, C T; Andersen, MA E entitled “Teaching power electronics with a design-oriented, project-based learning method at the Technical University of Denmark” in 2016. The article “Students' perception of a flipped classroom approach to facilitating online project-based learning in marketing research courses” with 8.89 c/y written by Dole, S; Bloom, L; Kowalske, K in seventh. Furthermore, there is "Students' perception of a flipped classroom approach to facilitating online project-based learning in marketing research courses" in 2016 written by Shih, W-L; Tsai, C-Y with 10.86 citations per year. Article written by Mutakinati, L; Anwari, L; Kumano, Y in 2018 entitled "Analysis of students' critical thinking skills of middle school through STEM education project-based learning" has 10.67 citations per year and is in ninth. Finally, in the tenth position most global cited documents, namely an article entitled “An assessment instrument of technological literacy in Makerspaces and FabLabs: Assessment of technological literacy in Makerspaces and FabLabs” by Blikstein, P; Kabayadondo, Z; Martin, A; Fields, D in 2017 there were 8.71 citations/year.

Table 2. Ten most global cited documents

R	Title	Author(s)	Year	C/Y
1	Project-based learning: A review of the literature	Kokotsaki, D; Menzies, V; Wiggins, A	2016	41.38
2	Visual programming languages integrated across the curriculum in elementary school: A two year case study using “Scratch” in five schools	Sáez-López, J; Román-González, M; Vázquez-Cano, E	2016	33.75
3	A review of project-based learning in higher education: Student outcomes and measures	Guo, P; Saab, N; Post, L S; Admiraal, W	2020	33.50
4	STEM learning through engineering design: Impact on middle secondary students' interest towards STEM	Mohd Shahali, E H; Halim, L; Rasul, M S; Osman, K; Zulkifeli, M A	2016	13.71
5	21st century skills development through inquiry-based learning	Chu, S K W; Reynolds, R B; Tavares, N J; Notari, M; Lee, C W Y	2017	11.88
6	Teaching power electronics with a design-oriented, project-based learning method at the Technical University of Denmark	Zhang, Z; Hansen, C T; Andersen, M A E	2016	10.25
7	Transforming pedagogy: Changing perspectives from teacher-centered to learner-centered	Dole, S; Bloom, L; Kowalske, K	2015	8.89
8	Students' perception of a flipped classroom approach to facilitating online project-based learning in marketing research courses	Shih, W-L; Tsai, C-Y	2016	10.86
9	Analysis of students' critical thinking skill of middle school through STEM education project-based learning	Mutakinati, L; Anwari, L; Kumano, Y	2018	10.67
10	An assessment instrument of technological literacies in Makerspaces and FabLabs: Assessment of technological literacies in Makerspaces and FabLabs	Blikstein, P; Kabayadondo, Z; Martin, A; Fields, D	2017	8.71

C/Y: citation per year

The next data is about trend topics in 2014-2023 (see Figure 13). The topic about Covid-19 that is infecting the world began to be written around 2021 and ended in 2022 as the pandemic ended. The topic of project-based learning and project-based learning is around 2019 to 2021 increase in 2020.

Meanwhile, the topic of teacher education takes place throughout the year from 2016-2022 and even after. The topic of collaborative learning takes place from 2017 to the present. Higher education, project-based learning (PBL), and stem education will continue to be topics of interest until 2022 and beyond. However, for professional development it is only a topic in 2016-2020.

