Problem-based learning in medical degree teaching: a scoping review

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Abstract

Problem-based learning (PBL) is a pedagogical approach that shifts the role of the teacher to the student (student-centred) and is based on self-directed learning. Although PBL has been adopted in undergraduate and postgraduate medical education, the effectiveness of the method is still under discussion. We employed a scoping review to appraise available international evidence concerning to the effectiveness and usefulness of PBL methodology in undergraduate medical teaching programs. We applied the Arksey and O'Malley framework to undertake a scoping review. A search of literature published in English and Spanish identified one hundred and twenty four publications eligible for this review. Despite the fact that this review includes many studies, their design is heterogeneous and only a few provide a high scientific evidence methodology (randomized design and/or systematic review with meta-analysis). Furthermore, most are single-center experiences with small sample size and there are no large multi-center studies. PBL methodology obtains a high level of satisfaction, especially among students. It is more effective than other more traditional (or lecture-based methods) at improving social and communication skills, problem-solving and self-learning skills. Knowledge retention and academic performance are no worse (and in many studies are better) than with traditional methods. PBL is not universally widespread, probably because it requires greater human resources and continuous training for its implementation. More comparative and randomized studies and/or other systematic reviews and meta-analysis are required to determine which educational strategies are the most suitable for training the doctors of the future.

Background

There has always been enormous interest in identifying the best learning methods. In the mid-twentieth century, US educator Edgar Dale proposed which actions would lead to deeper learning than others and published the well-known (and at the same time controversial) "Cone of Experience or Cone of Dale". At the apex of the cone are oral representations (verbal descriptions, written descriptions, etc.) and at the base is direct experience (based on a person carrying out the activity that they aim to learn), which represents the greatest depth of our learning. In other words, each level of the cone corresponds to various learning methods. At the base are the most effective, participative methods (what we do and what we say) and at the apex are the least effective, abstract methods (what we read and what we hear) (Dale 1932). In 1990, psychologist George Miller proposed a framework pyramid to assess clinical competence. At the lowest level of the pyramid is knowledge (knows), followed by the competence (knows how), execution (shows how) and finally the action (does) (Miller 1990). Both Miller's pyramid and Dale's cone propose a very efficient way of training and, at the same time, of evaluation. Miller suggested that the learning curve passes through various levels, from the acquisition of theoretical knowledge to knowing how to put this knowledge into practice and demonstrate it. Dale stated that to remember a high percentage of the acquired knowledge, a theatrical representation should be carried out or real experiences should be simulated.

In the last 50 years, various university education models have emerged and have attempted to reconcile teaching with learning, according to the principle that students should lead their own learning process. Perhaps one of the most successful models is problem-based learning (PBL) that came out of the English-speaking environment. There are many descriptions of PBL in the literature, but in practice there is great variability in what people understand by this methodology. The original conception of PBL as an educational strategy in medicine was initiated at McMaster University (Canada) in 1969, leaving aside the traditional methodology (which is often based on lectures) and introducing student-centred learning. The new formulation of medical education proposed by McMaster did not separate the basic sciences from the clinical sciences, and partially abandoned theoretical classes, which were taught after the presentation of the problem. In its original version, PBL is a methodology in which the starting point is a problem or a problematic situation. The situation enables students to develop a hypothesis and identify learning needs so that they can better understand the problem and meet the established learning objectives (Branda 2013; Bodagh N et al. 2017).

As attractive as the PBL method may seem, we should consider whether it is really useful and effective as a learning method. Although PBL has been adopted in undergraduate and postgraduate medical education, the effectiveness of the method is still under discussion. This is due partly to the methodological difficulty in comparing PBL with traditional curricula based on lectures.

The primary goal of this study was to appraise available international evidence concerning to the effectiveness and usefulness of PBL methodology in undergraduate medical teaching programs. As the intention was to synthesize the scattered evidence available, the option was to conduct a scoping review. A scoping study tends to address broader topics where many different study designs might be applicable. Scoping studies may be particularly relevant to disciplines, such as medical education, in which the paucity of randomized controlled trials makes it difficult for researchers to undertake systematic reviews (Arksey and O'Malley 2005; Levac et al. 2010). Even though the scoping review methodology is not widely used in medical education, it is well established for synthesizing heterogeneous research evidence (Pham et al. 2014).

The specific aims were: 1) to determine the effectiveness of PBL in learning and retention of knowledge in medical education; 2) to determine the effectiveness of PBL for social and communication skills in medical education; 3) know the level of satisfaction perceived by the medical students (and/or tutors) when they are taught with the PBL methodology (or when they teach in case of tutors).

Methods

This review was guided by Arksey and O'Malley's methodological framework for conducting scoping reviews. The five main stages of the framework are: (1) identifying the research question; (2) ascertaining relevant studies; (3) determining study selection; (4) charting the data; and (5) collating, summarising and reporting the results (Arksey and O'Malley 2005). We reported our process according to the PRISMA Extension for Scoping Reviews (Tricco et al. 2018).

Stage 1: Identifying the research question

With the goals of the study established, the four members of the research team established the research questions. The primary research question was “Which is the effectiveness of PBL methodology for teaching in undergraduate medicine?” The secondary questions include “Which is the perception and satisfaction of medical students and tutors in relation to PBL methodology?”

Stage 2: Identifying relevant studies

After the research questions and a search strategy were defined, the searches were conducted in PubMed and Web of Science using the MeSH terms “problem-based learning” and “Medicine” (the Boolean operator “AND” was applied to the search terms). No limits were set on language, publication date, study design or country of origin. The search was carried out on 14th February 2021. Citations were uploaded to the reference manager software Mendeley Desktop (version 1.19.8) for title and abstract screening, and data characterization.

Stage 3: Study selection

The searching strategy in our scoping study generated a total of 2399 references. The literature search and screening of title, abstract and full-text for suitability was performed independently by one author (JCT) based on predetermined inclusion criteria. The inclusion criteria were: 1) PBL methodology was the major research topic; 2) participants were undergraduate medical students or tutors; 3) the main outcomes were one of the following: knowledge retention, social and communication skills and/or student/tutor satisfaction; 4) all types of studies were included including descriptive papers, qualitative, quantitative and mixed studies methods, perspectives, opinion, commentary pieces and editorials. Exclusion criteria were studies including other types of participants such as postgraduate medical students, residents and other health non-medical specialties such as pharmacy, veterinary, dentistry or nursing. Studies published in languages other than Spanish and English were also excluded. Situations in which uncertainty arose, all authors (CB, BS, RP) discussed the publication together to reach a final consensus. The outcomes of the search results and screening are presented in Fig. 1. One-hundred and twenty-four articles met the inclusion criteria and were included in the final analysis.

Stage 4: Charting the data

A data extraction table was developed by the research team. Data extracted from each of the 124 publications included general publication details (year, author, and country), sample size, study population, design/methodology, main and secondary outcomes and relevant results and/or conclusions. We compiled all data into a single spreadsheet in Microsoft Excel for coding and analysis. The characteristics and the study subject of the 124 articles included in this review are summarized in Tables 1, 2 and 3. The detailed results of the Microsoft Excel file are also shown in Table 4.

