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A Bibliometric Analysis of Publications on Problem-Based Learning

Özge Sarıkaya [a*] ***& Huriye Deniş-Çeliker*** [b]

a Ph.D Student., Burdur Mehmet Akif Ersoy University, https://orcid.org/0000-0002-8941-1185
*ozgesarikaya01@gmail.com
b. Prof. Dr., Burdur Mehmet Akif Ersoy University, https://orcid.org/0000-0001-8059-6067

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Abstract

The study aims to perform a bibliometric analysis of scientific research published in the field of problem-based learning (PBL). In this context, 3522 scientific studies published between 1980 and 2020 in the field of PBL were examined bibliometrically and the trend in the last 40 years was revealed. In the Web of Science Core Collection database, a search was carried out under the title of "Problem-Based Learning" and bibliometric data of the studies were obtained. The studies were examined under the sub-titles of the number of publications by years, publication types, country and institution collaborations, publication and author citation networks, research areas, and keywords used. As a result of the analyses, collaborations and relationship patterns were visualized in the form of cognitive maps. It has been determined that more than half of the studies on PBL have been published in the last ten years, the most published type of study on the subject in the article. In addition, it has been revealed that the author of the most cited source is Hmelo-Silver (2004), the most cited researcher is Howard S. Barrows. It is thought that the results of the research will guide those who will research with problem-based learning.

Keywords: Bibliometric analysis, problem-based learning, Web of Science Core Collection.

Probleme Dayalı Öğrenmeye İlişkin Yayınların Bibliyometrik Analizi

Öz

Çalışmanın amacı probleme dayalı öğrenme (PDÖ) konu alanında yayımlanan bilimsel araştırmaların bibliyometrik analizini gerçekleştirmektir. Bu kapsamda, PDÖ alanında 1980-2020 yılları arasında yayımlanan 3522 bilimsel çalışma bibliyometrik olarak analiz edilmiş, son 40 yıldaki eğilim ortaya çıkarılmıştır. Web of Science Core Collection veri tabanında "Probleme Dayalı Öğrenme" konu başlığında tarama yapılmış ve çalışmalara ait bibliyometrik veriler elde edilmiştir. Çalışmalar; yıllara göre yayın sayıları, yayın türleri, ülke ve kurum iş-birliktelikleri, yayın ve yazar atıf ağları, araştırma alanları ve kullanılan anahtar kelimeler alt başlıklarında incelenmiştir. Ayrıca PDÖ alanında yayımlanan araştırmalarda kullanılan anahtar kavramların belirlenmesi için kelime analizi gerçekleştirilmiştir. Anahtar kelimelerin görselleştirilmesi için WordSift yazılımı tercih edilmiştir. Analizler sonucunda ulaşılan sonuçlar bilişsel haritalar şeklinde görselleştirilmiştir. PDÖ ye ilişkin çalışmaların yarısından çoğunun son on yılda yayımlandığı, konuya ilişkin en çok makalenin yayımlanmış olduğu, en çok ABD'ni ülke iş birliğinin olduğu, kurum iş birliğinin en çok olduğu kurum Maastrciht Üniversitesi ortaya çıkmıştır. Ayrıca en çok atıf alan kaynağın yazarın Hmelo-Silver (2004) olduğu, en çok atıf alan araştırmacının Howard S. Barrows, en çok eğitim araştırmalarında PDÖ kullanıldığı ve en sık kullanılan anahtar kelimenin probleme dayalı öğrenme olduğu belirlenmiştir. Araştırma sonuçlarının probleme dayalı öğrenmeyle araştırma yapacaklara rehber olacağı düşünülmektedir. Farklı araştırmalarda eğitimin farklı alanlarında yapılan çalışmaların bibliyometrik analizi yapılarak daha detaylı bilgiler sunulabilir.

Anahtar kelimeler: Bibliyometrik analiz, probleme dayalı öğrenme, Web of Science Core Collection.

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INTRODUCTION

Education in the 21st century requires dealing with real-world problems, and problem solving skill is one of the most important skills of this century (Erden & Yalçın, 2021; Tan, 2021). Along with the fact that students start to learn subjects and concepts formally or informally, the knowledge and skills they acquire while they encounter problem situations related to subjects and concepts and actively participate in the process of producing solutions for these problems extend to pre-school periods (Karamustafaoğlu et al., 2018). Problem-based learning is one of the methods that can be used to convey the knowledge and skills that students have gained in daily life and to display different perspectives on each problem they encounter (Kaptan & Korkmaz, 2001). The fact that education is continuous and present in all areas of individuals' lives (Hun & Değirmençay, 2020) reveals the importance of education in problem-based learning. Problem-based learning has a long history in experience-based education. Problem-based learning (PBL) is a teaching method in which students learn by problem solving (Hmelo-Silver, 2004), and it was developed by educators at McMaster University in the 1960s in response to the problems faced by medical students in traditional methods and to prepare students for clinical practice (Thorndahl & Stentoft, 2020). In Turkey, with the renewed curriculum studies in education, PBL first started to take place in the curriculum in 2006 (Ministry of National Education, 2006). In the updated final version of the science curriculum, PBL is implemented by being supported with scenarios inspired by daily life to provide students in the learning environment with problem-solving skills (Ministry of National Education, 2018).

PBL a method based on the constructivist approach, which aims to enable students to take responsibility for their learning, in other words, to gain the skill of "learning to learn" and to increase their learning capacity (Kılınç, 2007). In learning environments where the constructivist approach is based, students are at the center of the learning process, while teachers are involved in the process as a guide in the stages of accessing information, not giving the necessary information, but encouraging the student (Balım et al., 2012). In science courses where the constructivist approach is at the forefront, students gain many knowledge and skills that they can transfer to daily life (Yıldız & Beşoluk, 2019). What is expected from students in PBL is to introduce the problem through scenarios prepared by teachers for daily life problems and to acquire knowledge and skills around the problems (Ahmed & Kannaiah, 2018). In the process of producing solutions to the given problem scenarios, taking into account the individual differences of the students; questioning and critical thinking, decision making, social skills, communication and collaborative learning skills, independent learning skills, and thus high-level thinking skills develop (Puspasari & Puspasari, 2019; Temel, Şen & Yılmaz, 2014; Tosun & Yaşar, 2013). The main tool used in PBL environments is problem scenarios (Deniş-Çeliker, 2021). Well-structured problem scenarios allow students to trigger their learning by enabling them to define the problem, analyze the problem, form hypotheses, and identify learning problems. In the face of problem scenarios, students first define the problems individually and then interact with the problem scenarios they encounter in small groups and reach their learning goals through teacher-guided discussion (Kaptan & Korkmaz, 2001; Tan, 2002; Wood, 2003; Wulandari, 2018). In addition, the problem scenarios presented in the PBL method lead students to think about different possible solutions instead of directing them to a single correct answer (Mutlu & Aydoğmuş, 2019). Integration of science and technology with education, PBL is a promising learning process that helps students understand various social, economic and environmental problems (Thakur et al., 2021).