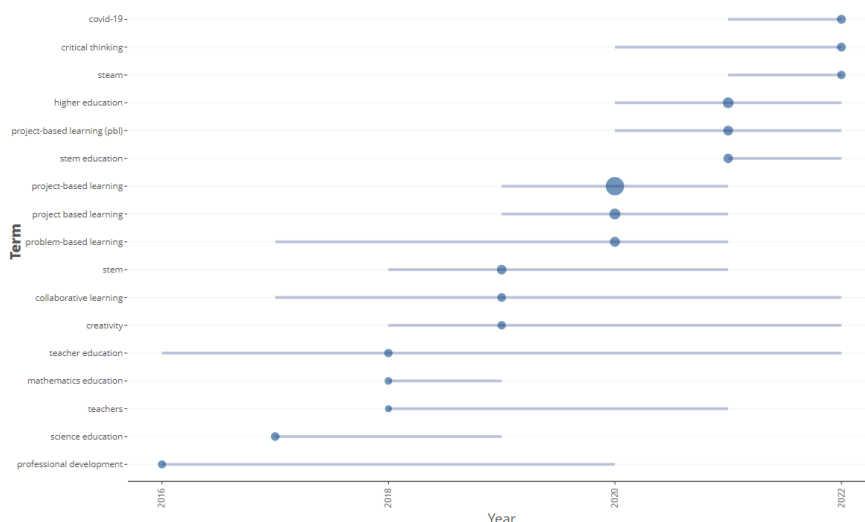


Figure 13. Trend topics

Other results describe the thematic map (see Figure 14). This result shows four quadrants, each of which has an explanation. The first quadrant (motor theme) only shows part of the project –based learning, higher education, and problem-based learning. The second quadrant (niche theme) contains self-efficacy, 21st century skills, teacher education, professional development, and curriculum design. Meanwhile, in the third quadrant (emerging or declining theme) there are no related topics. The fourth quadrant (basic theme) contains topics on covid-19, experiential learning, sustainability, project-based learning, PBL, collaborative learning, higher education, and problem-based learning. Quadrant four describes the research that needs to be done, as well as possible future research trends related to these topics.



Figure 14. Thematic map

Thematic evolution (see Figure 15) for author keywords describes the evolution of topics in articles in three groups of timeframes. The first group, namely 2014-2017, has several topics such as professional development, projects, education, collaborative learning, project-based learning (PBL), project-based learning, cooperative learning, project-based learning, computational thinking, and sustainable development. The second group in the 2018-2021 timeframe includes project-based learning, project-based learning, sustainability, project, project-based, pre-service teachers, academic performance, stem education, student achievement, critical thinking, motivation, student learning, science education, digital technologies, innovation, and 21st century skills. Whereas in the third timeframe, namely in 2022-2023 there are project-based learning, project-based learning (pbl), higher education, project-based, education for sustainable development, pbl, critical thinking skills, active

learning, steam, project-based teaching, covid-19, and case studies. Based on the three time-groups, it can be seen that the addition of the project-based learning keywords increases from each time group.

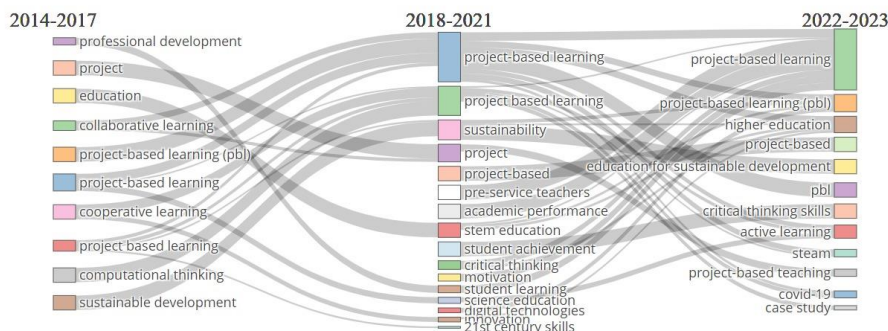


Figure 15. Thematic evolution for authors keywords

Figure 16 is about the topic of the dendrogram. It represents the hierarchical order and relationship between the keywords generated by hierarchical clustering. Based on the results of the topic dendrogram, there are two clusters. The first cluster with topics adult, male, female, article, human, and humans. While the second cluster is more specific on learning such as motivation, active learning, project based, teaching, student, knowledge, learning, methodology, and others.