Results

Stage 5: Collating, summarizing and reporting the results

As indicated in the search strategy (Fig. 1) this review resulted in the inclusion of 124 publications. Publication years of the final sample ranged from 1990 to 2020 and the distribution of publications by years is shown in Fig. 2. The majority of the publications (51, 41%) were identified for the years 2010–2020 and the years in which there were more publications were 2001, 2009 and 2015. Countries from the six continents were represented in this review. Most of the publications were from Asia (especially China and Saudi Arabia) and North America followed by Europe, and few studies were from Africa, Oceania and South America. The country with more publications was the United States of America ($n = 27$). The most frequent designs of the selected studies were surveys or questionnaires ($n = 45$) and comparative studies ($n = 48$, only 16 were randomized) with traditional or lecture-based learning methodologies (in two studies the comparison was with simulation) and the main outcome was performance followed by student satisfaction (45 studies measured more than one outcome). The studies with the highest level of scientific evidence (systematic review and meta-analysis and randomized studies) were conducted mostly in Asian countries (Tables 1 and 3). The study subject was specified in 81 publications finding a high variability but at the same time great representability of almost all disciplines of the medical studies (Table 2).

The sample size was available in 99 publications and the median [range] of the participants was 132 [14–2061]. According to study population, there were more participants in the students’ focused studies (median 134 and range 16–2061) in comparison with the tutors’ studies (median 53 and range 14–494)

Finally, after reviewing in detail the measured outcomes (main and secondary) according to the study design (Tables 3 and 4) we present a narrative overview and a synthesis of the main findings.

Learning and knowledge retention

Seventy-five of the 124 publications had learning and/or knowledge retention as their main or secondary outcomes, most of them (45) were comparative studies with traditional or lecture-based learning and 16 were randomized. These studies were varied in their methodology, were performed in different geographic zones, and normally analysed the experience of just one education centre. Most studies (53) reported superiority of PBL in learning and knowledge acquisition (Sokas et al. 1990; Richards et al. 1996; Gresham & Philp 1996; Hill et al. 1998; Blake & Parkison 1998; Hmelo 1998; Finch 1999; Casassus et al. 1999; Purdy et al. 1999; Farrell et al. 1999; Finch 1999; Curtis et al. 2001; Trevena & Clarke 2002; Astin et al. 2002; Whitfield et al. 2002; Whitfield et al. 2002; McParland et al. 2004; Casey et al. 2005; Gurbinar et al. 2005; Tamblyn et al. 2005; Abu-Hijleh et al. 2005; Distlehorst et al. 2005; Distlehorst et al. 2005; Hoffman et al. 2006; Kong et al. 2009; Tsou et al. 2009; Tsou et al. 2009; Wang et al. 2010; Abou-Elhamd et al. 2011; Urrutia et al. 2101; Tian et al. 2012; Hoover et al. 2012; Li et al. 2013; Ding et al. 2014; Meo 2014; Khoshnevisasl et al. 2014; Al-Drees et al. 2015; Al-Shaikh et al. 2015; Hande et al. 2015; González et al. 2015; Yanamadala et al. 2016; Balendran & John 2017; Chang et al. 2017; Eltony et al. 2017; Zhang et al. 2018; Hincapié et al. 2018; Ma & Lu 2019; Berger et al. 2019; Alquliti et al. 2019; Li et al. 2020; Zhao et al. 2020; Liu et al. 2020; Margolius et al. 2020) but there was no difference between traditional and PBL curriculums in another 19 studies (Schwart et al. 1992; Mennin et al. 1993; Vernon, & Hosokawa 1996; Kaufman & Mann 1998; Kaufman & Mann 1999; Antepohl & Herzig 1999; Dyke et al. 2001; Brewer 2001; Seneviratne et al. 2001; Alleyne et al. 2002; Norman et al. 2008; Cohen-Schotanus et al. 2008; Wenk et al. 2009; Collard et al. 2009; Nouns et al. 2012; Saloojee & van Wyk et al. 2012; Mughal & Shaikh et al. 2018; Hu et al. 2019; Thompson et al. 2019). Only three studies reported that PBL was less effective (Vernon & Hosokawa 1996; Steadman et al. 2006; Johnston et al. 2009), in one case favouring simulation-based

learning (Steadman et al. 2006). It is noteworthy that the four systematic reviews and meta-analysis included in this scoping review, all carried out in China, found that PBL was more effective than lecture-based learning in improving knowledge and other skills (clinical, problem-solving, self-learning and collaborative) (Ding et al. 2014; Zhang et al. 2018; Ma et al. 2019; Liu et al. 2020). Another relevant example of the superiority of the PBL method over the traditional method is the experience reported by (Hoffman et al. 2006) from the University of Missouri-Columbia. The authors analysed the impact of implementing the PBL methodology in its Faculty of Medicine and revealed an improvement in the academic results that lasted for over a decade.

Social and communication skills

We found five studies in this scoping review that focussed on these outcomes and all of them described that a curriculum centred on PBL seems to instil more confidence in social and communication skills among students. Students perceived PBL positively for team work, communication skills and interpersonal relations (Seneviratne et al. 2001; Suleman et al. 2010; Hande et al. 2015; Al-Shaikh et al. 2015; Mughal & Shaikh 2018).

Student satisfaction

Fifty-six publications analysed student satisfaction with PBL methodology. The most frequent methodology were surveys or questionnaires (29 studies) followed by comparative studies with traditional or lecture-based methodology (19 studies, 7 of them were randomized). Almost all the studies (47) have shown that PBL is generally well-received (Sokas et al. 1990; Blosser & Jones 1991; Usherwood 1991; Bernstein et al. 1995; Kaufman & Mann 1996; Kalaian & Mullan 1996; Gresham & Philp 1996; Vincelette 1997; Kaufman & Mann 1999; Antepohl & Herzig 1999; Casassus et al. 1999; Purdy et al. 1999; Farrell et al. 1999; Ghosh & Dawka 2000; Dyke et al. 2001; Walters 2001; Leung et al. 2001; Khoo et al. 2001; Villamor 2001; Curtis et al. 2001; Trevena & Clarke 2002; Chang et al. 2004; McLean 2004; Casey et al. 2005; Abu-Hijleh et al. 2005; Lucas et al. 2006; Burgun et al. 2006; Gurpinar et al. 2009; Suleman et al. 2010; Wang et al. 2010; Tian et al. 2012; Elzubeir 2012; Sulaiman & Hamdy 2013; Albarak et al. 2013; Li et al. 2013; Meo 2014; Khoshnevisasl et al. 2014; Nosair et al. 2015; González et al. 2015; Tshitenge et al. 2017; Eltony et al. 2017; Yadav et al. 2018; Asad et al. 2019; Mpalanyi et al. 2020; Korkmaz & Ozelik 2020; Li et al. 2020; Liu et al. 2020) but in 9 studies the overall satisfaction scores for the PBL program were neutral (Macallan et al. 2009; Grisham et al. 2015; Khan & Al-Swailmi 2015; Alduraywish et al. 2017; Yoo et al. 2019; Aldayel et al. 2019; Hu et al. 2019) or negative (DeLowerntal 1996; Tufts 2009). Some factors that have been identified as key components for PBL to be successful include: a small group size, the use of scenarios of realistic cases and good management of group dynamics. Despite a mostly positive assessment of the PBL methodology by the students, there were some negative aspects that could be criticized or improved. These include unclear communication of the learning methodology, objectives and assessment method; bad management and organisation of the sessions; tutors having little experience of the method; and a lack of standardisation in the implementation of the method by the tutors.