The increasing importance of problem-based learning in the education system and as a research topic with an important area in the relevant literature, it appears as a teaching method that is increasingly used around the world (Mutlu & Aydoğmuş, 2019; Temel, Şen & Yılmaz, 2014). It was determined that these studies on PBL examined the effects of PBL on various variables (academic achievement, attitude, thinking skills, collaborative working skills, problem solving skills, etc.) in various fields (science education, physics education, chemistry education, mathematics education, medical education etc.) (Ceylan & Umdu Topsakal, 2023; Divarcı & Saltan, 2017; Gül & Konu, 2018; Kim, Vicentini & Belland, 2022; Liu & Pásztor, 2022; Phungsuk, Viriyavejakul, & Ratanaolarn, 2017; Siagan, Saragih & Sinaga, 2019; Trullàs, Blay, Sarri & Pujol, 2022; Wahyudiati, 2022). Additionally, when the studies in the field of PBL are examined, the trend, content and context studies on the subject are frequently encountered in the literature (Çakıcı et al., 2020; Gao et al., 2020; Kim et al., 2017; Leary, Walker, Shelton & Fitt, 2013; Özturan et al., 2020; Yıldırım & Say, 2020). When the analyses of problem-based learning studies are explored; it has been determined that these studies differentiate according to the fields they are studied such as science education, chemistry education, medical education, and mathematics education. It was determined that similar analysis studies such as content-analysis, meta-analysis, literature analysis and bibliometric analysis were carried out (Arıcı, 2022; Ghani, Rahim, Yusoff & Hadie, 2021; Juandi & Tamur, 2021;

Leary, Walker, Lefler & Kuo, 2019; Temel, Şen & Yılmaz, 2014; Tosun, Şenocak & Taşkesenligil, 2021; Zakaria, Maat & Khalid, 2019; Zhang, Wang, Bai. & Zhang, 2022).

Although many compilation and analysis studies have been published in the domain of problem-based learning in recent years, it can be said that analysis studies covering all fields are limited. The increase in interest and studies in PBL reveals the necessity of summarizing the results of these studies. Therefore, in the current study, answers to the following questions were sought in the studies carried out in the field of problem-based learning between 1980 and 2020 in the Web of Science database:

1. What is the distribution of problem-based learning studies by years?
2. What are the publication types of problem-based learning studies?
3. How are countries collaborations in problem-based learning studies?
4. What are the institutional collaborations like in problem-based learning studies?
5. What are the most cited studies in problem-based learning studies?
6. Who are the most cited authors in problem-based learning studies?
7. How are problem-based learning studies distributed according to research areas?
8. What are the most used keywords in problem-based learning studies?

METHOD

Design Model

Bibliometric analysis method was used in the analysis of studies on PBL. Bibliometrics can be defined as the process of quantifying content analysis (Böyükyılmaz & Oktay, 2020). However, unlike content analysis, bibliometrics is a method that provides information about the activities of scientific publications, analysis of certain features of publications (joint citations, journals in which they are published, keywords, cooperation between countries and institutions, etc.), and statistically visualizing the trends specific to the researched domain (Al, 2008; Al & Çoştur, 2007; Özkaya, 2019). Findings obtained from bibliometric analyses can be shown and classified with percentage and frequency tables used in content analysis (Böyükyılmaz & Oktay, 2020). Intercalarily these tables, cross-country collaborations and common citation networks can be visualized by using social network analysis in bibliometric studies (Güzeller & Çeliker, 2017). Social network analysis is a form of analysis that includes various analysis and measurement tools to analyze and understand interrelated data within a social structure, enabling the visualization of the obtained information and thus showing the important factors in the researched area (Karagöz & Yüncü, 2013). Bibliometric methods are used to provide quantitative analysis of written publications (Ellegaard & Wallin, 2015) and to improve access to information and learn more about the structure of information (Carter-Templeton et al., 2018). To reveal the data, bibliometric methods based on content or citation analysis are used (Wallin, 2005).

Collection of Data

Scientific documents whose bibliometric analyzes were performed were accessed from the Web of Science database by typing the keyword "problem-based learning". The documents obtained are limited to the 1980–2020 year range. Consequently, the scanning carried out in Web of Science, a total of 3522 documents were reached. All document types were analyzed without any restrictions on document types. Analyzes were carried out through the social network analysis program CiteSpace II. CiteSpace II program; It is an open-access Java application that can be used to visualize and analyze trends and changes emerging in the literature (Chen et al., 2010). In order to perform analyzes on the documents, the data has been converted into a format that can be processed in the CiteSpace II program.

In the current study, 3522 publications; detailed information about publication year, publication type, abstract, author's name, number of citations, keywords and bibliography were obtained. Within the scope of the analysis, first of all, the distribution of scientific documents published in the PBL subject area in the Web of Science database by years and the frequency values for the types of publications were determined, and the periods in which the publications in the PBL field were concentrated and the most used document types were determined. The author co-citation network was determined by analyzing the authors most cited by the studies and important authors working in the field of PBL education were determined. Within the scope of the research, the determination of the key concepts used in the studies published in the field of PBL and included in the data set was also carried out by word analysis. WordSift (word cloud software) was used to visualize key concepts. In studies conducted in the field of PBL; Social network analysis and frequency tables were used to identify country and institution

collaborations, publication common citation network, in which fields they were studied and the most cited authors, and to visualize the related relations. The number of citations obtained from the citation sources obtained as a result of the analyses, their collaborations and their position in the network were evaluated according to the "centrality betweenness". The betweenness centrality value is defined for each node in a network. In betweenness centrality, Each node in the network shows the analyzed variable, and each link shows the relationships between those variables. As the number of connections between the variables increases, the connections between the nodes also thicken (Ukşul, 2016).

FINDINGS

Within the scope of the study, the number of publications by years, publication types, country collaborations, links of institutions, fields of study, common citation networks and key concepts were examined, and the following findings were reached. Key concepts, collaborations, connections and relationship patterns are visualized in the form of cognitive maps.