Topic Dendrogram

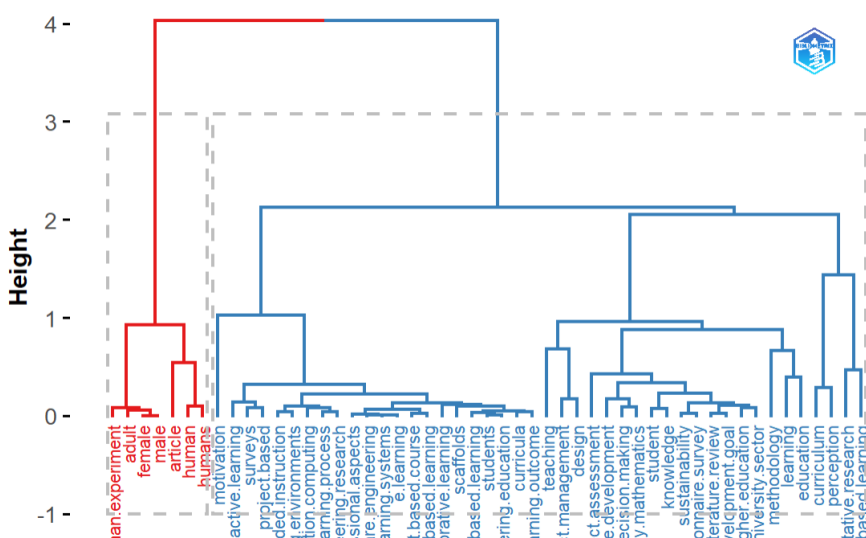


Figure 16. Dendrogram

The next results describe the collaboration network for authors. Based on the data about the authors that have been obtained based on the data analysis, it is continued to see the collaboration network for authors. Based on Figure 12, it was found that Du x collaborated with Chaaban y, Naji kk, Chowdhury Meh, and Ayari ma. The next collaborations are Ajana S with Bakjali S, Isa mu with Kamin yb, Capraro rm with capraro mm, bloom I with dole S, Lavonen J with Krajck and Juuti, Admiraal with Saab and Guo p, Charosky with Bragos, Lou S-J with Chung c-c, and the last Seouw p-s with Pan G.



Figure 17. Collaboration network for authors

In accordance with the results shown in the collaboration world map, the authors of the articles have collaborated not only with other authors within one affiliate or country but also across countries. The collaboration is carried out even across continents. Many American writers have collaborated with Asian writers, especially China and Japan. Besides that, they also collaborated with writers from Australia. Apart from that, Chinese writers also collaborated with writers from Europe such as France and England as well as with Australian writers. This shows that space limitations do not hinder the development of science.

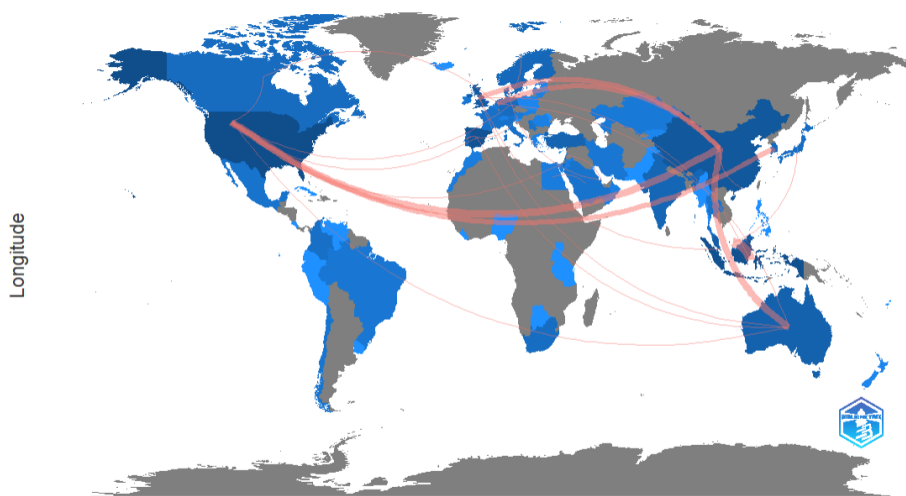


Figure 18. Collaboration world map

### VOSViewer analysis results

The results of the analysis using VOSViewer get the 5 clusters. The first result describes about network visualization (see Figure 19). Based on Figure 14, it is explained that project-based learning is related to education, learning, students, engineering education, higher education, collaboration, learning systems, project management, stem education, sustainability, knowledge, literature review, e-learning, curricula, problem based learning, teaching, science education, critical thinking, creativity, public relations, male, female, motivation, innovation, active learning, cooperative learning, teamwork, pbl, teacher education, covid-19, and surveys. In another word, project-based learning is a learning methodology using the concepts of creativity, teamwork, active learning, innovation, and project-based and can motivate male and female students.