Tutor satisfaction

There are only 12 publications that analyze the satisfaction of tutors, most of them surveys or questionnaires (Bernstein et al. 1995; Vincelette et al. 1997; Khoo et al. 2001; Gurpinar et al. 2009). In comparison with the satisfaction of the students, here the results are more neutral (Macallan et al. 2009; Subramaniam et al. 2014; Khan & Al-Swailmi 2015; Chang 2016; Yoo et al. 2019) and even unfavorable to the PBL methodology in two publications (Griffith et al. 1996; De Lowerntal 1996). PBL teaching was favored by tutors when the institutions train them in the subject, when there was administrative support and adequate infrastructure and coordination (Navarro & Zamora 2014). In some experiences, the PBL modules created an unacceptable toll of anxiety, unhappiness and strained relations.

Other outcomes and descriptive experiences

The effectiveness of the PBL methodology has also been explored in other outcomes such as the ability to solve problems and to self-directed learning. All studies have shown that PBL is more effective than lecture-based learning in problem-solving and self-learning skills (Casassus et al. 1999; Seneviratne et al. 2001; Whitfield et al. 2002; Ding et al. 2014; Balendran & John 2017; Mughal & Shaikh 2018; Yadav et al. 2018; Villamor 2001; Demiroren et al. 2016).

Finally, other publications have reported the experience of some faculties in the implementation of the PBL methodology. Different experiences have demonstrated that it is both possible and feasible to shift from a traditional curriculum to a PBL program, recognizing that PBL methodology is complex to plan and structure, needs a large number of human and material resources, requiring an immense teacher effort (Desmarchais 2003; Chang et al. 2004; Tamblyn et al. 2005; Hoffman et al. 2006). In addition, and in spite of its cost implication, a PBL curriculum can be successfully implemented in resource-constrained settings (Amoako-Sakyi & Amonoo-Kuofi 2015; Carrera et al. 2003).

Discussion

We conducted this scoping review to explore the effectiveness and satisfaction of PBL methodology for teaching in undergraduate medicine and, to our knowledge, it is the first study of its kind that has been carried out. PBL methodology is implemented in medical studies on the 6 continents but there is more experience (or at least more publications) from Asian countries and North America. In spite of its difficulties on implementation, a PBL curriculum can be successfully implemented in resource-constrained settings (Amoako-Sakyi & Amonoo-Kuofi 2015; Carrera et al. 2003). Although it is true that the studies with the highest level of scientific evidence (randomized studies and meta-analysis) were carried out mainly in Asian countries (and some in North America and Europe), there were no significant differences in the main results according to geographical origin.

In this scoping review we have included a large number of publications that, despite their heterogeneity, tend to show favorable results for the usefulness of the PBL methodology in teaching and learning medicine. The results tend to be especially favorable to PBL methodology when it is compared with traditional or lecture-based teaching methods, but when compared with simulation it is not so clear. There are two studies that show neutral (Wenk et al. 2009) or superior (Steadman et al. 2006) results to simulation for the acquisition of specific clinical skills. It seems important to highlight that the four meta-analysis included in this review, which included a high number of participants, show results that are clearly favorable to the PBL methodology in terms of knowledge, clinical skills, problem-solving, self-learning and satisfaction (Ding et al. 2014; Zhang et al. 2018; Ma et al. 2019; Liu et al. 2020).

Regarding the level of satisfaction described in the surveys or questionnaires, the overall satisfaction rate was higher in the PBL students when compared with traditional learning students. Students work in small groups, allowing and promoting teamwork and facilitating social and communication skills. As sessions are more attractive and dynamic than traditional classes, this could lead to a greater degree of motivation for learning.

These satisfaction results are not so favorable when tutors are asked and this may be due to different reasons; first, some studies are from the 90s, when the methodology was not yet fully implemented; second, the number of tutors included in these studies is low; and third, and perhaps most importantly, the complaints are not usually due to the methodology itself, but rather due to lack of administrative support, and/or work overload. PBL methodology implies more human and material resources. The lack of experience in guided self-learning by lecturers requires more training. Some teachers may not feel comfortable with the method and therefore do not apply it correctly.

Despite how effective and/or attractive the PBL methodology may seem, some (not many) authors are clearly detractors and have published opinion articles with fierce criticism to this methodology. Some of the arguments against are as follows: clinical problem solving is the wrong task for preclinical medical students, self-directed learning interpreted as self-teaching is not appropriate in undergraduate medical education, relegation to the role of facilitators is a misuse of the faculty, small-group experience is inherently variable and sometimes dysfunctional, etc. (Shanley 2007).

Limitations

Scoping reviews are not without limitations. Our review includes 124 articles from the 2399 initially identified and despite our efforts to be as comprehensive as possible, we may have missed some articles. Despite the fact that this review includes many studies, their design is very heterogeneous, only a few include a large sample size and high scientific evidence methodology. Furthermore, most are single-center experiences and there are no large multi-center studies. However, the adoption of a scoping review methodology was effective in terms of summarizing the research findings, identifying limitations in studies' methodologies and findings and provided a more rigorous vision of the international state of the art.

Conclusions

This systematic scoping review provides a broad overview of the efficacy of PBL methodology in undergraduate medicine teaching from different countries and institutions. PBL is not a new teaching method given that it has already been 50 years since it was implemented in medicine courses. It is a method that shifts the leading role from teachers to students and is based on guided self-learning. If it is applied properly, the degree of satisfaction is high, especially for students. PBL is more effective than traditional methods (based mainly on lectures) at improving social and communication skills, problem-solving and self-learning skills, and has no worse results (and in many studies better results) in relation to knowledge retention and academic performance. Despite that, its use is not universally widespread, probably because it requires greater human resources and continuous training for its implementation. In any case, more comparative and randomized studies and/or other systematic reviews and meta-analysis are required to determine which educational strategies could be most suitable for the training of future doctors.

Declarations

Compliance with ethical standards

Funding: no funding was received for conducting this study

Conflict of interest: all authors declare that they have no conflict of interest.

Ethical approval: not applicable for a literature review

Author Contribution statement: JCT: had the idea for the article; JCT performed the literature search and data analysis; JCT drafted the first version of the manuscript. CB, BS and RP contributed to the data analysis and suggested revisions to the manuscript. All authors read and approved the final manuscript.