1. Number of PBL Publications by Years

Distribution of 3522 studies published in the PBL subject area between 1980 and 2020 is examined. The results obtained are given in Table 1.

Table 1. Distribution of Publications on PBL by Years

Years	Frequency (f)	Percent (%)
1980-1990	41	1
1991-2000	516	15
2001-2010	1026	29
2011-2020	1939	55
Total	3522	100

It is seen that most research in the subject area was published between 2011 and 2020 (n=1939). According to the Table 1, although there were a total of 557 publications in the field of PBL in the 20 years from 1980 to 2000, it is seen that academic research in this field has increased more since 2000. In addition, it has been stated that the studies in the field of PBL have accelerated in the last 10 years, and the publication rate between 2011-2020 constitutes 55% of the total publications.

2. Publication Types

Secondly, the types of publications made in the domain of problem-based learning were analyzed in the research. Analysis results are given below. (See Table 2).

Table 2. Distribution of Publications on PBL by Publication Types

Publication Types	Frequency (f)	Percent (%)
Article	1906	51,5
Paper	1017	27,5
Summary	245	6,6
Editorial Material	144	3,9
Book Section	100	2,7
Cover Letter	92	2,5
Compilation	81	2,2
Book Review	52	1,4
News Items	23	0,6
Studies in Publication Stage	17	0,5
Note	12	0,3
Correction	9	0,2
Book	4	0,1
Software Review	1	0,0
Total	3703	100%

When Table 2 is examined, publications related to PBL were carried out in 14 different ways (Article, Paper, Abstract, Editorial Material, Book Chapter, Cover Letter, Review, Book Review, News Items, Studies in the Publication Stage, Note, Correction, Book and Software Review). It was concluded that the studies on PBL between 1980 and 2020 were mostly published in Article type (n=1906) and Paper type (n=1017). These publications are respectively Editorial Materials (n=144), Book Chapters (n=100), Cover Letters (n=92), Reviews (n=81), Book Reviews (n=52), News Items (n=23). Studies in Publication (n=17), Notes (n=12), Revisions (n=9), Books (n=4) and Software Review (n=1).

3. Country Collaborations of Publications on PBL

In studies conducted in the field of PBL, determining the collaborations of researchers according to their countries; social network analysis and frequency values were determined. The 10 countries that have the most cooperation with other countries are presented in Figure1 and Table 3.

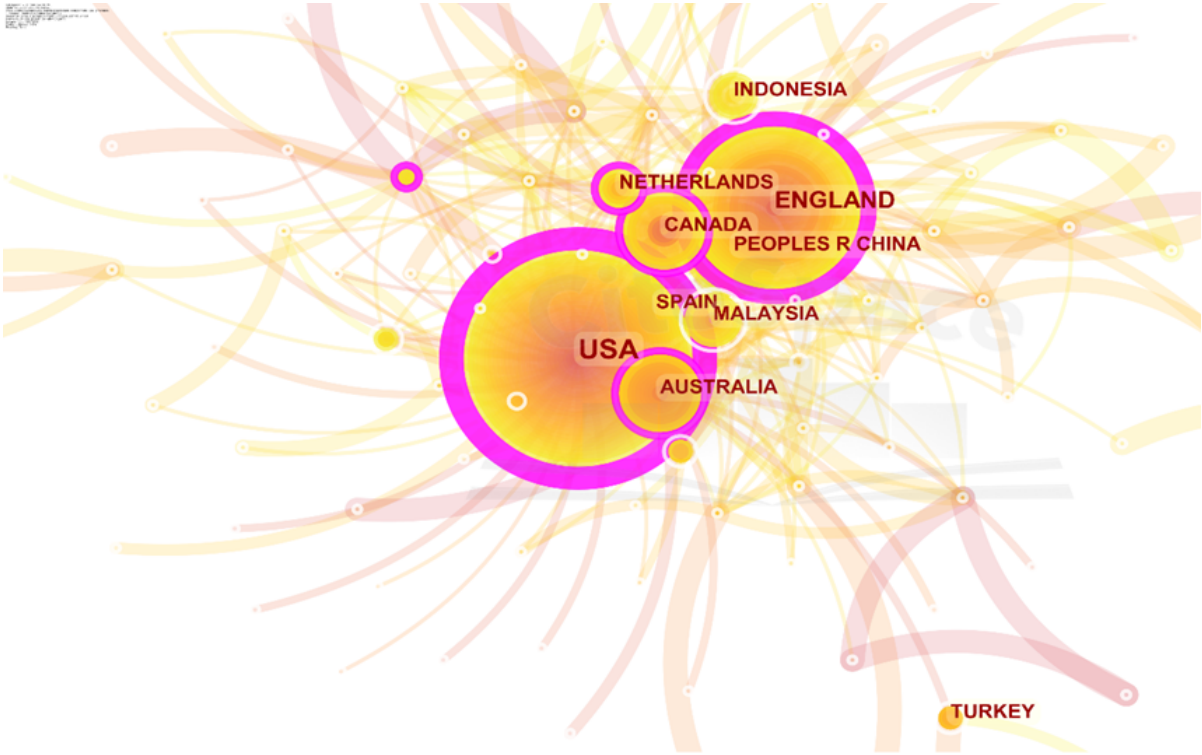

Figure 1. *Country Collaborations of Publications on PBL*

Table 3. Country Collaborations, Degrees of Centrality and Years

Countries	Frequency (f)	Centrality	Year
USA	809	0.46	1982
England	249	0.25	1993
Indonesia	227	0.04	2000
Canada	184	0.12	1987
Australia	171	0.15	1989
China	165	0.04	1992
Spain	151	0.09	2005
Netherlands	138	0.11	1992
Malaysia	134	0.03	1998
Turkey	105	0.04	1995

Each node in the network represents a country, and each link represents cooperation between countries. Colorings in the network show the years of collaborations. The thickness and size of the purple circle around the nodes indicate that the centrality degrees of the nodes are high (Ukşul, 2016).

According to the findings in Table 3 and Figure 1, it is seen that the USA is the country that cooperates most with other countries (n=809). In the network analysis in Figure 1, the USA is the country with the highest

degree of centrality. According to this finding, it can be stated that the USA plays a crucial function in the establishment and continuation of cooperation between countries in the field of PBL. It has been concluded that the countries with high cooperation with other countries are England, Indonesia, Canada, Australia, China, Spain, Netherlands, Malaysia and Turkey.