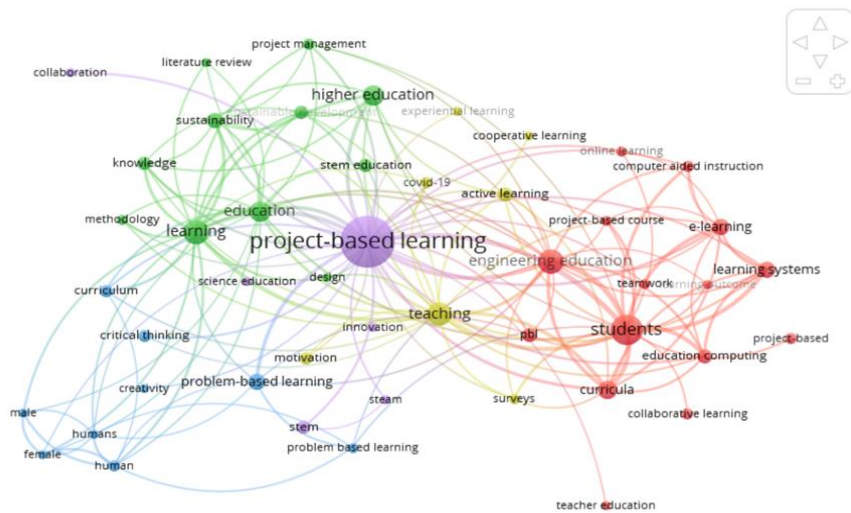


Figure 19. Network visualization

The next results describe the overlay visualization. Based on Figure 20, it was found that there were the most articles on project-based learning in 2019-2020. This year apart from project-based learning, there is also education, engineering education, teaching, students, learning systems, and e-learning. In 2020-2021 or after related topics are critical thinking, curriculum, stem education, covid-19, online learning, knowledge, steam, and project-based. Whereas before 2018-2019 the related topics were about science education, problem-based learning, humans, human, female, male, stem, pbl, teaching, and collaborative learning.

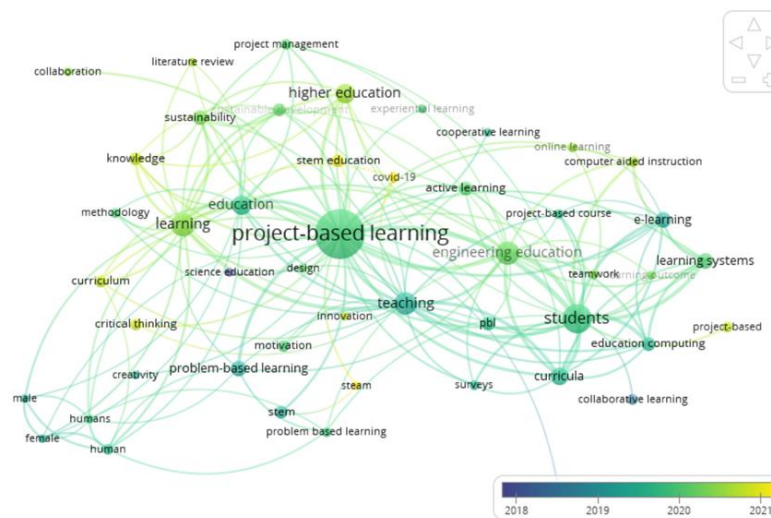


Figure 20. Overlay visualization

The next results of the VosViewer analysis (see Figure 21) describe the density visualization (item density). Project-based learning keywords show a relationship with themes or other keywords indicated by item density. The keywords are learning, education, students, teaching, higher education, engineering education, motivation, problem-based learning, stem, problem based learning, surveys, curriculum, teacher education, collaborative learning, educational computing, project based, learning system, e-learning, project-based courses, computer aided instruction, cooperative learning, active learning, project management, literature review, sustainability, knowledge, collaboration, curriculum, critical thinking, creativity and others. The denser the density of the keywords shows the stronger the bond between these keywords and project-based learning.





