

Original Research

A Scientometric Analysis of Problem-Based Learning in Medical Education in Medline and Web of Science

Vahideh Zarea Gavvani¹, Hakimeh Hazrati^{2*}, Mortaza Gojazadeh³, Raza Ghafari²

¹Tabriz Health Services Management Research Center, National Public Health Management Center (NPMC), Tabriz University of Medical Sciences, Tabriz, Iran

²Medical Education Research Center, Education Development Center (EDC), Tabriz University of Medical Sciences, Tabriz, Iran

³Liver and Gastrointestinal Diseases Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

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Abstract

Introduction: Scientometrics is one of the most effective ways of investigating and quantifying research in academic databases. It can help examine the scientific output of various countries, and the authors' and articles' impacts on different subject areas can be determined. The main objective of this study was to analyze global scientific productions of problem-based learning (PBL) found in scientific productions indexed in the Web of Science (WoS) and PubMed databases from 2003-2013.

Methods: PubMed and WoS were searched for PBL-related articles with the keywords "Problem Based Learning" AND "Medical Education", excluding the keyword "problem solving". The analysis was done based on scientometric indicators, like number of publications, citation count and Journals Impact Factor.

Results: Among the countries publishing research in PubMed and WoS, the USA was the most prominent producer, was identified as a leading and active contributor among others in the field of medical education. A statistically significant relationship was found between geographical distribution of continents and PBL application in the specific field, authors' articles and the continents of authors' affiliations.

Conclusion: Attention should be paid to the importance of problem-based learning in medical education, especially in developed countries, because a growing body of research suggests that it is necessary to train students who are researchers and can meet the needs of society.

Introduction

Science production is the most sensible and valid index of a country's research rank measurement and their academic study. Some outstanding scientists like Kool, Inler and Holm have applied scientific articles as criteria for comparing scientific productions of different countries. They have compared scientific productions of different countries quantitatively and qualitatively and have clarified their status in scientific productions.¹ Scientometrics, a method for evaluating published scientific research of scientific indices as valid scientific documents, shows the most important index of one country's scientific power on an international scale.² Scientometrics is one of the most efficient ways of investigating the quantitative status of research within a country. By using scientometrics, we can discover the frequency of publication of each country's researchers, scientific courses, authors, impact

of articles on the scientific community,³⁻¹⁰ authors' contribution and subject dispersion and core journals in each course.¹¹ Scientometrics can also help us in accurate programming, targeting scientific movement, determining research priorities and also determining weak points and deficiencies of scientific production.¹¹ Different studies on scientometrics have investigated Iran's scientific productions in different fields of medicine. Osareh and Wilson in 1997 investigated the scientific productions of world's countries in ISI from 1985-1989 and showed that five countries (American, Brazil, Mexico, Argentina, Chile) have the highest contribution in scientific productions.¹² In scientometrics, Hamidi et al. America declared that in this field, countries like America, England, Germany and the Netherlands ranked first, second, third and fourth respectively to fourth rank, respectively.¹³ Makkizadeh, in

*Corresponding authors: Hakimeh Hazrati, Email:hakimeh.hazrati@gmail.com

a citation analysis and map projection of scientific output of Medical Ethics from Web of Science during 1990-2008, has introduced the Journal of Medical Ethics as the most active journal. Additionally, America, England, Canada, Germany and France are the most highly cited countries, and Harvard, Toronto, Washington, Georgetown, and Peen are the universities with the most citations.¹⁴

Mehdad and Gazani mentioned that three countries—Turkey, Iran and Egypt—had the highest scientific productions in the Islamic world, where the Islamic world makes up only 1% of the world's scientific production.¹⁵ Mansori, in investigating the number of scientific productions of the Muslim world, declared that just 16 Islamic countries out of 57 countries had 7000 articles in the ISI database, and that the presence of 41 countries in this database was trivial. Iran's scientific production growth among Islamic countries is progressing, and it is currently producing 24.79% of the research in these countries.¹⁶ In Medical Education, a scientometrics study can determine the number of educational scientific productions on problem-based learning. In recognizing the medical educational distribution pattern of PBL in world, Iran's contribution to this field can be effective, both quantitatively and qualitatively, and can clarify the pros and cons of scientific productions. Medical Education has changed from the traditional method of teacher-based learning to student-based learning, and educational methods have changed. Problem-based learning is considered one of the modern student-based educational methods that involves students with clinical matters and merges basic sciences with clinical practice. Students learn the related knowledge in clinical content, and this leads to retention of knowledge and its subsequent application in a real environment.¹⁷⁻¹⁸ A review of the related literature showed that various studies have been done on the effects of PBL in health domains, but no scientometrics study has been carried out on PBL, and little has been examined on applying problem-based learning and rate of change in educational methods. An exception is the study by Jerome Rotgans that paid attention to scientometric indicators in abstracts of 60 journals in Medical Education during 1988-2010, which investigated the most highly-cited articles and individuals. The study also marked the trends of the most highly cited articles and the three most highly cited journals' over a period of 22 years.¹⁹ Considering the important change of educational trends in clinical sciences educators and the shortage of scientometric studies on the rate of applying this method, we wanted to survey PBL application in last 10 years on a global scale.