4. Institutional Collaborations of Studies on PBL

In the analyzed studies, in determining the collaborations carried out by the researchers according to the universities they are affiliated with; In the field of PBL, it is aimed to determine which university researchers collaborate with researchers from other universities the most.

According to the findings obtained from the social network analysis, the two large nodes in the network belong to Maastricht University and McMaster University. This finding shows that Maastricht University and McMaster University are the institutions that work the most in the field of PBL with other institutions (See Figure 2).

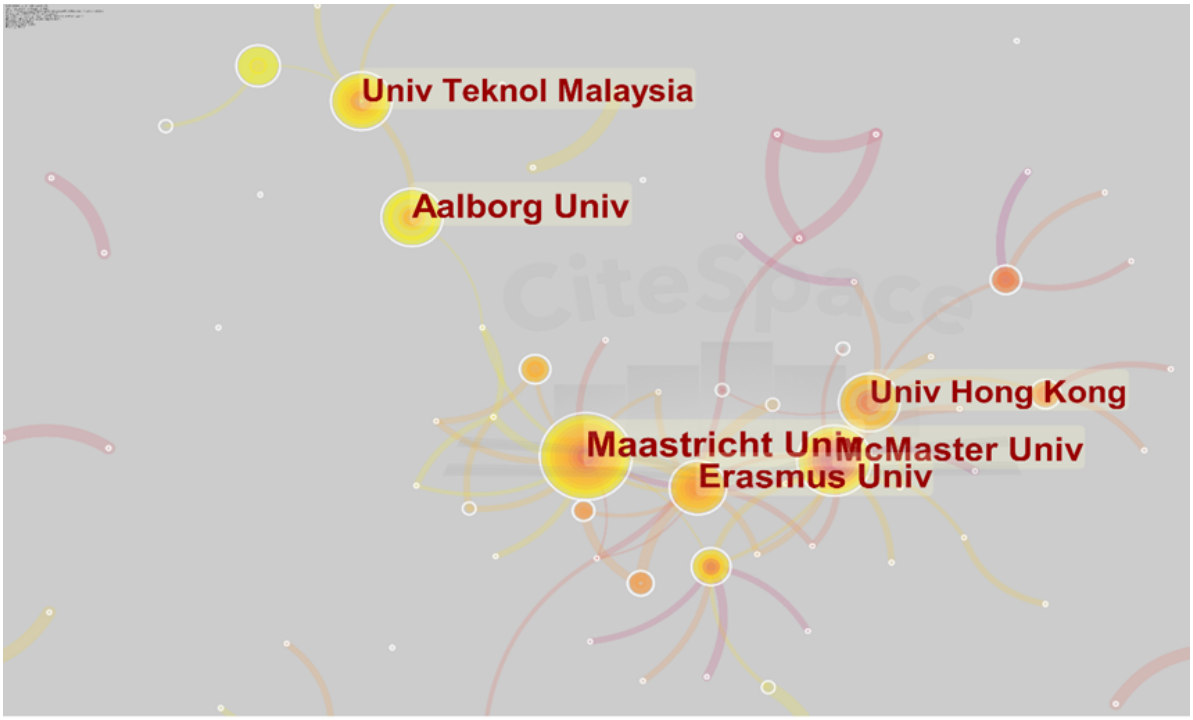

Figure 2. *Institutional Collaborations of Studies on PBL*

As a result of the analysis, the top 10 universities with high cooperation rates with other universities were determined and presented in Table 4.

Table 4. Frequency Distributions of Institutional Collaborations

Institution	Frequency (f)
Maastricht University	54
McMaster University	42
Aalborg University	38
Erasmus University	35
Malaysian University of Technology	32
University of Hong Kong	31
Indonesian University of Education	29
Indiana University	20
University of Delaware	20
Negeri Malang University	19

When Table 4 is examined, after Maastricht University (n=54) and McMaster University (n=42), Aalborg University (n=38), Erasmus University (n=35), Malaysian University of Technology (n=32), Hong Kong

University (n=31), Indonesia Education University (n=29), Indiana University (n=20), University of Delaware (n=20), and Negeri Malang University (n=19) are the most collaborating institutions in the field of PBL. universities have been identified.

5. Publication Common Citation Network

The 10 most cited articles in the studies published in the PBL subject area were analyzed in the CiteSpace II program, and their publication information and citation numbers are given in Table 5.

Table 5. Most Cited Articles

Article Information	Citation
Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn?	1585
Albanese M.A. & Mitchell S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues.	1348
Norman G.R. & Schmidt H.G. (1992). The psychological basis of problem-based learning: a review of the evidence.	838
Vernon, D.T.A. & Blake, R.L. (1993). Does problem-based learning work? A meta-analysis of evaluative research.	760
Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of Problem-Based Learning: A Meta-Analysis.	722
Colliver J.A. (2000). Effectiveness of problem-based learning curricula: research and theory	539
Wood, D.F. (2003). Problem based learning.	450
Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J. et al. (2003). Problem-Based Learning Meets Case-Based Reasoning in the Middle-School Science Classroom: Putting Learning by DesignTM into Practice. Journal of the Learning Sciences.	440
Norman, G.R. (2000). Effectiveness of problem-based learning curricula: Theory, practice and paper darts.	384
Dolmans, D. (2005). Problem-based learning: Future challenges for educational practice and research.	360
Gijbels, D., Dochy, F., Van den Bossche, P., & Segers, M. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment.	359
Yew, E.H.J. & Schmidt, H.G. (2011). What Students Learn in Problem-Based Learning: A Process Analysis.	287

When Table 5 is examined, the sources with the highest number of citations in the studies in the field of PBL are, in order, the Albanese M.A. & Mitchell S. they appear to be articles published in 1993. These studies are common reference sources that guide the field of PBL.

6. Author Co-Citation Network

The 10 most cited researchers in the field of PBL were determined as a consequence of the analysis are presented in Table 6 and Figure 3.