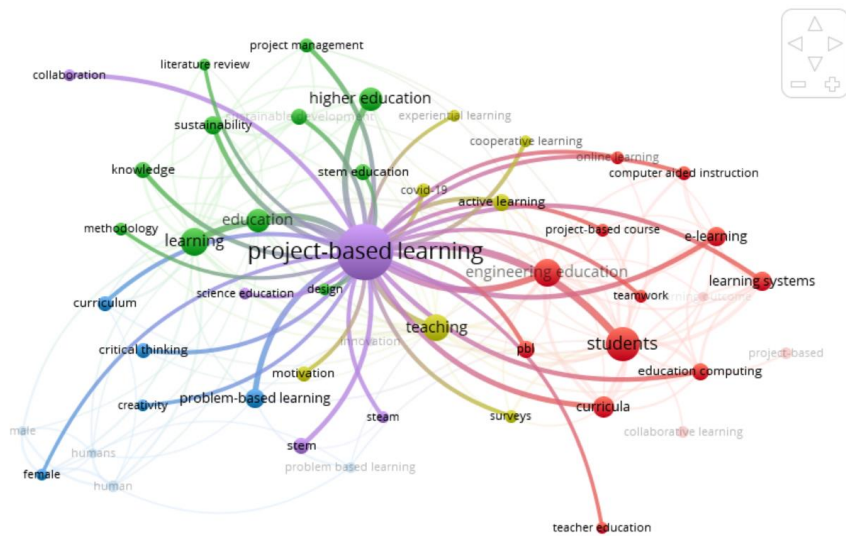


Figure 23. Topics related to Project Based Learning

Next results from project-based learning if students are selected, data is obtained that there is a strong relationship on the topics of e-learning, project-based courses, computer aided instruction, learning systems, education computing, PBL, collaborative learning, and PBL indicated by color red (see Figure 24). In addition, there are also relations in project management, higher education, and education with green groups. In the yellow and blue topic groups, namely active learning, teaching, surveys, and problem-based learning.

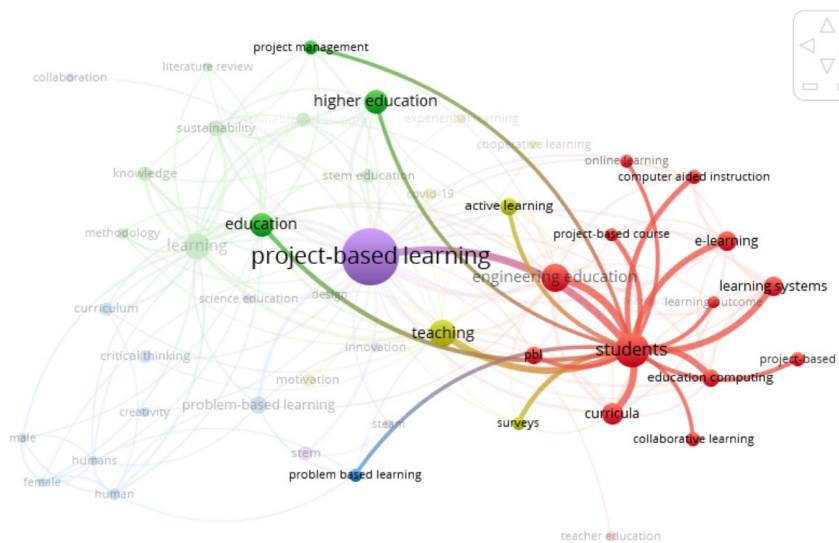


Figure 24. Topics related to Students

Next, if teaching is selected, then the mapping of projects related to this matter will be described (see Figure 25). The results show four groups marked in green, yellow, red, and blue. The green group stated topics related to teaching, they are higher education, sustainability, methodology, education, learning, knowledge, and design. While the red topic groups are engineering education, e-learning, learning systems, students, education computing, and curricula. The yellow group describes motivation, surveys, covid-19, and active learning. The last group of topic teaching is curriculum and critical thinking which are depicted in blue.