The main objective of this study was to investigate scientometric study of PBL-related scientific production (articles) retrieved from two databases: Pub Med and Web of Science. The specific aims were to recognize highly cited journals, articles and authors, and rate cooperation authors from a variety of continents.

Materials and Methods

Pub Med and ISI Web of Science/WoS (the world's largest

citation database) have been searched in order to extract all the studies about PBL in medical education on September 24, 2013. The keywords “problem-based learning” AND “Medicine” or “Medical Education” were searched and “problem-solving” was excluded from the study because of intervention. As problem-based medical education is a new method in Iranian medical education, emerging in 2008, we limited our search to five years before and after PBL's entrance into Iran's medical education system (from 2003 to 2013). Limited English has been used in this study as well. All the citations of conferences were excluded, and only published articles in scientific journals were included. The extracted papers were reviewed by two individuals after unrelated and duplicated citations were omitted.

468 articles were found about PBL from the Web of Science (WOS), though among them 158 articles were unrelated and omitted from this study. Also, 1103 articles were retrieved from Medline, and 325 articles were deleted due to not meeting the criteria of our study. After a primary review of titles and abstracts, and elimination of unrelated articles, from two databases a total of 1068 articles were found eligible for our study, eliminating duplicated articles, a number of 843 articles were selected. 78 articles out of 843 had no determined geographical affiliation. Therefore, 765 articles with determined affiliation were analyzed to investigate the different continents' share in scientific productions related to PBL (Figure 1).

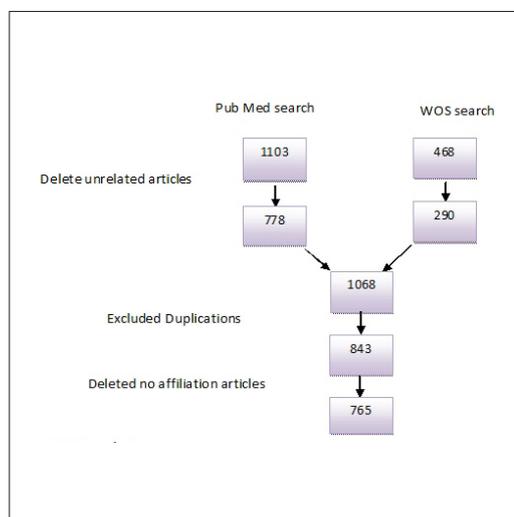


Figure 1. Data selection process

Results

It was found that the most published articles on PBL were related to America, with a total of 284 (37.12%). After America, Europe was ranked the second with 192 (25.09%), and Asia was in the third rank with 188 (24.57%). Australia was in the fourth rank with 59 (7.71%), and the least written articles were related to African countries with 42 (5.49%). From 2003 to 2006, America had the most articles (40.27%) in this field and the second rank belonged to Europe with 28.1%, and Asia was in third rank

(17.59%). In 2007 to 2010, like the first period, America had the highest contribution (34.35%) in comparison with other continents, and Europe was in the next rank (26.76%) with Asia in third (24.24%). This shows that America and Europe had falling trends in comparison with the first period, but Asia had a rising trend. From 2011 to 2013, Asia had worked more in this field (36.1%) and America fell to the second rank (33.7%) and Europe was in the third rank (30.3%) This shows that Asia has become more interested in this particular field over last decade (Figure 2).