Table 6. Author Co-Citation Analysis and Years

Authors	Citation	Year
Henk G Schmidt	632	1983
Howard S. Barrows	620-608-235	1981-1985-1986
Mark A Albanese	502	1993
Cindy Hmelo-Silver	432	2006
Geoffrey Norman	417	1989
Diana Dolmans	365	1994
David Boud	315	1986
David T.A. Vernon	304	1993
Maggi Savin-Baden	239	2001
John R. Savery	232	1998

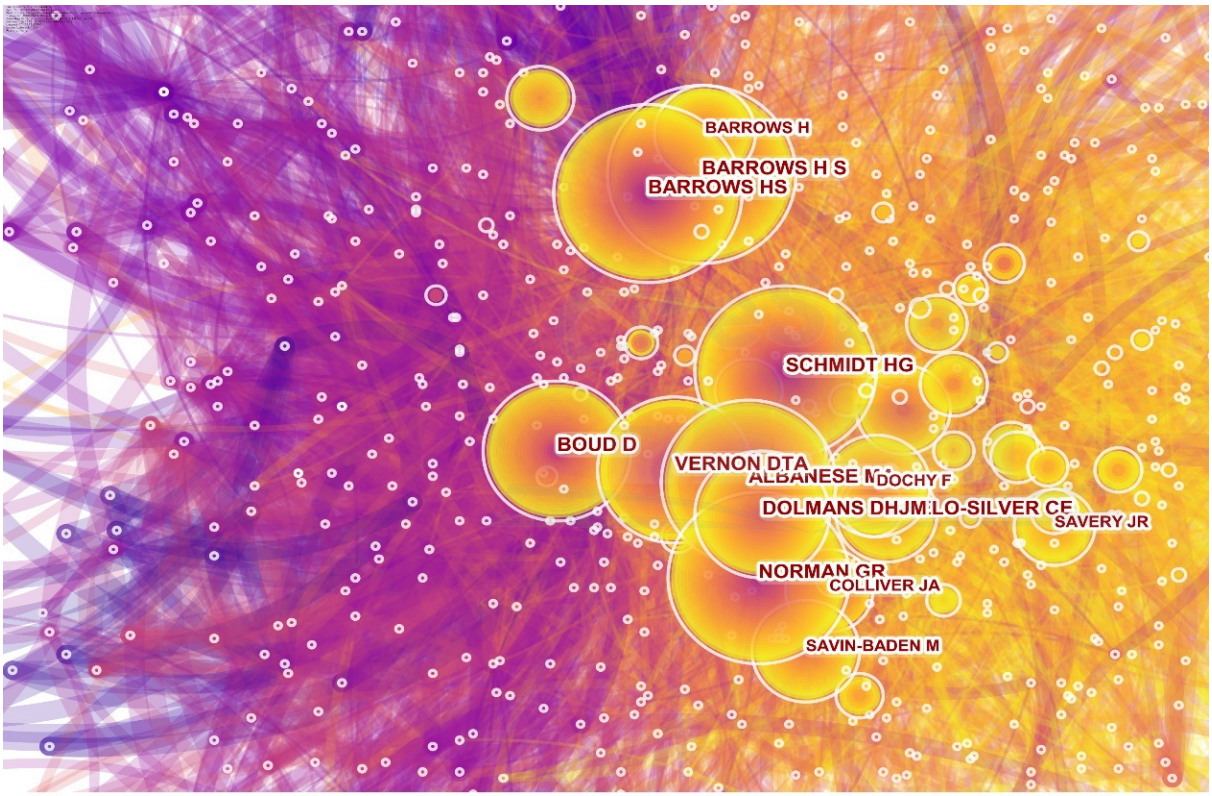

Figure 3. *Author Co-Citation Network*

It was concluded that the most cited researcher in the field of PBL was Howard S. Barrows (n=620, 1981; n=608, 1985; n=235, 1986). Henk G Schmidt (n=632) was identified as another researcher with a high number of common citations in studies conducted in the literature. Authors with a high number of citations in studies conducted within the scope of PBL; Mark A Albanese (n=502), Cindy Hmelo-Silver (n=432), Geoffrey Norman (n=417), Diana Dolmans (n=365), David Boud (n=315), David T.A. Vernon (n=304), Maggi Savin-Baden (n=239) and John R. Savery (n=232).

7. PBL Method Research Areas

The results of the analysis performed to determine in which areas the PBL method is most studied are presented in Table 7 and Figure 4.

Table 1. Demographic Information Regarding Pre-school Teachers Who Have Participated in the Research

Research Area	Frequency (f)	Centrality	Year
Educational Research	2150	0.71	1981
Educational and Scientific Discipline Studies	1141	0.15	1981
Health Sciences and Services	471	0.03	1981
Engineering	315	0.25	1994
Computer Science	281	0.08	1994
General Medicine and Internal Medicine	186	0.09	1987
Medicine, General & Internal Medicine	180	0.03	1987
Engineering Discipline	151	0.01	1998
Computer Science and Interdisciplinary Practice	145	0.02	1994
Nursing	145	0.14	1992

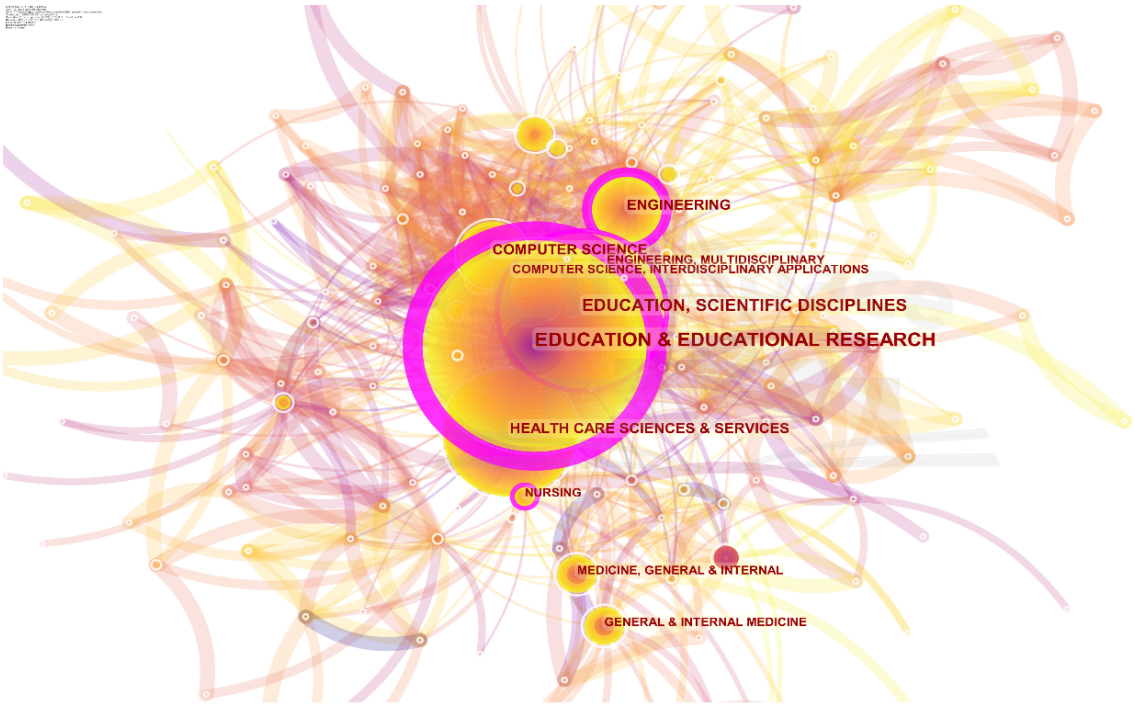

Figure 4. *Research Areas*

The findings show that the PBL method is used in different disciplines. According to the analysis results, PBL is mostly used in educational research (n=2150). After education, PBL was mostly used in health services (n=471), medical education (n=186 and n=180) and nursing (n=145), engineering (n=315 and n=151), and computer science (n=281) and (n=145) as a research topic.