or in groups. [Thomas \(2000\)](#) discusses the definition, effectiveness, and characteristics of students with project-based learning, related research, and its application in the future. [discussed the definition, effectiveness, and characteristics of students with project-based learning, related research, and its application in the future.](#) Although research on project-based learning was rare ten years prior, many people have started to write research on it in 2020, as seen in the Scopus analysis graph.

The following research discusses the implementation of project-based learning and the subjects in which it is used. According to the study, 52.1% of project-based learning is implemented in the context of social science. Other subjects where the learning model can be applied include environmental science, energy, arts & humanities, psychology, mathematics, health professions, and others. The study by [Subramanian & Budhrani \(2019\)](#) showed the effectiveness of project-based learning in computer science by assigning programming projects that combined several topics for students and providing feedback and reflection.

The study also analyzed the affiliation and origin of research articles on project-based learning. Universitas Negeri Malang had the highest number of articles compared to other universities. The United States was the country with the highest number of research articles, with one article by [Maddox et al. \(2014\)](#) titled "PBL in the United States Defense Sector: Progress and Prospects" discussing the potential for implementing project-based learning through a contingency approach.

The results of the next analysis are articles based on their sources. Four journals are included in this analysis: Education Science, Interdisciplinary Journal of Problem-Based Learning, Sustainability Switzerland, and International Journal of Instruction. However, not all of these journals extensively discuss project-based learning. Sustainability Switzerland Journal had the highest number of articles related to project-based learning published from 2020 onwards.

The bibliometric analysis of main information stated that there were 802 documents from 322 sources related to project-based learning. A total of 2,374 authors participated in the study, and 109 single authors wrote their documents. This indicates that most scientific articles are the result of collaboration. This was also highlighted in [Rahayu & Christiani \(2020\)](#) in their research results, which reported that the number of articles written collaboratively was greater than the number of independently written articles, indicating a high level of collaboration. The analysis also revealed a high number of citations for related documents, indicating the development of recent research on project-based learning. The average number of citations for each document was 7,468.

The result of the next analysis is about keywords that the author often uses. The keywords are those related to project-based learning, according to this research. Based on the results of the word cloud, tree map, or graphic display, it was revealed that there were several relevant keywords related to project-based learning. These include PBL, higher education, problem-based learning, and other similar terms. Project-based learning is primarily applied in higher education, where students are more independent and can collaborate to create a shared project. This approach has been shown to help students develop self-control over their performance ([Krumova et al., 2020](#)). As such, students who use project-based learning in higher education are expected to be better prepared to enter the labor market after graduation ([Menshikova et al., 2019](#)).

In addition to discussing the use of project-based learning, the analysis also looked at the authors of articles on this topic, their origins, and the number of articles they had written. It also identified the countries with the most citations, with Spain being the highest-ranking country. For document analysis, several article titles with the most citations per year were obtained, namely "Project-based learning: A review of the literature" by [Kokotsaki et al. in 2016](#). The more an article is cited, the higher the citation value per year. Citation values can help illustrate a specific article's importance and impact. This analysis also helps to identify future research trends and areas for further exploration. Scholars can influence future scientific publications by mapping related keywords and identifying gaps in current research ([Stojanovski et al., 2015](#)).

Scientific articles are often a collaborative effort. This is also found in the analysis results, which describe collaboration between authors from the same or different countries. Collaborative analysis data shows that many authors from the United States, China, France, Australia, and the United Kingdom have worked together on such articles. According to [Khaparde & Pawar \(2013\)](#), research in the field of information technology is often focused on team or group research rather than individual research. This is also confirmed by [Pradhan et al. \(2011\)](#), who state that chemical researchers are more inclined towards team or group research rather than individual research.

