Bibliometric Analysis of Research Trends in Problem Based Learning and Problem Solving Ability (2002-2022)

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Article Info	Abstract
	This study aims to analyze research trends in problem-based learning and problem-solving ability through bibliometric analysis in the Dimensions.ai databases from 2002 to 2022. The method used is bibliometric analysis with stages following the flow chart of Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). The results of the research show that the number of problem-based learning publications and problem-solving ability has continued to increase since 2018. The number of publications on problem-based learning and problem-solving ability ranks first in the field of education. While the most published journal is the Journal of Physics Conference Series. The first rank in the number of publications reviewed by the researcher, I Made Arnawa. Based on the keywords problem based learning and problem solving ability the two are not connected. Thus, the topic of problem-based learning and problem-solving ability can be used as novelty for research and will become a trend in the future. Articles that can be used as references in research that reviews problem-based learning and problem-solving ability are from the Journal of Physics Conferences Series. Meanwhile, the author who can be used as a reference is I Made Arnawa.

Introduction

Along with the changing times, there is a need for development in the learning aspect (Nakakoji & Wilson, 2020). One of the developments is associated with 21st century skills (Haag et al., 2022; Shadiev & Wang, 2022; Wang, 2022). Teachers must equip skills to realize the potential of students (Islam et al., 2022). It has been proposed that the workforce of the future should have 21st century skills (Mann et al., 2023). Research shows that 21st century skills can help produce competent graduates (Louis et al., 2021). Therefore, 21st century skills are important for learners to have.

One of the 21st century skills that must be possessed by students is the ability to solve problems (Louis et al., 2021). Because, if the problem-solving ability of students is not trained, students will tend to use conceptual knowledge (Braithwaite & Sprague, 2021). This ability is not only used as a learning goal but also as the main tool to carry out activities mathematically (Sholehah et al., 2022). In addition, problem-solving ability are needed to train reasoning and decision-making (Hwang & Oh, 2021; Mayasari et al., 2021). Because in the early stages a contextual problem is presented and then a solution is sought (Hayati, 2018). Problem-solving ability are able to

give students an experience to solve a problem (La Ili et al., 2022; Choi & Jeon, 2022). Therefore, problem-solving ability must be possessed by learners.

In order for problem-solving ability to be achieved, it is necessary to use learning models in the teaching and learning process (Hakim et al., 2020). One of the learning models that can be used to achieve problem-solving ability is problem-based learning (Lidiana & Sukestiyarno, 2023; Kibret et al., 2021). Problem-based learning is a direct learning method that focuses on investigating and solving problems in the real world (Zhang et al., 2022). In addition, this model is learner-centered (Trullàs et al., 2022; Luo et al., 2021). Students are presented with a problem which is then sought for a solution in groups (Matlala, 2021). The advantages of problem-based learning are improving problem-solving ability, developing communication skills, developing critical thinking skills, developing collaborative skills and forming a lifelong learner and taking responsibility for himself (Tadesse et al., 2022; Manuaba et al., 2022; Ghani et al., 2021). Research has been conducted that shows that problem-based learning can improve students' problem-solving ability (Sinaga & Minarni, 2017; J.-S. Choi et al., 2022; Panjaitan & Suhendra, 2022; Davari et al., 2021). Because, the learning steps in it are contextual, constructive, collaborative, and independent (Pinho et al., 2021). Therefore, problem-based learning is suitable to be used to achieve problem-solving ability.

The following is an example of research that has been conducted related to problem-based learning, namely the evaluation of the implementation of problem-based learning (Almulhem & Almulhem, 2022), online problem-based learning in dental clinic education (Morgado et al., 2021), implementation of problem-based learning (Fernandes, 2021), integrating competency-based education with problem-based learning (Sistermans, 2020), a problem-based learning program for infection control in nursing homes (Y.-R. Choi et al., 2022), and many others. While research related to problem-solving ability, for example, is the effect of maternal nursing competency strengthening programs on problem-solving ability (Kim & Lee, 2021), the relationship between problem-solving ability and laterality (Isparta et al., 2020), improved problem-solving ability in urban environments (Vrbanec et al., 2021). The influence of problem-solving characteristics on the cooperative problem-solving ability of adolescents (Gu et al., 2022), the problem-solving ability of mathematics learning of middle school students (Xu & Qi, 2022) and many others. Therefore, there has been a lot of research related to problem-based learning and problem-solving ability.