8. Analysis of Keywords

The frequencies of the 100 most used keywords in the studies conducted in the field of PBL were calculated through the CiteSpace II program. WordSift software was used to visualize the words and it is given in Figure 5.

Figure 5. *Keywords Written in PBL Studies*

The most used keywords as a result of the calculations; “problem-based learning (n=1071), education (n=377), student (n=347), curriculum (n=249), medical education (n=164), outcome (n=111), knowledge (n= 96), skill (n=92), performance (n=88), and critical thinking (n=86). WordSift software was used to visualize the words. Figure 1 shows the 100 most used key concepts in the studies conducted in the field of PBL between 1980 and 2020.

DISCUSSION & CONCLUSION

The current study examined the bibliometric features of 3522 studies published in the international citation index Web of Science between 1980 and 2020 in the domain of problem-based learning and the findings showed an increase in the number of publications was observed according to the years when the distribution of publications was examined, and there was a dramatic increase in the studies on PBL, especially since the year 2000. In the period from 1980 to 2020, it has been determined that the studies on the subject have increased every year. Temel et al., (2014) analyzed the content of PBL studies conducted in the field of science teaching in Turkey and they stated in their research that there was an increase and decrease in the number of studies conducted since 2001, and that the number of studies was the highest in 2010. When the theses on problem-based learning in Turkey were researched, it was stated that the most thesis on the subject was written in 2011 (Erdogan, 2015).

When the studies published within the scope of PBL were examined according to their types, it was seen that they were carried out in 14 different publication types and the most publications were in the article type (51.5%). It has been determined that 79% of the total publications are articles and papers.

When country collaborations are examined, it has been determined that the USA cooperates most with other countries in the field of PBL. It has been seen that after the USA, England and Indonesia are the countries that have more cooperation with other countries in the field of PBL. It has been determined that Turkey has started to make its name known internationally in the field of PBL and interacts with other countries in scientific communication. Beddoes et al. (2010) identified few studies on the use of PBL in engineering education research. In the bibliometric analysis of PBL studies in health sciences and engineering, it was determined that there were studies in 84 different countries (Li et al., 2018). According to the findings obtained from the study of Azer (2017), the countries that have the most cooperation with other countries in the studies on PBL in the Science Citation Index and Google Scholar databases are the United States, the Netherlands, the United Kingdom and Canada. In addition, among the 3 most cited articles, “Problem-based learning: a review of literature on its outcomes and implementation issues (Academic Medicine)” and “Problem-based learning: what and how do students learn?” It was observed that the inclusion of the articles was similar to the current study findings.

In the analysis carried out to determine the interaction between institutions in the field of PBL, it was concluded that Maastricht University and McMaster University are the two universities that cooperate the most with other institutions and play a key role in scientific communication. PBL researchers who share similar interests rarely cooperate (Xian & Madhavan, 2013).

According to the findings of the analysis conducted to determine the most cited publications in the article type in the studies, the common reference sources that guide the field of PBL are “Problem-Based Learning: What and How Do Students Learn?” conducted by Hmelo-Silver, C. E. in 2004 and it is seen that there are articles named “Problem-based learning: A review of literature on its outcomes and implementation issues” by Albanese M.A. & Mitchell S. in 1993.

According to the findings of the analysis conducted to determine the most cited publications in the article type in the studies, the common reference sources that guide the field of PBL are “Problem-Based Learning: What and How Do Students Learn?” written by Hmelo-Silver, C. E. in 2004 and it has been determined that studies on PBL and PBL are mostly used in educational research. After the educational researches, it was determined that PBL was mostly chosen as a research topic in health services and medical education. It has been determined that studies on PBL in Turkey are mostly written in the fields of natural sciences and social sciences (Alper et al., 2014).

In the study, it was seen that the most cited author among the authors was Howard S. Barrows. It can be said that the author named Henk G Schmidt is one of the most cited authors and that the works of Howard S. Barrows and Henk G Schmidt are the most basic reference sources referenced in studies in the field. In their study, Azer (2017) presented the citations in the journals searched in SCI and Google Scholar in two separate tables. While Barrows was the fifth most cited name within the scope of SCI, it was seen as the third most cited name in Google Scholar. Schmidt, on the other hand, ranks seventh in both databases. Although the rankings are different, it is seen that the names in the top ten are similar. This difference may be due to the effect of citations used by published studies on PBL since 2017. It may be due to the differences in the databases examined. Considering Howard Barrows' contributions to PBL research, Scientometric large-scale data and visualization-based analysis of his work has also been the subject of an article in itself (Xian & Madhavan, 2013). The findings of the most cited authors in the study are similar to the findings of Hallinger's (2020) study. In this study, the most cited authors in the field were determined by examining the common citation networks of studies on PBL published in the

Scopus database between 1974 and 2019. According to the findings obtained as a result of the study, the 4 most cited authors in the field of PBL were determined as Henk Schmidt, Howard Barrows, Cies van der Vleuten, and Geoffrey Norman.

Most cited articles and authors can be described as the dissemination and discussion of scientific knowledge in the field of research and the names and articles that shape the field (Ioannidis et al., 2014). In addition, articles with a high number of citations are also important in terms of being articles that generally reveal new ideas in the research area or offer solutions to long-standing problems (Azer, 2017). For these reasons, it is thought that it is important to determine the authors and their studies that guide the studies in the field of PBL.

When the most frequently used keywords in studies on PBL are examined, the most up-to-date concepts are; it was determined that “problem-based learning, education, student, curriculum, medical education, outcome, knowledge, skills, performance and critical thinking” It has been determined that this finding supports the way PBL is applied, its content, and the fields in which it is studied. In addition, Azer (2017) determined the most used keywords in studies conducted in the field of PBL as "problem-based learning, PBL education, student, PBL program, evaluation".