The final analysis is the result of the VOSViewer analysis. The VOSViewer analysis provides insight into the keywords related to project-based learning, both in general and specific contexts, such as students, teaching, and higher education. In a general analysis, project-based learning relates to education, learning, students, engineering education, higher education, collaboration, learning systems, project management, stem education, sustainability, knowledge, literature review, e-learning, curricula, problem-based learning, teaching, science education, critical thinking, creativity, etc. The analysis reveals that project-based learning is relevant to various fields, such as science and engineering education. It can also be applied to higher education and has been found to enhance students' critical thinking, creativity, and collaboration. Research has shown that project-based learning trains students to work together in teams and can significantly improve their critical thinking abilities (Indrawan & Jalinus, 2018; Aliftika et al., 2021).

## CONCLUSION

The results of the mapping analysis of project-based learning keywords are presented in annual distribution, subject area, affiliation, country or region, citations, main information, tree map, authorship, documents with the most citations, inter-year relationships, dendograms, collaboration between authors, collaboration between countries and continents, and the relationship between keywords in the article. The number of research documents on PjBL has significantly increased from 2014 to 2022, with over 50% of these documents being from the field of social sciences. Malang State University in Indonesia has published the most articles on PjBL, while the United States is the country that has published the most publications on this topic, followed by Indonesia. Interestingly, despite having the most documents, the United States is the second most cited country, with Spain being in the first place. The most cited document is a literature review on PjBL by Kokotsaki et al. in 2016. The United States, China, Australia, France, and the United Kingdom collaborate frequently between countries and continents. The most used keywords by authors are PBL, higher education, and problem-based learning, indicating that project-based learning systems can be applied to higher education, not only science education but also engineering education. Project-based learning is also related to problem-based learning, which can enhance students' critical thinking, creativity, and collaboration skills. The mapping results obtained can be used to group and describe research in the future.

## REFERENCES

- Aliftika, O., Astra, I. M., & Supriyati, Y. (2021). Project based blended learning and independent learning on critical thinking skill. *Journal of Physics: Conference Series*, 2019(1), 012051. <https://doi.org/10.1088/1742-6596/2019/1/012051>
- Ayas, K., & Zeniuk, N. (2001). Project-based learning: Building communities of reflective practitioners. *Management Learning*, 32(1), 61–76. <https://doi.org/10.1177/1350507601321005>
- Durieux, V., & Geveno, P. A. (2010). Bibliometric indicators: Quality measurements of scientific publication. *Radiology*, 255(2), 342–351. <https://doi.org/10.1148/radiol.09090626>
- Enver, S. (2022). *Motivation by project-based learning in mathematics education. 1*, 153–160. <https://doi.org/10.46687/ITZJ2845>
- Gerhana, M. T. C., Mardiyana, M., & Pramudya, I. (2017). The effectiveness of project based learning in trigonometry. *Journal of Physics: Conference Series*, 895, 012027. <https://doi.org/10.1088/1742-6596/895/1/012027>
- Huda, S., Anggraini, L., Saputri, R., Syazali, M., & Umam, R. (2019). Learning model to improve the ability to understand mathematical concepts. *PRISMA*, 8(2), 173–181. <http://repository.iainkediri.ac.id/108/>
- Indrawan, E., & Jalinus, N. (2018). Review project based learning. *International Journal of Science and Research (IJSR)* ISSN, 8(4), 1014–1018. <http://repository.unp.ac.id/27250/1/6%20Review%20Project%20Based%20Learning.pdf>
- Khaparde, V., & Pawar, S. (2013). Authorship pattern and degree of collaboration in information technology. *Journal of Computer Science & Information Technology*, 1(1), 46–54.