However, when typed in the keywords "Problem Based Learning" or "Problem Solving Ability" with a range of 2002 to 2022, there has been no bibliometric analysis of research trends in problem-based learning and problem-solving ability reported by Dimensios.ai indexed journal publications. Therefore, this study aims to objectively provide information related to problem-based learning research trends and problem-solving ability. The novelty of this study is using bibliometric analysis methods to quantify the development of international articles on problem-based learning and problem-solving ability from 2002 to 2022 in journal publications through Dimensions.ai database. The questions that will be answered in this study are (1) How is the development of the number of publications per year?, (2) How is the development of the number of citations per year?, (3) How is the development of the number of publications in terms of the category of research fields?, (4) How is the development of the number of publications viewed from the journal category?, (5) How is the development of the

number of publications reviewed from researchers?, (6) How is the network visualization co-occurrence problem based learning and problem-solving ability?, (7) How is density visualization co-occurrence problem-based learning and problem-solving ability?, and (8) How is network visualization co-authorship problem-based learning and problem-solving ability?.

Bibliometric analysis is a research method using statistical methods to analyze various types of publications (Fu et al., 2023). This analysis uses a quantitative approach to identify published journals and assess research productivity in a particular field (Sweileh et al., 2017) . In addition, it is appropriate to provide information on scientific advances and publication trends (Chen & Ho, 2015; Gupta et al., 2022; Soares et al., 2020). The results of this study are presented in the form of figures and tables to understand the relationship between explanators and various aspects of the study identified (Çağlayan et al., 2022). Thus, this study analyzes research trends in problem-based learning and problem-solving ability in the form of published articles from 2002 to 2022.

Method
PRISMA

This research is based on previous findings from various publications in the form of articles through Dimensions.ai database. The method used is bibliometric analysis with stages following the flow chart Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Veile et al., 2018). The stages in PRISMA include identification, screening, and inclusion (Veile et al., 2018). Stage 1 (identification) is present 10767 notes from Dimensions.ai, taking into account for each major search term "Problem Based Learning" or "Problem Solving Ability" published from 2002 to 2022. Stage 2 (screening) selected the type of publication in the form of articles in the field of each search term, so that 6342 records were issued. Stage 3 (included), the final sample produces accessible article 4425. Figure 1 shows the stages of PRISMA.
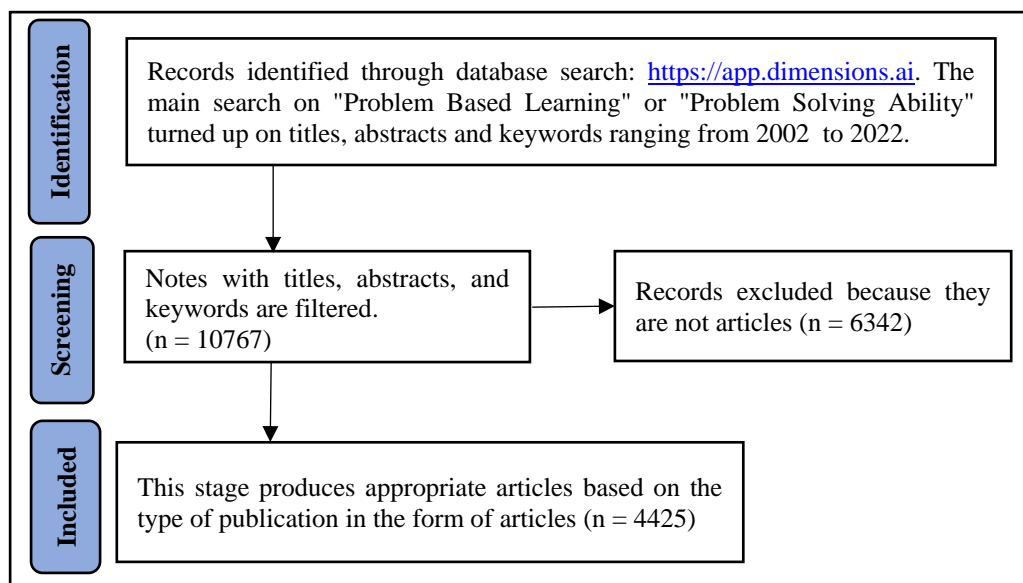

Figure 1. Sample of Selected Articles Based on Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)

VOSviewer

The latest research can be obtained by using the VOSviewer application. VOSviewer will visualize and analyze the co-citation of references, co-authorship, and co-occurrence of keywords (Huang et al., 2022). The procedure for co-occurrence analysis in VOSviewer is as follows. (1) Type of data selected option create a map based on text data. This option is selected to create a co-authoring map based on text data (keywords). (2) The selected data source read data from reference manager files. File types that support are RIS, EndNote, and RefWorks. (3) The file type is selected RIS. Enter the search result file "Problem Based Learning" or "Problem Solving Ability" that has been downloaded from Dimensions.ai. (4) In choose fields selected the title field. This option only surfaces by title. (5) Choose counting method selected full counting. (6) Choose threshold select minimum number of occurrences of a term is 5. Of the 1429 terms, 65 met the threshold. (7) In verify selected terms, 38 items are selected according to the topic. The results of data from VOSviewer that will be used in this study are network visualization and density visualization.