References

- Aboonq, M. (2015). Perception of the faculty regarding problem-based learning as an educational approach in Northwestern Saudi Arabia. *SAUDI MEDICAL JOURNAL*, 36(11), 1329–1335. <https://doi.org/10.15537/smj.2015.11.12263>
- Aboonq, M., Alquliti, A., Abdulmonem, I., Alpuq, N., Jalali, K., & Arabi, S. (2019). STUDENTS' APPROACHES TO LEARNING AND PERCEPTION OF LEARNING ENVIRONMENT: A COMPARISON BETWEEN TRADITIONAL AND PROBLEM-BASED LEARNING MEDICAL CURRICULA. *INDO AMERICAN JOURNAL OF PHARMACEUTICAL SCIENCES*, 6(2), 3610–3619. <https://doi.org/10.5281/zenodo.2562660>
- Abou-Elhamd, K. A., Rashad, U. M., & Al-Sultan, A. I. (2011). Applying problem-based learning to otolaryngology teaching. *The Journal of Laryngology and Otology*, 125(2), 117–120. <https://doi.org/10.1017/S0022215110001702>
- Abu-Hijleh, M. F., Chakravarty, M., Al-Shboul, Q., Kassab, S., & Hamdy, H. (2005). Integrating applied anatomy in surgical clerkship in a problem-based learning curriculum. *Surgical and Radiologic Anatomy: SRA*, 27(2), 152–157. <https://doi.org/10.1007/s00276-004-0293-4>
- Albarak, A. I., Mohammed, R., Abalhassan, M. F., & Almutairi, N. K. (2013). Academic satisfaction among traditional and problem based learning medical students A comparative study. *SAUDI MEDICAL JOURNAL*, 34(11), 1179–1188.

- Aldayel, A. A., Alali, A. O., Altuwaim, A. A., Alhussain, H. A., Aljasser, K. A., Bin Abdulrahman, K. A., Alamri, M. O., & Almutairi, T. A. (2019). Problem-based learning: medical students' perception toward their educational environment at Al-Imam Mohammad Ibn Saud Islamic University. *ADVANCES IN MEDICAL EDUCATION AND PRACTICE*, 10, 95–104. <https://doi.org/10.2147/AMEPS189062>
- Al-Drees, A. A., Khalil, M. S., Irshad, M., & Abdulghani, H. M. (2015). Students' perception towards the problem based learning tutorial session in a system-based hybrid curriculum. *SAUDI MEDICAL JOURNAL*, 36(3), 341–348. <https://doi.org/10.15537/smj.2015.3.10216>
- Alduraywish, A. A., Mohager, M. O., Alenezi, M. J., Nail, A. M., & Aljafari, A. S. (2017). Evaluation of students' experience with Problem-based Learning (PBL) applied at the College of Medicine, Al-Jouf University, Saudi Arabia. *JOURNAL OF THE PAKISTAN MEDICAL ASSOCIATION*, 67(12), 1870–1873.
- Alleyne, T., Shirley, A., Bennett, C., Addae, J., Walrond, E., West, S., & Pinto Pereira, L. (2002). Problem-based compared with traditional methods at the Faculty of Medical Sciences, University of the West Indies: a model study. *Medical Teacher*, 24(3), 273–279. <https://doi.org/10.1080/01421590220125286>
- Al-Shaikh, G., Al Mussaed, E. M., Altamimi, T. N., Elmorshedy, H., Syed, S., & Habib, F. (2015). Perception of Medical Students Regarding Problem Based Learning. *KUWAIT MEDICAL JOURNAL*, 47(2), 133–138.
- Amoako-Sakyi, D., & Amonoo-Kuofi, H. (2015). Problem-based learning in resource-poor settings: lessons from a medical school in Ghana. *BMC MEDICAL EDUCATION*, 15. <https://doi.org/10.1186/s12909-015-0501-4>
- Antepohl, W., & Herzig, S. (1999). Problem-based learning versus lecture-based learning in a course of basic pharmacology: a controlled, randomized study. *MEDICAL EDUCATION*, 33(2), 106–113. <https://doi.org/10.1046/j.1365-2923.1999.00289.x>
- Arksey H & O'Malley L. (2005). Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology*, 8(1), 19–32. doi:10.1080/1364557032000119616
- Asad, M. R., Tadv, N., Amir, K. M., Afzal, K., Irfan, A., & Hussain, S. A. (2019). Medical Student's Feedback towards Problem Based Learning and Interactive Lectures as a Teaching and Learning Method in an Outcome-Based Curriculum. *INTERNATIONAL JOURNAL OF MEDICAL RESEARCH & HEALTH SCIENCES*, 8(4), 78–84. <https://doi.org/10.33844/ijol.2019.60392>
- Astin, J., Jenkins, T., & Moore, L. (2002). Medical students' perspective on the teaching of medical statistics in the undergraduate medical curriculum. *Statistics in Medicine*, 21(7), 1003–1006; discussion 1007. <https://doi.org/10.1002/sim.1132>
- Balendran, K., & John, L. (2017). COMPARISON OF LEARNING OUTCOMES IN PROBLEM BASED LEARNING AND LECTURE BASED LEARNING IN TEACHING FORENSIC MEDICINE. *JOURNAL OF EVOLUTION OF MEDICAL AND DENTAL SCIENCES-JEMDS*, 6(2), 89–92. <https://doi.org/10.14260/jemds/2017/22>
- Berger, C., Brinkrolf, P., Ertmer, C., Becker, J., Friederichs, H., Wenk, M., Van Aken, H., & Hahnenkamp, K. (2019). Combination of problem-based learning with high-fidelity simulation in CPR training improves short and long-term CPR skills: a randomised single blinded trial. *BMC MEDICAL EDUCATION*, 19. <https://doi.org/10.1186/s12909-019-1626-7>
- BERNSTEIN, P., TIPPING, J., BERCOVITZ, K., & SKINNER, H. A. (1995). SHIFTING STUDENTS AND FACULTY TO A PBL CURRICULUM - ATTITUDES CHANGED AND LESSONS LEARNED. *ACADEMIC MEDICINE*, 70(3), 245–247. <https://doi.org/10.1097/00001888-199503000-00019>
- Blake, R. L., & Parkison, L. (1998). Faculty evaluation of the clinical performances of students in a problem-based learning curriculum. *TEACHING AND LEARNING IN MEDICINE*, 10(2), 69–73. https://doi.org/10.1207/S15328015TLM1002_3
- BLOSSER, A., & JONES, B. (1991). PROBLEM-BASED LEARNING IN A SURGERY CLERKSHIP. *MEDICAL TEACHER*, 13(4), 289–293. <https://doi.org/10.3109/01421599109089907>
- Bodagh N, Bloomfield J, Birch P & Ricketts W (2017). Problem-based learning: a review. *Br J Hosp Med (Lond)*, 78, C167–C170. doi:10.12968/hmed.2017.78.11.C167.
- Bosch-Barrera, J., Briceno Garcia, H. C., Capella, D., De Castro Vila, C., Farres, R., Quintanas, A., Ramis, J., Roca, R., & Brunet, J. (2015). TEACHING BIOETHICS TO STUDENTS OF MEDICINE WITH PROBLEM-BASED LEARNING (PBL). *CUADERNOS DE BIOETICA*, 26(87), 303–309.
- Branda LA. (2013) El abc del ABP: Lo esencial del aprendizaje basado en problemas. (In Fundación Dr. Esteve, Cuadernos de la fundación Dr. Antonio Esteve nº27: El aprendizaje basado en problemas en sus textos, (pp.1-16). Barcelona).
- Brewer, D. W. (2001). Endocrine PBL in the year 2000. *Advances in Physiology Education*, 25(1–4), 249–255. <https://doi.org/10.1152/advances.2001.25.4.249>
- Brynhildsen, J., Dahle, L. O., Behrbohm Fallsberg, M., Rundquist, I., & Hammar, M. (2002). Attitudes among students and teachers on vertical integration between clinical medicine and basic science within a problem-based undergraduate medical curriculum. *Medical Teacher*, 24(3), 286–288. <https://doi.org/10.1080/01421590220134105>
- Bui-Mansfield, L. T., & Chew, F. S. (2001). Radiologists as clinical tutors in a problem-based medical school curriculum. *Academic Radiology*, 8(7), 657–663. [https://doi.org/10.1016/S1076-6332\(03\)80693-1](https://doi.org/10.1016/S1076-6332(03)80693-1)