<https://www.sdipress.com/volume/BJCSIT/01/02/authorship-pattern-and-degree-of-collaboration-in-information-technology-5d9332ca50d40.pdf>

- Krumova, V., Danalev, D., & Terzieva, S. (2020). Project based learning: Strategy for professional competence development in higher education. *Science, Engineering & Education*, 5(1), 27–40. [https://see.uctm.edu/node/jsee2020-1/6\\_20-05\\_p\\_27-40.pdf](https://see.uctm.edu/node/jsee2020-1/6_20-05_p_27-40.pdf)
- Kubiatko, M., & Vaculová, I. (2011). Project-based learning: Characteristic and the experiences with application in the science subjects. *Energy Education Science and Technology Part B-Social and Educational Studies*, 3(1), 65–74.
- Maddox, J., Rendon, R., & Snider, K. (2014). PBL in the United States defense sector: Progress and prospects. In M. Eßig & A. Glas (Eds.), *Performance based logistics* (1st ed., pp. 283–298). Springer Gabler, Wiesbaden. [https://doi.org/10.1007/978-3-8349-3726-1\\_13](https://doi.org/10.1007/978-3-8349-3726-1_13)
- Menshikova, M. A., Gavrilova, T., Smirnova, P. V., & Piunova, Y. V. (2019). Improving the quality of higher education with the project based learning. In I.T.&Q.M.&I.S. (Ed.), *2019 International Conference "Quality Management, Transport and Information Security, Information Technologies"* (pp. 50–53). <https://doi.org/10.1109/ITQMIS.2019.8928306>
- Nation, M. L. (2008). Project-based learning for sustainable development. *Journal of Geography*, 107(3), 102–111. <https://doi.org/10.1080/00221340802470685>
- Nurfitriyanti, M. (2016). Model pembelajaran project based learning terhadap kemampuan pemecahan masalah matematika. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 6(2), 149–160. <https://doi.org/10.30998/formatif.v6i2.950>
- Ozdemir, A. S., Yildiz, F., & Yildiz, S. G. (2015). The effect of project based learning in “ratio, proportion and percentage” unit on mathematics success and attitude. *European Journal of Science and Mathematics Education*, 3(1), 1–13. <https://doi.org/10.30935/scimath/9417>
- Pradhan, P., Chandrakar, R., & Panda, S. K. (2011). *Authorship pattern and degree of collaboration in Indian chemistry literature*. International CALIBER at Goa University.
- Rahayu, S. P., & Christiani, L. (2020). Kolaborasi dan produktivitas penulis artikel ilmiah pada jurnal lentera pustaka. *Jurnal Ilmu Perpustakaan*, 9(1), 83–91. <https://ejournal3.undip.ac.id/index.php/jip/article/view/29973>
- Stojanovski, J., Frančula, N., & Lapaine, M. (2015). Indexing of mapping science journals. *Geography, Environment, Sustainability*, 8(1), 27–52. <https://doi.org/10.24057/2071-9388-2015-8-1-27-52>
- Subramanian, K., & Budhrani, K. (2019). Applying project-based learning for an online object-oriented systems course. *SIGCSE '19: Proceedings of the 50th ACM Technical Symposium on Computer Science Education*. <https://doi.org/10.1145/3287324.3293786>
- Thomas, J. W. (2000). *A review of research on project-based learning*. Autodesk Foundation. [http://www.bobpearlman.org/BestPractices/PBL\\_Research.pdf](http://www.bobpearlman.org/BestPractices/PBL_Research.pdf)
- Tupan, Rahayu, R. N., Rachmawati, R., & Rahayu, E. S. R. (2018). Analisis bibliometrik perkembangan penelitian bidang ilmu instrumentasi. *BACA: Jurnal Dokumentasi dan Informasi*, 39(2), 135–149. <https://doi.org/10.14203/j.baca.v39i2.413>
- Wurdinger, S., Haar, J., Hugg, R., & Bezon, J. (2007). A qualitative study using project-based learning in a mainstream middle school. *Improving Schools*, 10(2), 150–161. <https://doi.org/10.1177/1365480207078048>
- Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. *Organizational Research Methods*, 18(3), 429–472. <https://doi.org/10.1177/1094428114562629>