Furthermore, the co-authorship analysis procedure for problem-based learning research and problem-solving ability from 2002 to 2022 is as follows:

(1) Type of data selected option create a map based on bibliographic data. This option is selected to create a co-authoring map based on co-authorship, keyword co-occurrence, citation, bibliographic coupling, or co-citation map based on bibliographic data.

(2) The selected data source read data from reference manager files. File types that support are RIS, EndNote, and RefWorks.

(3) The file type is selected RIS. Enter the search result file "Problem Based Learning" or "Problem Solving Ability" that has been downloaded from Dimensions.ai.

(4) Select the type of analysis that is co-authorship with full counting. Ignore documents with lots of authors.

(5) In the choose threshold, select the minimum number of documents of an author as much as 2. Of the 4066 authors, 236 met the threshold.

(6) In verify selected terms, 12 appropriate items are selected.

Results

In this section, the results of the study were presented according to the eight questions.

Number of Publications per Year

The results obtained through Dimensions.ai show the trend of problem-based learning research and problem-solving ability from 2002 to 2022. The trend began to increase sustainably in 2018 to 2022. The data can be seen in Figure 2.
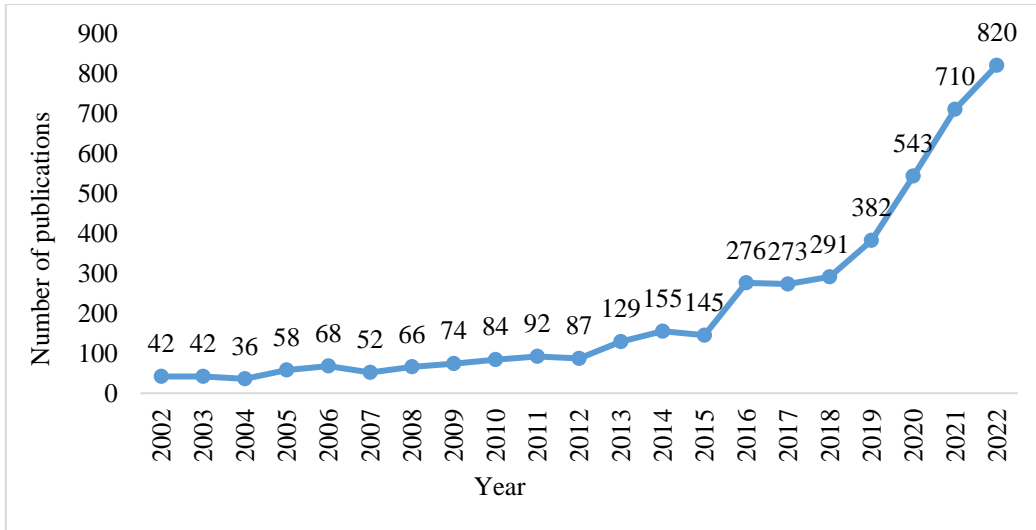
Figure 2. Annual Number of Publications per Year (Data Source: https://app.dimensions.ai)