- Burgun, A., Darmoni, S., Le Duff, F., & Weber, J. (2006). Problem-based learning in medical informatics for undergraduate medical students: An experiment in two medical schools. *INTERNATIONAL JOURNAL OF MEDICAL INFORMATICS*, 75(5), 396–402. <https://doi.org/10.1016/j.ijmedinf.2005.07.014>
- Carrera, L. I., Tellez, T. E., & D'Ottavio, A. E. (2003). Implementing a problem-based learning curriculum in an Argentinean medical school: Implications for developing countries. *ACADEMIC MEDICINE*, 78(8), 798–801. <https://doi.org/10.1097/00001888-200308000-00010>
- Casassus, P., Hivon, R., Gagnayre, R., & d'Ivernois, J. F. (1999). An initial experiment in haematology instruction using the problem-based learning method in third-year medical training in France. *Hematology and Cell Therapy*, 41(4), 137–144. <https://doi.org/10.1007/s00282-999-0137-0>
- Casey, P. M., Magrane, D., & Lesnick, T. G. (2005). Improved performance and student satisfaction after implementation of a problem-based preclinical obstetrics and gynecology curriculum. *American Journal of Obstetrics and Gynecology*, 193(5), 1874–1878. <https://doi.org/10.1016/j.ajog.2005.07.061>
- Chang, B. J. (2016). Problem-based learning in medical school: A student's perspective. *ANNALS OF MEDICINE AND SURGERY*, 12, 88–89. <https://doi.org/10.1016/j.amsu.2016.11.011>
- Chang, C.-H., Yang, C.-Y., See, L.-C., & Lui, P.-W. (2004). High satisfaction with problem-based learning for anesthesia. *Chang Gung Medical Journal*, 27(9), 654–662.
- Chang, G., Cook, D., Maguire, T., Skakun, E., Yakimets, W. W., & Warnock, G. L. (1995). Problem-based learning: its role in undergraduate surgical education. *Canadian Journal of Surgery. Journal Canadien de Chirurgie*, 38(1), 13–21.
- Chang, H.-C., Wang, N.-Y., Ko, W.-R., Yu, Y.-T., Lin, L.-Y., & Tsai, H.-F. (2017). The effectiveness of clinical problem-based learning model of medico-jurisprudence education on general law knowledge for Obstetrics/Gynecological interns. *Taiwanese Journal of Obstetrics & Gynecology*, 56(3), 325–330. <https://doi.org/10.1016/j.tjog.2017.04.011>
- Chng, E., Yew, E. H. J., & Schmidt, H. G. (2015). To what extent do tutor-related behaviours influence student learning in PBL? *Advances in Health Sciences Education: Theory and Practice*, 20(1), 5–21. <https://doi.org/10.1007/s10459-014-9503-y>
- Cohen-Schotanus, J., Muijtjens, A. M. M., Schoenrock-Adema, J., Geertsma, J., & van der Vleuten, C. P. M. (2008). Effects of conventional and problem-based learning on clinical and general competencies and career development. *MEDICAL EDUCATION*, 42(3), 256–265. <https://doi.org/10.1111/j.1365-2923.2007.02959.x>
- Collard, A., Gelaes, S., Vanbelle, S., Bredart, S., Defraigne, J.-O., Boniver, J., & Bourguignon, J.-P. (2009). Reasoning versus knowledge retention and ascertainment throughout a problem-based learning curriculum. *Medical Education*, 43(9), 854–865. <https://doi.org/10.1111/j.1365-2923.2009.03410.x>
- Curtis, J. A., Indyk, D., & Taylor, B. (2001). Successful use of problem-based learning in a third-year pediatric clerkship. *Ambulatory Pediatrics: The Official Journal of the Ambulatory Pediatric Association*, 1(3), 132–135. [https://doi.org/10.1367/1539-4409\(2001\)001<0132:suopbl>2.0.co;2](https://doi.org/10.1367/1539-4409(2001)001<0132:suopbl>2.0.co;2)
- Dale E. (1932). Methods for Analyzing the Content of Motion Pictures. *Journal of Educational Sociology*, 6, 244-250.
- DeLowerntal, E. (1996). An evaluation of a module in problem-based learning. *INTERNATIONAL JOURNAL OF EDUCATIONAL DEVELOPMENT*, 16(3), 303–307. [https://doi.org/10.1016/0738-0593\(96\)00001-6](https://doi.org/10.1016/0738-0593(96)00001-6)
- Demiroren, M., Turan, S., & Oztuna, D. (2016). Medical students' self-efficacy in problem-based learning and its relationship with self-regulated learning. *MEDICAL EDUCATION ONLINE*, 21. <https://doi.org/10.3402/meo.v21.30049>
- DESMARCHAIS, J. E. (1993). A STUDENT-CENTERED, PROBLEM-BASED CURRICULUM - 5 YEARS EXPERIENCE. *CANADIAN MEDICAL ASSOCIATION JOURNAL*, 148(9), 1567–1572.
- Ding, X., Zhao, L., Chu, H., Tong, N., Ni, C., Hu, Z., Zhang, Z., & Wang, M. (2014). Assessing the effectiveness of problem-based learning of preventive medicine education in China. *Scientific Reports*, 4, 5126. <https://doi.org/10.1038/srep05126>
- Distlehorst, L. H., Dawson, E., Robbs, R. S., & Barrows, H. S. (2005). Problem-based learning outcomes: The glass half-full. *ACADEMIC MEDICINE*, 80(3), 294–299. <https://doi.org/10.1097/00001888-200503000-00020>
- Doig, K., & Werner, E. (2000). The marriage of a traditional lecture-based curriculum and problem-based learning: are the offspring vigorous? *MEDICAL TEACHER*, 22(2), 173–178.
- Dyke, P., Jamrozik, K., & Plant, A. J. (2001). A randomized trial of a problem-based learning approach for teaching epidemiology. *Academic Medicine: Journal of the Association of American Medical Colleges*, 76(4), 373–379. <https://doi.org/10.1097/00001888-200104000-00016>
- Eltony, S. A., El-Sayed, N. H., El-Araby, S. E.-S., & Kassab, S. E. (2017). Implementation and Evaluation of a Patient Safety Course in a Problem-based Learning Program. *EDUCATION FOR HEALTH*, 30(1), 44–49. <https://doi.org/10.4103/1357-6283.210512>
- Elzubeir, M. A. (2012). Teaching of the renal system in an integrated, problem-based curriculum. *Saudi Journal of Kidney Diseases and Transplantation: An Official Publication of the Saudi Center for Organ Transplantation, Saudi Arabia*, 23(1), 93–98. <http://www.ncbi.nlm.nih.gov/pubmed/22237226>