Since the PBL method is a method studied in various fields, it is thought that the results of this study will guide researchers who will conduct research on PBL. More detailed information can be presented by bibliometric analysis of studies conducted in different fields of education and related to different teaching methods and techniques in different studies.

REFERENCES

Ahmed, R. & Kannaiah, D. (2018). Problem based learning in accounting: where are we now? *Available at SSRN 3517613*. http://dx.doi.org/10.2139/ssrn.3517613

Al, U. (2008). *Turkey's scientific publication policy: a bibliometric approach based on citation indexes*. (PhD Thesis). Hacettepe University, Ankara.

Al, U. & Coştur, R. (2007). Bibliometric profile of the Turkish psychology journal. *Turkish Librarianship, 21*(2), 142-163.

Alper, A., Öztürk, S. & Altun, C. A. (2014). Problem-based learning studies in Turkey. *Journal of Ankara University Faculty of Educational Sciences, 47*(1), 397-422.

Arıcı, F. (2022). Research trends on the use of problem-based learning in science education: bibliometric mapping analysis. *Eğitim & Bilim,* 2022-III, 91-112.

Azer, S. A. (2017). Top-cited articles in problem-based learning: a bibliometric analysis and quality of evidence assessment. *Journal of Dental Education, 81*(4), 458-478.

Balım, A. G., Deniş-Çeliker, H., Türkoğuz, S., Evrekli, E. & İnel-Ekici, D. (2015). The effect of problem-based learning method supported by concept cartoons on students' conceptual understanding levels and perceptions of problem solving skills. *Turkish Journal of Science Education, 12*(4), 53-76.

Beddoes, K. D., Jesiek, B. K. & Borrego, M. (2010). Identifying opportunities for collaborations in international engineering education research on problem- and project-based learning. *Interdisciplinary Journal of Problem-Based Learning, 4*(2), 7-34.

Böyükyılmaz, S. & Oktay, K. (2020). Bibliometric analysis on tourism related articles scanned in the Social Sciences Citation Index (SSCI). *Journal of Tourism and Gastronomy Studies, 8*(2), 1362-1380.

Carter-Templeton, H., Frazier, R. M., Wu, L. & H. Wyatt, T. (2018). Robotics in nursing: a bibliometric analysis. *Journal of Nursing Scholarship, 50*(6), 582-589.

Ceylan, Ö. & Umdu Topsakal, Ü. (2023). The effect of a differentiated problem-based science program on gifted students' cooperative working skills and problem-solving skills. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Özel Eğitim Dergisi,* 1-20.

Chen, C., Ibekwe-Sanjuan, F. & Hou, J. (2010). The structure and dynamics of co-citation clusters: a multiple-perspective co-citation analysis. *Journal of the American Society for Information Science and Technology,* 61, 1386-1409.

Çakıcı, Y., Söyleyici, H. & Oğuzhan-Dinçer, E. (2020). Investigation of the effect of problem-based learning on middle school students' scientific process skills, attitudes and achievements: light unit example. *Trakya University Journal of Social Sciences, 22*(1), 419-437.

Deniş-Çeliker, H. (2021). Problem-based scenario method with experiments: determining the prospective science teachers' biology self-efficacy and critical thinking tendency. *Science Education International, 32*(1), 23-33.

Divarcı, Ö. F. & Saltan, F. (2017). Science of multimedia supported problem based learning approach its effect on academic achievement and attitude in education. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 18*(3), 1-23.

Ellegaard, O. & Wallin, J. A. (2015). The bibliometric analysis of scholarly production: how great is the impact?. *Scientometrics, 105*(3), 1809-1831.

Erden, Ş. & Yalçın, V. (2021). Investigation of the effect of preschool stem activities prepared according to the problem based learning approach on children's problem-solving skills. *Trakya Eğitim Dergisi, 11*(3), 1239-1250.

Erdogan, T. (2015). Research trends in dissertations on pbl: a content analysis study. *Procedia-Social and Behavioral Sciences,* 197, 308-315.

Gao, J., Yang, L., Zhao, J., Wang, L., Zou, J., Wang C., Zou, J., Wang, C. & Fan, X. (2020). Comparison of problem based learning and traditional teaching methods in medical psychology education in China: a systematic review and meta-analysis. *Public Library of Science, 15*(12), 1-11.

Ghani, A. S. A., Rahim, A. F. A., Yusoff, M. S. B. & Hadie, S. N. H. (2021). Effective learning behavior in problem-based learning: a scoping review. *Medical Science Educator, 31*(3), 1199-1211.

Gül, Ş. & Konu, M. (2018). The effect of context- and problem-based learning activities on the students' achievements. *Yaşadıkça Eğitim, 32*(1), 45-68.

Güzeller, C. O. & Çeliker, N. (2017). Gastronomy from past to today: a bibliometrical analysis. *Journal of Tourism and Gastronomy Studies, 5*(2), 88-102.

Hallinger, P. (2020). Mapping continuity and change in the intellectual structure of the knowledge base on problem-based learning, 1974–2019: a systematic review. *British Educational Research Journal, 46*(6), 1423-1444.

Hmelo-Silver, C. E. (2004). Problem-based learning: what and how do students learn?. *Educational Psychology Review, 16*(3), 235-266.

Hun, F. & Değirmençay, Ş. A. (2020). Effect of 5e teaching model supported by problem based learning on the achievement and attitude. *OPUS International Journal of Society Researches, 16*(29), 1689-1717.

Ioannidis, J. P. A., Greenland, S., Hlatky, M. A., Khoury, M. J., Macleod, M. R., Moher, D., Schulz, K. F. & Tibshirani, R. (2014). Increasing value and reducing waste in research design, conduct, and analysis. *The Lancet,* 383(9912), 166-175.

Juandi, D. & Tamur, M. (2021). 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. In *Journal of Physics: Conference Series* (Vol. 1722, No. 1, p. 012103). IOP Publishing.

Kaptan, F. & Korkmaz, H. (2001). Problem-based learning approach in science education. *Hacettepe University Journal of the Faculty of Education,* 20, 185-188.

Karagöz, D. & Yüncü, H.R. (2013). Examining the research topics of doctoral theses written in the field of tourism with social network analysis. *Adıyaman University Journal of Social Sciences Institute, 6*(15), 205-232.

Karamustafaoğlu, O., Tezel, Ö. & Sarı, U. (2018*). Activity supported science teaching with current approaches and methods.* Pegem Academy.