Number of Citations per Year

The results show that the number of citations per year from 2002 to 2022 has consistently increased. In 2002, there were 11 articles and in 2022 there were 11752 articles. The author who has the most citations is Gwo-Jen Hwang as many as 1014. The data can be seen in Figure 3.
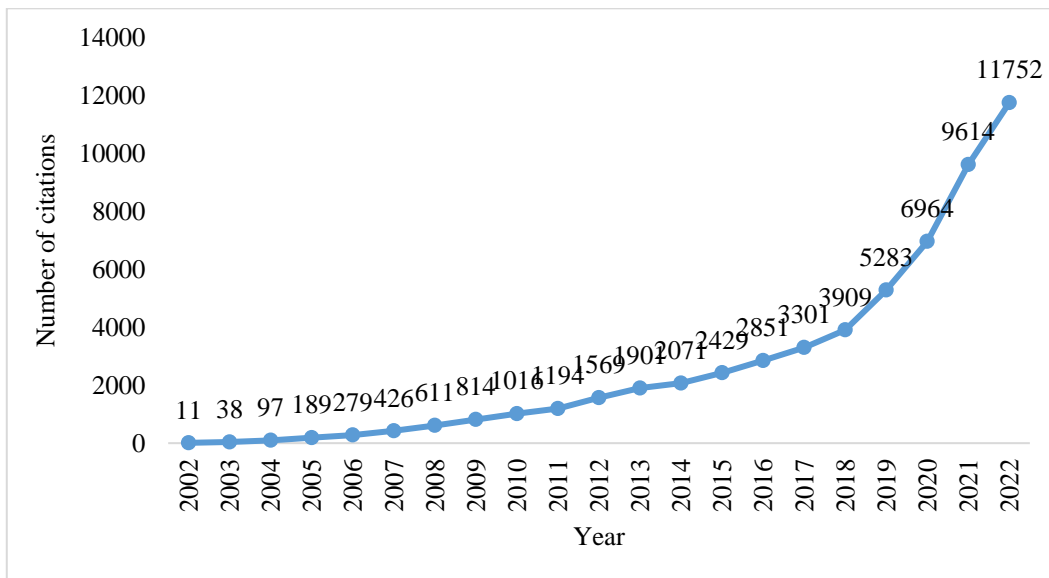
Figure 3. Annual Number of Citations per Year (Data Source: https://app.dimensions.ai)

The Number of Publications Reviewed from the Research Field Category

The results show the number of publications in terms of the category of the most research fields in education (2717 articles). While at least in history, heritage and archaeology research (5 articles). The data can be seen in Figure 4.
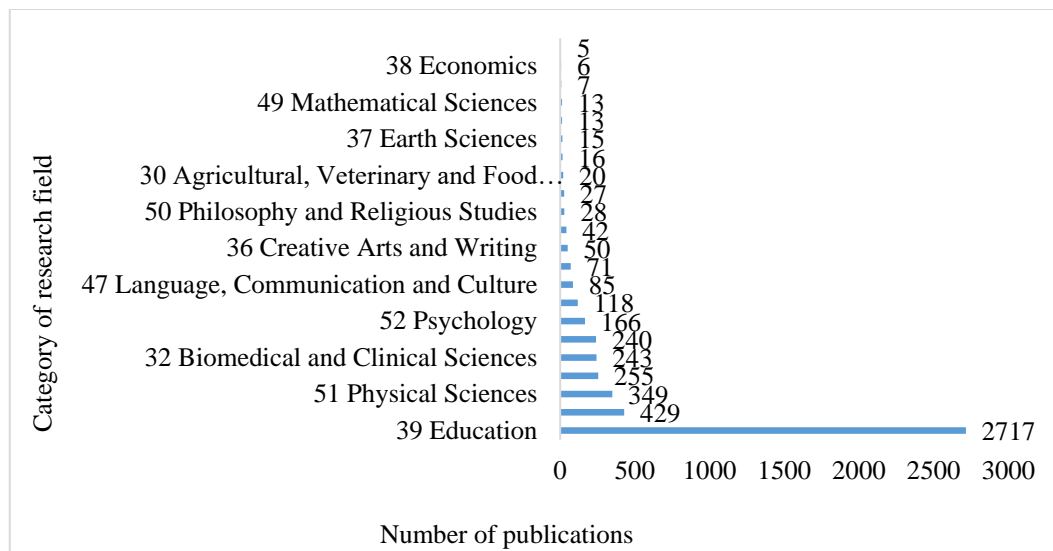
Figure 4. The Number of Publications Viewed from the Category of Research Fields (Data Source: https://app.dimensions.ai)