- Farrell, T. A., Albanese, M. A., & Pomrehn, P. R. J. (1999). Problem-based learning in ophthalmology: a pilot program for curricular renewal. *Archives of Ophthalmology (Chicago, Ill. : 1960)*, 117(9), 1223–1226. <https://doi.org/10.1001/archophth.117.9.1223>
- Finch, P. N. (1999). The effect of problem-based learning on the academic performance of students studying podiatric medicine in Ontario. *MEDICAL EDUCATION*, 33(6), 411–417.
- Ghosh, S., & Dawka, V. (2000). Combination of didactic lecture with problem-based learning sessions in physiology teaching in a developing medical college in Nepal. *ADVANCES IN PHYSIOLOGY EDUCATION*, 24(1), 8–12.
- Gonzalez Mirasol, E., Gomez Garcia, M. T., Lobo Abascal, P., Moreno Selva, R., Fuentes Rozalen, A. M., & Gonzalez Merlo, G. (2015). Analysis of perception of training in graduates of the Faculty of Medicine at Universidad de Castilla-Mancha. *EVALUATION AND PROGRAM PLANNING*, 52, 169–175. <https://doi.org/10.1016/j.evalprogplan.2015.06.001>
- Gresham, C. L., & Philp, J. R. (1996). Problem-based learning in clinical medicine. *TEACHING AND LEARNING IN MEDICINE*, 8(2), 111–115. <https://doi.org/10.1080/10401339609539776>
- Griffith, C. D., Blue, A. V., Mainous, A. G., & DeSimone, P. A. (1996). Housestaff attitudes toward a problem-based clerkship. *MEDICAL TEACHER*, 18(2), 133–134. <https://doi.org/10.3109/01421599609034147>
- Grisham, J. W., Martiniuk, A. L. C., Negin, J., & Wright, E. P. (2015). Problem-based learning (PBL) and public health: an initial exploration of perceptions of PBL in Vietnam. *Asia-Pacific Journal of Public Health*, 27(2), NP2019-27. <https://doi.org/10.1177/1010539512436875>
- Grkovic, I. (2005). Transition of the medical curriculum from classical to integrated: Problem-based approach and Australian way of keeping academia in medicine. *CROATIAN MEDICAL JOURNAL*, 46(1), 16–20.
- Gurpinar, E., Musal, B., Aksakoglu, G., & Ucku, R. (2005). Comparison of knowledge scores of medical students in problem-based learning and traditional curriculum on public health topics. *BMC Medical Education*, 5(1), 7. <https://doi.org/10.1186/1472-6920-5-7>
- Gurpinar, E., Senol, Y., & Aktekin, M. R. (2009). Evaluation of Problem Based Learning by Tutors and Students in a Medical Faculty of Turkey. *KUWAIT MEDICAL JOURNAL*, 41(2), 123–127.
- Hande, S., Mohammed, C. A., & Komattil, R. (2015). Acquisition of knowledge, generic skills and attitudes through problem-based learning: Student perspectives in a hybrid curriculum. *JOURNAL OF TAIBAH UNIVERSITY MEDICAL SCIENCES*, 10(1, SI), 21–25. <https://doi.org/10.1016/j.jtumed.2014.01.008>
- Hill, J., Rolfe, I. E., Pearson, S. A., & Heathcote, A. (1998). Do junior doctors feel they are prepared for hospital practice? A study of graduates from traditional and non-traditional medical schools. *MEDICAL EDUCATION*, 32(1), 19–24. <https://doi.org/10.1046/j.1365-2923.1998.00152.x>
- Hincapie Parra, D. A., Ramos Monobe, A., & Chrino-Barcelo, V. (2018). Problem Based Learning as an Active Learning strategy and its impact on academic performance and critical thinking of Medical students. *REVISTA COMPLUTENSE DE EDUCACION*, 29(3), 665–681. <https://doi.org/10.5209/RCED.53581>
- Hmelo, C. E. (1998). Problem-based learning: Effects on the early acquisition of cognitive skill in medicine. *JOURNAL OF THE LEARNING SCIENCES*, 7(2), 173–208. https://doi.org/10.1207/s15327809jls0702_2
- Hoffman, K., Hosokawa, M., Blake Jr., R., Headrick, L., & Johnson, G. (2006). Problem-based learning outcomes: Ten years of experience at the University of Missouri-Columbia School of Medicine. *ACADEMIC MEDICINE*, 81(7), 617–625. <https://doi.org/10.1097/01.ACM.0000232411.97399.c6>
- Hoover, C. R., Wong, C. C., & Azzam, A. (2012). From primary care to public health: using Problem-based Learning and the ecological model to teach public health to first year medical students. *Journal of Community Health*, 37(3), 647–652. <https://doi.org/10.1007/s10900-011-9495-y>
- Hu, X., Zhang, H., Song, Y., Wu, C., Yang, Q., Shi, Z., Zhang, X., & Chen, W. (2019). Implementation of flipped classroom combined with problem-based learning: an approach to promote learning about hyperthyroidism in the endocrinology internship. *BMC Medical Education*, 19(1), 290. <https://doi.org/10.1186/s12909-019-1714-8>
- Johnston, J. M., Schooling, C. M., & Leung, G. M. (2009). A randomised-controlled trial of two educational modes for undergraduate evidence-based medicine learning in Asia. *BMC Medical Education*, 9, 63. <https://doi.org/10.1186/1472-6920-9-63>
- Kalaian, H. A., & Mullan, P. B. (1996). Exploratory factor analysis of students' ratings of a problem-based learning curriculum. *ACADEMIC MEDICINE*, 71(4), 390–392. <https://doi.org/10.1097/00001888-199604000-00019>
- Kaufman, D. M., & Mann, K. V. (1996). Comparing students' attitudes in problem-based and conventional curricula. *ACADEMIC MEDICINE*, 71(10), 1096–1099. <https://doi.org/10.1097/00001888-199610000-00018>
- Kaufman, D. M., & Mann, K. V. (1998). Comparing achievement on the Medical Council of Canada Qualifying Examination Part I of students in conventional and problem-based learning curricula. *ACADEMIC MEDICINE*, 73(11), 1211–1213. <https://doi.org/10.1097/00001888-199811000-00022>
- Kaufman, D. M., & Mann, K. V. (1999). Achievement of Students in a Conventional and Problem-Based Learning (PBL) Curriculum. *ADVANCES IN HEALTH SCIENCES EDUCATION*, 4(3), 245–260. <https://doi.org/10.1023/A:1009829831978>