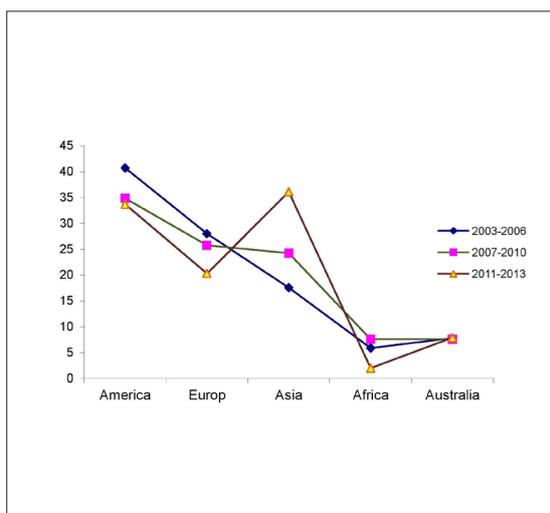


Figure 2. The publication trend of scientific production of PBL on different continents during the last 10 years (from 2003 to 2013)

Investigation of the application of PBL in seven fields (Medicine, Dentistry, Pharmacology, Nursing, Midwifery, Health, Paramedics) on five continents showed that there is a statistically significant relationship ($p=0.0001$) between the geographical distribution of continents and PBL application in each field. Yet geographical distribution and PBL application in these fields show similar distribution on each of the five continents. On each of the five continents, PBL has been applied more in medicine than nursing, dentistry and pharmacology. America has the highest contribution in seven fields (Table 1).

According to tables of the groups' frequencies, there was a significant relationship between authors' articles and the continents of authors' affiliations ($p=0.041$). The largest number of individuals who have worked in this field were in America with 73.6% ($N=209$), with 31 individuals have published three or more articles in this field. The next rank belonged to Europe at 69.2% ($N=135$), with 19 individuals who have published three or more articles in this field. The third rank belonged to Asia with 69.5% ($N=132$), where 26 individuals have published three or more articles in this field. The cooperation coefficient or co-compilation in Europe was highest, where America was second, and in Australia it was less than other continents. Also, articles that were geographically affiliated to Europe had a higher chance of publication in journals with high IF

in comparison to other geographical places, and they had the highest citations. The articles of Australia and America had the highest chance of presence in journals with a high IF and high citations. According to ANOVA, there was a statistically significant relationship between Europe and Africa ($p=0.019$) and Europe and Asia ($p=0.002$) considering citational analysis.

The highest number of articles on PBL were published in the top ten journals (Table 2). The journals Medical Teacher with 50 articles, Medical Education with 44 articles, Journal of Dental Education with 26 articles and Advances in Health Sciences Education: Theory and Practice with 25 articles were the top journals of PBL (Table 2).

The most-highly cited authors in the problem-based learning field among five continents of world were Wood from Europe with 541 citations, Steadman from America with 256 citations, Tiwari from Asia with 201 citations, Farmers from Australia with 147 citations and Williams B. from Africa with 73 citations (Table 3).

Comparing 10 active countries on PBL showed that America was the most active country in problem-based scientific productions of medical education. Canada's articles were 47 out of 843. This shows that there is no relationship between the history of PBL application in a country's Medical Education program and their cooperation in problem-based scientific production of education. This attitude that universities like McMaster, which has applied PBL in their educational curriculum since 1969, should have a larger portion of the related scientific production is rejected (Figure 3).

Iran's share in scientific productions on the implementation of problem based learning in medical education

Our study about the Iranian share in scientific productions related to medical education based on PBL showed that one Iranian journal was listed among the 235 journals that contributed to the publication of 853 articles in PBL on medical education worldwide. Iran shared six articles in the subject and ranked 17 among the 21 ranked, such as Singapore and Nepal, preceding Egypt, Hawaii and Korea (with four articles). Pakistan and Denmark preceded Iran with 7 and 8 articles respectively. Iranian's part in scientific productions related to PBL was 0.7 out of 853 articles. Among these articles, four articles (66.6%) were in medicine, one article (16.6%) in nursing, and one article (16.6%) in midwifery. Chronologically, Iranians' cooperation in PBL articles was in the period of 2007-2008 and 2013 and 50% of articles were published in 2013. Regarding citation analysis, the most cited article in this field was Dehkordi's article (22 citations) published in 2008. Published articles in 2013 had the lowest number of citations. Since 2013 was not over during the time of our information searching, this low number of citations seems natural. The highest impact factor ($IF=2.089$) belongs to Pourshanazari's article, which was published in Advances in Health Sciences Education: Theory and Practice in 2013.