Number of Publications Reviewed from Journals

From various journals that publish problem-based learning research and problem-solving ability, the top 10 have the most publications. The results show the most publishers are the Journal of Physics Conferences Series (346 articles). While the order of 10 that is Al-Jabar Jurnal Pendidikan Matematika (30 articles). The data can be seen in Figure 5.
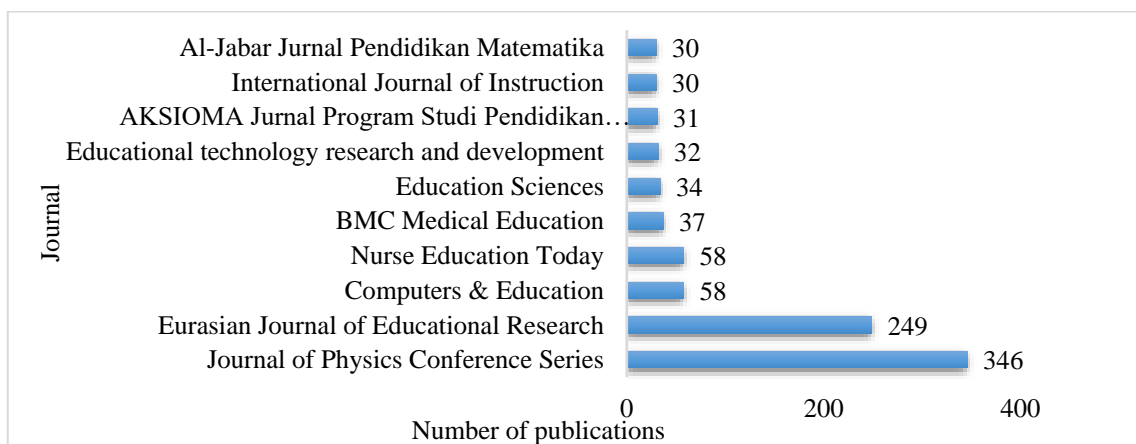
Figure 5. Number of Publications Viewed from Journals (Data Source: https://app.dimensions.ai)

The Number of Publications Reviewed from the Author

From various authors who are involved in research problem-based learning and problem-solving ability, the top 10 have the most publications. The results showed the first rank in the number of publications reviewed by researchers, namely I Made Arnawa from Indonesia (22 articles). While the order of 10 that is Edi Syahputra from Indonesia (10 articles). Data can be seen in Table 1.

Table 1. The Number of Publications in Terms of Authors (Data Source: https://app.dimensions.ai)

	Author	Number of publications	Country
1	I Made Arnawa	22	Indonesian
2	Big-June Hwang	19	Taiwan
3	Dadang Juandi	19	Indonesian
4	Brian R Belland	14	United States
5	Binar Kurnia Prahani	14	Indonesian
6	Dwi Agus Kurniawan	12	Indonesian
7	Yerizon	11	Indonesian
8	Ali- Asmar	10	Indonesian
9	Tommy Tanu Wijaya	10	China
10	Edi Syahputra	10	Indonesian

Network Visualization Co-Occurrence Problem-Based Learning and Problem-Solving Ability

The results obtained in network visualization co-occurrence show the relationship between items. Based on the keywords problem-based learning (pbl) and problem-solving ability the two are not connected. The data can be seen in Figure 6.
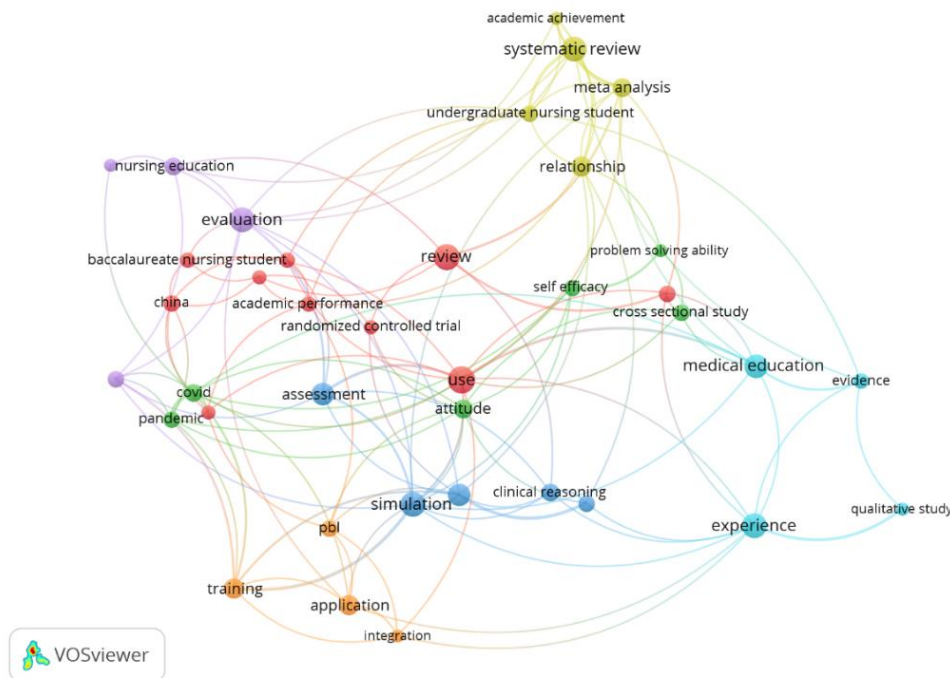

Figure 6. Network Visualization Co-Occurrence Problem-Based Learning and Problem-Solving Ability (Data Source: https://app.dimensions.ai)