- Kelly, A. M. (2000). A problem-based learning resource in emergency medicine for medical students. *Journal of Accident & Emergency Medicine*, 17(5), 320–323. <https://doi.org/10.1136/emj.17.5.320>
- Kemahli, S. (2005). Hematology education in a problem-based curriculum. *Hematology (Amsterdam, Netherlands)*, 10 Suppl 1, 161–163. <https://doi.org/10.1080/10245330512331390267>
- Khan, I. A., & Al-Swailmi, F. K. (2015). Perceptions of faculty and students regarding Problem Based Learning: A mixed methods study. *JOURNAL OF THE PAKISTAN MEDICAL ASSOCIATION*, 65(12), 1334–1338.
- Khoo, H. E., Chhem, R. K., Gwee, M. C. E., & Balasubramaniam, P. (2001). Introduction of problem-based learning in a traditional medical curriculum in Singapore - Students' and tutors' perspectives. *ANNALS ACADEMY OF MEDICINE SINGAPORE*, 30(4), 371–374.
- Khoshnevisasl, P., Sadeghzadeh, M., Mazloomzadeh, S., Feshareki, R. H., & Ahmadiafshar, A. (2014). Comparison of Problem-based Learning With Lecture-based Learning. *IRANIAN RED CRESCENT MEDICAL JOURNAL*, 16(5). <https://doi.org/10.5812/ircmj.5186>
- Kong, J., Li, X., Wang, Y., Sun, W., & Zhang, J. (2009). Effect of digital problem-based learning cases on student learning outcomes in ophthalmology courses. *Archives of Ophthalmology (Chicago, Ill. : 1960)*, 127(9), 1211–1214. <https://doi.org/10.1001/archophthalmol.2009.110>
- Korkmaz, N. S., & Ozelik, S. (2020). Evaluation of the Opinions of the First, Second and Third Term Medical Students About Problem Based Learning Sessions in Bezmialem Vakif University. *BEZMIALEM SCIENCE*, 8(2), 144–149. <https://doi.org/10.14235/bas.galenos.2019.3471>
- Leung, G. M., Lam, T. H., & Hedley, A. J. (2001). Problem-based public health learning - from the classroom to the community. *Medical Education*, 35(11), 1071–1072.
- Levac D, Colquhoun H, & O'Brien KK. (2010). Scoping studies: Advancing the methodology. *Implementation Science*, 5(1), 69. doi:10.1186/1748-5908-5-69
- Li, J., Li, Q. L., Li, J., Chen, M. L., Xie, H. F., Li, Y. P., & Chen, X. (2013). Comparison of three problem-based learning conditions (real patients, digital and paper) with lecture-based learning in a dermatology course: a prospective randomized study from China. *Medical Teacher*, 35(2), e963-70. <https://doi.org/10.3109/0142159X.2012.719651>
- Li, X., Xie, F., Li, X., Li, G., Chen, X., Lv, J., & Peng, C. (2020). Development, application, and evaluation of a problem-based learning method in clinical laboratory education. *CLINICA CHIMICA ACTA*, 510, 681–684. <https://doi.org/10.1016/j.cca.2020.08.037>
- Lin, Y.-C., Huang, Y.-S., Lai, C.-S., Yen, J.-H., & Tsai, W.-C. (2009). PROBLEM-BASED LEARNING CURRICULUM IN MEDICAL EDUCATION AT KAOHSIUNG MEDICAL UNIVERSITY. *KAOHSIUNG JOURNAL OF MEDICAL SCIENCES*, 25(5), 264–269. [https://doi.org/10.1016/S1607-551X\(09\)70072-5](https://doi.org/10.1016/S1607-551X(09)70072-5)
- Liu, C.-X., Ouyang, W.-W., Wang, X.-W., Chen, D., & Jiang, Z.-L. (2020). Comparing hybrid problem-based and lecture learning (PBL plus LBL) with LBL pedagogy on clinical curriculum learning for medical students in China: a meta-analysis of randomized controlled trials. *MEDICINE*, 99(16). <https://doi.org/10.1097/MD.0000000000001967>
- Lucas, M., García Guasch, R., Moret, E., Llasera, R., Melero, A., & Canet, J. (2006). [Problem-based learning in an undergraduate medical school course on anesthesiology, recovery care, and pain management]. *Revista española de anestesiología y reanimación*, 53(7), 419–425.
- Ma, Y., & Lu, X. (2019). The effectiveness of problem-based learning in pediatric medical education in China: A meta-analysis of randomized controlled trials. *Medicine*, 98(2), e14052. <https://doi.org/10.1097/MD.00000000000014052>
- Macallan, D. C., Kent, A., Holmes, S. C., Farmer, E. A., & McCrorie, P. (2009). A model of clinical problem-based learning for clinical attachments in medicine. *MEDICAL EDUCATION*, 43(8), 799–807. <https://doi.org/10.1111/j.1365-2923.2009.03406.x>
- Margolius, S. W., Papp, K. K., Altose, M. D., & Wilson-Delfosse, A. L. (2020). Students perceive skills learned in pre-clerkship PBL valuable in core clinical rotations. *MEDICAL TEACHER*, 42(8), 902–908. <https://doi.org/10.1080/0142159X.2020.1762031>
- McGrew, M. C., Skipper, B., Palley, T., & Kaufman, A. (1999). Student and faculty perceptions of problem-based learning on a family medicine clerkship. *Family Medicine*, 31(3), 171–176.
- McLean, M. (2004). A comparison of students who chose a traditional or a problem-based learning curriculum after failing year 2 in the traditional curriculum: A unique case study at the Nelson R. Mandela School of Medicine. *TEACHING AND LEARNING IN MEDICINE*, 16(3), 301–303. https://doi.org/10.1207/s15328015tlm1603_15
- McParland, M., Noble, L. M., & Livingston, G. (2004). The effectiveness of problem-based learning compared to traditional teaching in undergraduate psychiatry. *Medical Education*, 38(8), 859–867. <https://doi.org/10.1111/j.1365-2929.2004.01818.x>
- MENNIN, S. P., FRIEDMAN, M., SKIPPER, B., KALISHMAN, S., & SNYDER, J. (1993). PERFORMANCES ON THE NBME-I, NBME-II, AND NBME-III BY MEDICAL-STUDENTS IN THE PROBLEM-BASED LEARNING AND CONVENTIONAL TRACKS AT THE UNIVERSITY-OF-NEW-MEXICO. *ACADEMIC MEDICINE*, 68(8), 616–624. <https://doi.org/10.1097/00001888-199308000-00012>