Kılınç, A. (2007). Problem-based learning. *Kastamonu Journal of Education, 15*(2), 561-578.

Kim, N.J., Belland, B.R. & Walker, A.E. (2017). Effectiveness of computer-based scaffolding in the context of problem-based learning for stem education: bayesian meta-analysis. *Educational Psychology Review,* 30.

Kim, N. J., Vicentini, C. R. & Belland, B. R. (2022). Influence of scaffolding on information literacy and argumentation skills in virtual field trips and problem-based learning for scientific problem solving. *International Journal of Science and Mathematics Education,* 1(22), 397-429.

Köseoğlu, M. A. (2016). Mapping the institutional collaboration network of strategic management research: 1980–2014. *Scientometrics,* 109, 203–226.

Leary, H., Walker, A., Shelton, B. E. & Fitt, M. H. (2013). Exploring the relationships between tutor background, tutor training, and student learning: a problem-based learning meta-analysis. *Interdisciplinary Journal of Problem-Based Learning, 7*(1), 40-66.

Leary, H., Walker, A., Lefler, M. & Kuo, Y. C. (2019). Self-directed learning in problem-based learning: a literature review. *The Wiley Handbook of Problem-Based Learning,* 181-198.

Li, S. Yan, X., Guo, Z., Meng, X. & Huang, J. (2018). A bibliometric analysis of pbl teaching method. *Chinese Journal of Medical Education Research, 17*(11), 1096-1102.

Liu, Y. & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: a meta-analysis. *Thinking Skills and Creativity,* 45, 101069.

Ministry of National Education (2006). Science Curriculum (6th-8th grades). Board of Education and Discipline.

Ministry of National Education (2018). Science Curriculum (primary and secondary school 3rd-8th grades). Board of Education and Discipline.

Mutlu, A. & Aydoğmuş, M. (2019). Problem-based learning studies: a content analysis. *Turkish Studies – Educational Sciences, 14*(4), 1615-1630.

Özkaya, A. (2019). Bibliometric analysis of the publications made in stem education area. *Bartın University Journal of Faculty of Education, 8*(2), 590-628.

Özturan Sağırlı, M. & Baş, F. (2020). A content analysis for problem-themed articles published in Turkey. *Journal of Gazi University Gazi Education Faculty,40*(3), 1105-1135.

Phungsuk, R., Viriyavejakul, C. & Ratanaolarn, T. (2017). Development of a problem-based learning model via a virtual learning environment. *Kasetsart Journal of Social Sciences, 38*(3), 297-306.

Puspasari, D. & Puspasari, D. (2019). Development of student worksheet based on problem based learning in office management subject. *International Journal of Educational Research Review, 4*(3), 379-385.

Siagan, M. V., Saragih, S. & Sinaga, B. (2019). Development of learning materials oriented on problem-based learning model to improve students' mathematical problem solving ability and metacognition ability. *International Electronic Journal of Mathematics Education, 14*(2), 331-340.

Tan, O.S. (2002). Problem-based learning: More problems for teacher education. *Review of Educational Research and Advances for Classroom Teacher, 21*(1), 43-55.

Tan, O. S. (2021). *Problem-based learning innovation: Using problems to power learning in the 21st century.* Gale Cengage Learning.

Temel, S., Şen, Ş. & Yılmaz, A. (2014). A content analysis of the studies on problem-based learning in science education: the case of Turkey. *Kastamonu University Journal of Education, 23*(2), 565-580.

Thakur, P., Dutt, S. & Chauhan, A. (2021). problem based learning in education–its need for sustainable development. *Journal of Engineering Education Transformations, 34*(4), 58-66.

Thorndahl, K. L. & Stentoft, D. (2020). Thinking critically about critical thinking and problem-based learning in higher education: a scoping review. *Interdisciplinary Journal of Problem-Based Learning, 14*(1).

Tosun, C. & Yaşar, M.D. (2013). Comparison of problem-based learning studies in science education in Turkey with the world: content analysis of research papers. *Asia-Pacific Forum on Science Learning and Teaching, 14*(2), 3-34.

Tosun, C., Şenocak, E. & Taşkesenligil, Y. (2021). Bibliometric and descriptive content analyses for the articles related to problem-based learning in chemistry education. *Journal of Turkish Chemical Society Section C: Chemistry Education, 6*(2), 133-164.

Trullàs, J. C., Blay, C., Sarri, E. & Pujol, R. (2022). Effectiveness of problem-based learning methodology in undergraduate medical education: a scoping review. *BMC Medical Education, 22*(1), 104.

Ukşul, E. (2016). *Evaluation of scientific publications in the field of measurement and evaluation in education in Turkey with social network analysis: a bibliometric study.* (Master's Thesis). Akdeniz University, Antalya.

Xian, H. & Madhavan, K. (2013). Building on and honoring forty years of pbl scholarship from Howard Barrows: a scientometric, large-scale data, and visualization-based analysis. *Interdisciplinary Journal of Problem-Based Learning, 7*(1), 132-156.

Wahyudiati, D. (2022). The critical thinking skills and scientific attitudes of pre-service chemistry teachers through the implementation of problem-based learning model. *Journal Penelitian Pendidikan, 8*(1), 216-221.

Wallin, J. A. (2005). Bibliometric methods: pitfalls and possibilities. *Basic and Clinical Pharmacology and Toxicology, 97*(5), 261–275.

Wood, D. F. (2003). Problem based learning. *Abc of Learning and Teaching in Medicine, 326*(7384), 328–330.

Wulandari, T. (2018). Field trial analysis of teaching material civic education based on problem based learning (pbl) to improve student's outcome. *International Journal of Educational Methodology, 4*(4), 259-265.

Yıldırım, F., S. & Say, S. (2020). Examination of scientific studies in the field of science education related to the problem-based learning approach. *International Journal of New Approaches in Social Studies, 4*(1), 151-164.

Yıldız, Ş. & Beşoluk, Ş. (2019). The investigation of the effect of problem based teaching approach on students' problem solving skills and academic achievements in science course. *Journal of Individual Differences In Education, 1*(1), 50-68.

Zakaria, M. I., Maat, S. M. & Khalid, F. (2019). A systematic review of problem based learning in education. *Creative Education, 10*(12), 2671-2688.

Zhang, F., Wang, H., Bai, Y. & Zhang, H. (2022). A bibliometric analysis of the landscape of problem-based learning research (1981–2021). *Frontiers in Psychology,* 13, 1-10.