Density Visualization Co-Occurrence Problem-Based Learning and Problem-Solving Ability

The results obtained in density visualization co-occurrence show emphasis on the research group. Based on the

keywords problem-based learning and problem-solving ability, not much research has been done. The data can be seen in Figure 7.
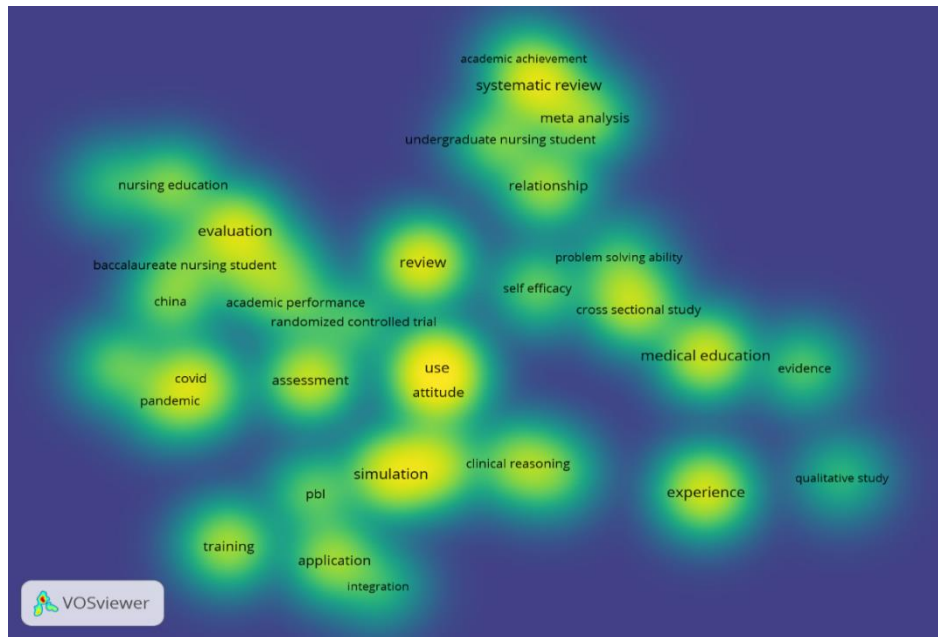
Figure 7. Density Visualization Co-Occurrence Problem-Based Learning and Problem-Solving Ability (Data Source: https://app.dimensions.ai)

Network Visualization Co-Authorship Problem-Based Learning and Problem-Solving Ability

Based on the results of network visualization co-authorship the most collaboration with other researchers is Elliott, Timothy R. Then followed by Berry, Jack W. Data can be seen in Figure 8.
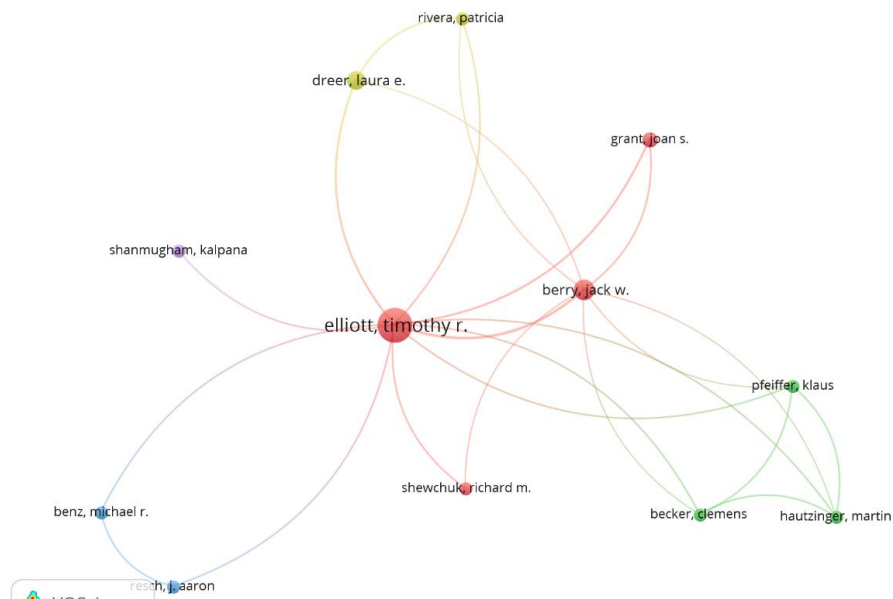

Figure 8. Network Visualization Co-Authorship Problem-Based Learning and Problem-Solving Ability (Data Source: https://app.dimensions.ai)

Discussion

This study was conducted to examine the publication trend of problem-based learning research and problem-solving ability from 2002 to 2022 using bibliometric analysis. The bibliometric analysis is used to evaluate the contributions of authors, journals, and cooperative relationships between authors (Nunen et al., 2018). The following is an explanation of the results of his research.