Table 1. The publication trend of scientific productions of PBL in different countries worldwide in various medical science fields from 2003 to 2013

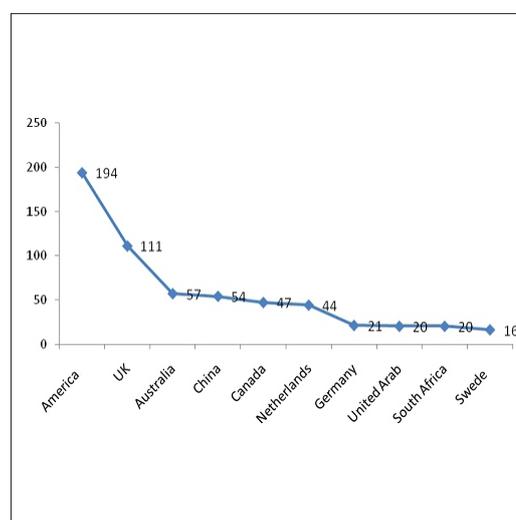
Continental	Medicine	Nursing	Dentistry	Pharmacology	Midwifery	Health	Total	P value
America	159(59.35%)	37(13.8%)	25 (9.3%)	26(9.7%)	0	16(6%)	268(100%)	
Europe	124 (64.6%)	30(15.6%)	17 (8.9%)	7(3.6%)	5(2.6%)	5(2.6%)	192 (100%)	
Asia	126(67.7%)	23(12.4%)	16(8.6%)	14(7.5%)	1 (0.5%)	3(1.6%)	186(100%)	
Africa	34(81%)	8(19%)	0	0	0	0	42(100%)	0.0001
Australia	41(70.72%)	5(8.6%)	6(10.3%)	4(6.9%)	0	2(3.4%)	58(100%)	
Total	484(64.9)	103(13.8%)	64(8.6%)	51(6.8%)	6(8%)	26(3.5%)	746 (100%)	

Table 2. Top Ten Journals in PBL

Row	Journal	IF	Number of Article
1	Med Teach	1.494	50
2	Med Educ	2.639	44
3	J Dent Educ	0.99	26
4	Adv Health SciEduc Theory Pract	2.089	25
5	nursing Educ Today	1.22	21
6	Am J Pharm Educ	1.21	15
7	nursing EducPract	--	15
8	ACADEMIC Medical	3.292	14
9	J NursEduc	1.13	14
10	Educ Health (Abingdon)	1.494	50

Discussion

The aim of this article is to investigate ten years' worth of articles published in Med-line and Web of Science indexed journals on PBL in medical education. The specific aim of this study a ten-year worth was to recognize highly active journals, highly cited articles and highly cited authors in different continents of the world. This study showed that among the 741 articles in the study, America and Europe's contribution in articles related to problem-based learning was higher than other continents. Ossareh and Makkizadehh came to the same conclusion in their study entitled, "Citation Analysis and Algorithmic Histogram of Medical Ethics in Web of Science in 1990-2008" and declared that American and European countries had the highest contribution.^{12,14} This showed that developed countries were progressing in science production in different fields and developing countries and third world countries were beginners in scientific production. The trend of publication growth of PBL in each of the five continents showed that during the first and second period (2003-2010), America had the highest number of articles and Europe and Asia were in the next ranks. From 2011 to 2013, Asia had a rising trend and had worked more (36.1%) in this field, where America was in the next rank (33.7%) and Europe was in the third rank (30.3%). America and Europe had a slight falling trend, and it represents that

**Figure 3.** Ten top countries cooperating in scientific productions of PBL in the world

during few last decades, there was more interest in this field in Asia. In all the continents, problem-based learning education was mostly implemented in medicine and then in nursing and dentistry. In Africa, it is applied just in medicine and nursing, awas and no attention was paid to the other fields of health related to the patient's clinical matters and scientific actions. All of the medical fields should be observed like a group which handles patient's health and lack of attention to related fields of medicine may reduce quality of teamwork.