Figure 2 shows the number of publications per year from 2002 to 2022. In 2002 and 2003 there were 42 articles published. From 2003 to 2004 there was a decrease of 6 articles. From 2004 to 2006 there was an average increase of 16 articles. From 2006 to 2007 there was a decrease of 16 articles. From 2007 to 2011 there was an average increase of 10 articles. From 2011 to 2012 there was a decrease of 5 articles. From 2012 to 2014 there was an average increase of 34 articles. From 2014 to 2015 there was a decrease of 10 articles. From 2015 to 2016 there was an increase of 131 articles. From 2016 to 2017 there was a decrease of 3 articles. The years 2018 to 2022 have increased continuously. The average increase in publications from 2018 to 2022 was 132 articles. This is in accordance with the results of bibliometric research related to problem-based learning by Zhang et al (2022) and Tosun et al (2021) which states that publications on problem-based learning research have continued to increase over the past few years. In addition, the results of bibliometric research related to problem-solving ability by Krisnaningsih et al (2021) It also states that research publications, problem-solving skills also increase every year. Thus, the topic of problem-based learning and problem-solving ability will become a trend in the future.

Furthermore, Figure 3 shows that the number of citations per year from 2002 to 2022 has increased exponentially. This is comparable to the results from Zhang et al (2022) which states that problem-based learning publications continue to increase and research from Krisnaningsih et al (2021) stated that the publication of problem-solving ability had increased. Based on the results of the two researchers, it is undeniable that there will be an increase in citations to problem-based learning and problem-solving ability. The smallest citation was obtained in 2002, which was 11 articles. Meanwhile, the most citations in 2022 are 11752 articles. The average citation is 2682 articles. The author who has the most citations is Gwo-Jen Hwang as many as 1014. Thus, the one that can be used as a reference with the most citations is Gwo-Jen Hwang.

Figure 4 shows that education ranked first by research field with 2713 articles. This is also in line with the results of the study Azer (2017) which states that problem-based learning research is mostly carried out in the field of education. The second position in the field of Health Sciences 429 articles. Followed by the field of Physical Sciences 349 articles. Next field Information and Computing Sciences 255 articles. Field of Biomedical and Clinical Sciences 243 articles. Engineering field 240 articles. Field of Psychology 166 articles. Field of Commerce, Management, Tourism and Services 118 articles. Field of Language, Communication and Culture 85 articles. Field of Human Society 71 articles. Field of Creative Arts and Writing 50 articles. Field Built Environment and Design 42 articles. Field of Philosophy and Religious Studies 28 articles. Field of Biological Sciences 27 articles. Field of Agricultural, Veterinary and Food Sciences 20 articles. Field of Law and Legal Studies 16 articles. Earth Sciences Field 15 articles. Environmental Sciences and Mathematical Sciences 13 articles. Field of Chemical Sciences 7 articles. Field of Economics 6 articles. While in the last place in the field

of History, Heritage and Archaeology 5 articles. Therefore, articles that can be used as references in research that reviews problem-based learning and problem-solving ability are the field of educational research.

Figure 5 shows the number of publications reviewed from journals. From various journals that publish problem-based learning research and problem-solving ability, the top 10 journals that have the most publications are taken. The results showed that the most journals were the Journal of Physics Conferences Series with 346 articles. In the Journal of Physics Conferences Series that has the most citations is "Review of Problem-Based Learning trends in 2010-2020: A Meta-Analysis Study of The Effect of Problem-Based Learning in Enhancing Mathematical Problem-Solving Skills of Indonesian Students" (Suparman et al., 2021). Furthermore, in second place is the Eurasian Journal of Educational Research 249 articles. Computers & Education and Nurse Education Today 58 articles. BMC Medical Education 37 articles. Education Sciences 34 articles. Educational Technology Research and Development 32 articles. AKSIOMA Jurnal Program Studi Pendidikan Matematika 31 articles. International Journal of Instruction and Al-Jabar Jurnal Pendidikan Matematika 30 articles. Therefore, articles that can be used as references in research that reviews problem-based learning and problem-solving ability are from the Journal of Physics Conferences Series.

Table 1 shows the number of publications reviewed from authors. From various authors involved in problem-based learning research and problem-solving ability, the top 10 that have the most publications are taken. The results showed that I Made Arnawa from Indonesia ranked first with 22 articles. The article with high relevance to this research was written by I Made Arnawa and collaborated with another author, namely "Improving Students' Problem-Solving Ability through Learning Tools Based on Problem Based Learning" (Permatasari et al., 2020). This was followed by Gwo-jen Hwang and Dadang Juandi with 19 articles. Brian R Belland and Binar Kurnia Prahani 14 articles. Dwi Agus Kurniawan 12 articles. Jeryzon 11 articles. Ali-Asmar, Tommy Tanu Wijaya, and Edi Syahputra 10 articles. Of the top 10 authors who are most influential in problem-based learning research and problem-solving ability come from Indonesia, as many as 7 people. Therefore, the author who can be used as a reference in research that reviews problem-based learning and problem-solving ability is I Made Arnawa.

Figure 6 shows network visualization co-occurrence in problem-based learning research and problem-solving ability from 2002 to 2022. The relationship between them is indicated by the cluster of nodes (color) corresponding to the distance from the various clusters (Jia & Mustafa, 2022). 7 main clusters were obtained in network visualization, namely yellow, purple, red, dark blue, green, brown, and Tosca blue. The yellow cluster consists of academic achievement, systematic review, meta-analysis, undergraduate nursing student, and relationship. The purple cluster consists of quasi experimental study, nursing education, evaluation, and experimental study. The red cluster consists of baccalaureate nursing student, trial, review, china, style, case study, academic performance, use, randomized controlled trial and perspective. The dark blue cluster consists of assessment, simulation, performance, clinical reasoning, and dental student. The green cluster consists of COVID, pandemic, attitude, self-efficacy, problem solving ability, and cross sectional study. The brown cluster consists of PBL, training, application, and integration. The Tosca blue cluster consists of medical education, evidence, experience, and qualitative study. Based on the keywords problem-based learning (PBL) and problem-solving ability the two are not connected. Therefore, problem-based learning (PBL) and problem-solving ability can be

used as novelty for future research.

Figure 7 shows the density of visualization co-occurrence in problem-based learning research and problem-solving ability from 2002 to 2022. Where, in this section to get an overview of the mapping of the area (Van Eck & Waltman, 2010). The light color indicates that a lot of research has been done. Topics in bright colors include academic achievement, systematic review, meta analysis, undergraduate nursing student, relationship, nursing education, evaluation, baccalaureate nursing studental, style, china, review, COVID, pandemic, assessment, use attitude, simulation, training, application, perspective, cross sectional study, medical education, and experience. While the dim color shows that research has not been done much. Topics that are in dim color include evidence, qualitative studies, self efficacy, PBL, and integration. Therefore, the recommended research topics are topics that have dim colors, such as problem-based learning and problem-solving ability.

Figure 8 shows network visualization, co-authorship problem-based learning, and problem-solving ability from 2002 to 2022. The relationship between them is indicated by the cluster of nodes (color) corresponding to the distance from the various clusters (Jia & Mustafa, 2022). There are 5 clusters and 12 authors. The clusters are purple, yellow, red, green, and blue. The purple cluster is Shanmugham, Kalpana. The yellow cluster consists of Rivera, Patricia and Dreee, Laura E. The red cluster consists of Grant, Joan S; Berry, Jack W; Elliott, Timothy R and Shewchul, Richard M. Green cluster consists of Pfeiffer, Klaus; Becker, Clemens and Hautzinger, Martin. While in the blue cluster are Benz, Michael R and Resch, J. Aaron. The predicate that has the most collaboration with other researchers is Elliott, Timothy R. Therefore, researchers who are advised to find problem-based learning writers and problem-solving ability who have the most collaboration are Elliott, Timothy R.

Conclusion

The topic of problem-based learning and problem-solving ability will be a trend in the future. Gwo-Jen Hwang can be used as a reference with the most citations. Articles that can be used as references in research that reviews problem-based learning and problem-solving ability are the field of educational research. Articles that can be used as references in research that reviews problem-based learning and problem-solving ability are from the Journal of Physics Conferences Series. The author who can be used as a reference in research that reviews problem-based learning and problem-solving skills is I Made Arnawa. The topic of problem-based learning (PBL) and problem-solving ability can be used as novelty for further research. Thus, the recommended topics for current research trends are problem-based learning and problem-solving ability. Researchers who are recommended for problem-based learning referrals and problem-solving ability that have the most collaboration are Elliott, Timothy R. The limitation of this study is that it uses a Dimensions.ai database with a range of years 2002 to 2022. Therefore, further research can be developed again using another database. For example, using Scopus databases, Publish or Perish, Google Scholar, and others.

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