European countries have published their articles in journals with high IF, and are ranked first in that area. Australia is in the second rank, and in spite of having only a few articles, they are published in journals with high IF. Australia has the highest number of citations after Europe and it may represent this continent's article validity. Makizadeh, in the study about medical ethics, came to a similar conclusion with England, which had high citations.¹⁴ Cooperation among European countries is higher than other continents, and Asia and America are in similar ranks with their amount of cooperation among authors. Although Australia has highly cited articles, less cooperation is seen among authors in this continent. It is contrary to expectations of scientometrics because, based

Table 3. Highly cited articles, authors and journals publishing scientific productions on PBL from 2003 to 2013

Title	Continent	Author	Country	Field	Journal	IF	Date	citation
Medical Simulation-based training is superior to problem-based learning for the acquisition of critical assessment and management skills.	America	Steadman RH	USA	medical	Critical Care Medical	6.124	2006	256
Problem-based learning outcomes: the glass half-full.	America	Distlehorst LH	USA	medical	ACADEMIC Medical	3.292	2005	91
A comparison of critical thinking in groups of third-year medical students in text, video, and virtual PBL case modalities	America	Kamin, C	USA	medical	Academic Medical	3.292	2003	88
ABC of learning and teaching in Medical - Problem based learning	Europe	Wood, DF	UK	medical	British Medical Journal	17.215.	2003	541
Problem-based learning: future challenges for educational practice and research	Europe	Dolmans	Netherlands	medical	Medical Education	2.639	2005	439
Psychiatry The effectiveness of problem-based learning compared to traditional teaching in undergraduate psychiatry	Europe	McParlandMs	UK	medical	Medical Education	2.639	2004	419
A comparison of the effects of problem-based learning and lecturing on the development of students' critical thinking	Asia	Tiwari, A	china	nursing	Medical Education	2.639	2006	201
Implementation of problem-based learning in Asian medical schools and students' perceptions of their experience.	Asia	Khoo HE.	Singapore	Medical	Medical Education	2.639	2003	121
From case-based reasoning to problem-based learning.	Asia	Eshach H	Israel	medical	Academic Medical	3.292	2003	100
Faculty development for problem-based learning.	Australia	Farmer EA.	South Australia	Dentistry	Eur J Dent Educ	1.01	2004	147
Do we need dissection in an integrated problem-based learning medical course? Perceptions of first- and second-year students	Australia	Azer, SA	Australia	medical	Surgical AND Radiology Anatomy	1.13	2007	95
Not knowing that they do not know: self-assessment accuracy of third-year medical students.	Australia	Langendyk V	Australia	medical	Medical Education	2.639	2006	92
Self direction in a problem based learning program	Africa	Williams B	South Africa	Nursing	nursing Educ Today	1.22	2004	73
Problem-based learning improves the academic performance of medical students in South Africa	Africa	Iputo JE	South Africa	medical	Medical Education	2.639	2005	54
The small group in problem-based learning: more than a cognitive 'learning 'experience for first-year medical students in a diverse population.	Africa	McLean M	South Africa	medical	Medical Teacher	1.494	2006	33

Table 4. Iran's cooperation on problem-based learning

Author	Country	Subject	Journal	IF	Year	Citation
Pourshanzari AA	Iran	Medicine	Adv Health SciEduc Theory Pract	2.089	2013	2
Dehkordi AH	Iran	Nursing	Dan Med Bull	0.92	2008	22
Vahidi RG	Iran	Medicine	East Mediterr Health J	--	2007	6
Heidari A	Iran	Medicine	J Med Ethics Hist Med	--	2013	2
Adibi, I	Iran	Medicine	Medical Teacher	1.494	2007	2
Sangestani G	Iran	Midwifery	Nursing Educ Today	1.22	2013	7

on the scientometric findings, it is believed that with the increase in articles' validity, academic cooperation as well as science production with high quality increases, therefore developing the science²⁰ Daneshfarshid declared that nowadays it was inevitable for specialists to cooperate so that they can reach to and they can reach better knowledge, skill, sources and facilities by scientific cooperation. Undoubtedly, they will have problems in their individual approach. If scientists get along with their patterns, methods and stages of cooperation, and accept team compatibility, scientific cooperation can not only help their individual knowledge, but the collective knowledge.²⁰ Nowadays, many authors pay less attention to individual work in research²¹ and Iran's cooperation in scientific productions of problem-based learning in these two databases is just 0.7% with six articles published in this field. This represents a slow-changing of educational trend and may represent that most Iranian students depend on their teachers and Iran is a beginner in updating itself in training self-sufficient students. This study suggests that attention should be paid to the importance of this method of education used often in developed countries, because the growing body of science indicates that it is necessary to train students who are researchers and can provide answers to the needs of society.

Competing interests

The authors declare that there is no conflict of interest.

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