- Meo, S. A. (2014). Undergraduate medical student's perceptions on traditional and problem based curricula: Pilot study. *JOURNAL OF THE PAKISTAN MEDICAL ASSOCIATION*, 64(7), 775–779.
- Miller GE (1990). The assessment of clinical skills/competence/performance. *Academic Medicine*, S63-7.
- Mpalanyi, M., Nalweyiso, I. D., & Mubuuke, A. G. (2020). Perceptions of radiography students toward problem-based learning almost two decades after its introduction at Makerere University, Uganda. *Journal of Medical Imaging and Radiation Sciences*, 51(4), 639–644. <https://doi.org/10.1016/j.jmir.2020.06.009>
- Mughal, A. M., & Shaikh, S. H. (2018). Assessment of collaborative problem solving skills in Undergraduate Medical Students at Ziauddin College of Medicine, Karachi. *PAKISTAN JOURNAL OF MEDICAL SCIENCES*, 34(1), 185–189. <https://doi.org/10.12669/pjms.341.13485>
- Navarro H, N., & Zamora S, J. (2014). The opinion of teachers about tutorial problem based learning. *REVISTA MEDICA DE CHILE*, 142(8), 989–997. <https://doi.org/10.4067/S0034-98872014000800006>
- Norman, G. R., Wenghofer, E., & Klass, D. (2008). Predicting doctor performance outcomes of curriculum interventions: problem-based learning and continuing competence. *MEDICAL EDUCATION*, 42(8), 794–799. <https://doi.org/10.1111/j.1365-2923.2008.03131.x>
- Nosair, E., Mirghani, Z., & Mostafa, R. M. (2015). Measuring Students' Perceptions of Educational Environment in the PBL Program of Sharjah Medical College. *JOURNAL OF MEDICAL EDUCATION AND CURRICULAR DEVELOPMENT*, 2, 71–79. <https://doi.org/10.4137/JMECDECD.S29926>
- Nouns, Z., Schaubert, S., Witt, C., Kingreen, H., & Schuettelpelz-Brauns, K. (2012). Development of knowledge in basic sciences: a comparison of two medical curricula. *MEDICAL EDUCATION*, 46(12), 1206–1214. <https://doi.org/10.1111/medu.12047>
- Pham MT, Rajic A, Greig JD, Sargeant JM, Papadopoulos A & McEwen SA (2014). A scoping review of scoping reviews: Advancing the approach and enhancing the consistency. *Research Synthesis Methods*, 5(4), 371–385. doi:10.1002/jrsm.1123.
- Purdy, R. A., Benstead, T. J., Holmes, D. B., & Kaufman, D. M. (1999). Using problem-based learning in neurosciences education for medical students. *CANADIAN JOURNAL OF NEUROLOGICAL SCIENCES*, 26(3), 211–216. <https://doi.org/10.1017/S0317167100000287>
- Richards, B. F., Ober, K. P., CariagoLo, L., Camp, M. G., Philp, J., McFarlane, M., Rupp, R., & Zaccaro, D. J. (1996). Ratings of students' performances in a third-year internal medicine clerkship: A comparison between problem-based and lecture-based curricula. *ACADEMIC MEDICINE*, 71(2), 187–189. <https://doi.org/10.1097/00001888-199602000-00028>
- Salinas Sánchez, A. S., Hernández Millán, I., Virseda Rodríguez, J. A., Segura Martín, M., Lorenzo Romero, J. G., Giménez Bachs, J. M., Donate Moreno, M. J., Ruiz Mondéjar, R., Cañamares Pabolaza, L., Polo Ruiz, L., Pastor Guzmán, J. M., Martínez Córcoles, B., & Martínez Martín, M. (2005). [Problem-based learning in urology training. The Faculty of Medicine of the Universidad de Castilla-La Mancha model]. *Actas urológicas españolas*, 29(1), 8–15. [https://doi.org/10.1016/s0210-4806\(05\)73193-4](https://doi.org/10.1016/s0210-4806(05)73193-4)
- Saloojee, S., & van Wyk, J. (2012). The impact of a problem-based learning curriculum on the psychiatric knowledge and skills of final-year students at the Nelson R Mandela School of Medicine. *SOUTH AFRICAN JOURNAL OF PSYCHIATRY*, 18(3), 116.
- SCHWARTZ, R. W., DONNELLY, M. B., NASH, P. P., & YOUNG, B. (1992). DEVELOPING STUDENTS COGNITIVE SKILLS IN A PROBLEM-BASED SURGERY CLERKSHIP. *ACADEMIC MEDICINE*, 67(10), 694–696. <https://doi.org/10.1097/00001888-199210000-00016>
- Seneviratne, R. D., Samarasekera, D. D., Karunathilake, I. M., & Ponnampuruma, G. G. (2001). Students' perception of problem-based learning in the medical curriculum of the Faculty of Medicine, University of Colombo. *ANNALS ACADEMY OF MEDICINE SINGAPORE*, 30(4), 379–381.
- Shanley P. F. (2007). Viewpoint: leaving the "empty glass" of problem-based learning behind: new assumptions and a revised model for case study in preclinical medical education. *Academic medicine: journal of the Association of American Medical Colleges*, 82(5), 479–485. <https://doi.org/10.1097/ACM.0b013e31803eac4c>
- SOKAS, R. K., DISERENS, D., & JOHNSTON, M. A. (1990). INTEGRATING OCCUPATIONAL-HEALTH INTO THE INTERNAL MEDICINE CLERKSHIP USING PROBLEM-BASED LEARNING. *CLINICAL RESEARCH*, 38(2), A735.
- Steadman, R. H., Coates, W. C., Huang, Y. M., Matevosian, R., Larmon, B. R., McCullough, L., & Ariel, D. (2006). Simulation-based training is superior to problem-based learning for the acquisition of critical assessment and management skills. *CRITICAL CARE MEDICINE*, 34(1), 151–157. <https://doi.org/10.1097/01.CCM.0000190619.42013.94>
- Subramaniam, R. M., Scally, P., & Gibson, R. (2004). Problem-based learning and medical student radiology teaching. *Australasian Radiology*, 48(3), 335–338. <https://doi.org/10.1111/j.0004-8461.2004.01317.x>
- Sulaiman, N., & Hamdy, H. (2013). Problem-based learning: where are we now? Guide supplement 36.3–Practical Application. *Medical Teacher*, 35(2), 160–162. <https://doi.org/10.3109/0142159X.2012.737965>
- Suleman, W., Iqbal, R., Alsultan, A., & Baig, S. M. (2010). Perception of 4(th) year Medical students about Problem Based Learning. *PAKISTAN JOURNAL OF MEDICAL SCIENCES*, 26(4), 871–874.

- Tamblyn, R., Abrahamowicz, M., Dauphinee, D., Girard, N., Bartlett, G., Grand'Maison, P., & Brailovsky, C. (2005). Effect of a community oriented problem based learning curriculum on quality of primary care delivered by graduates: historical cohort comparison study. *BMJ (Clinical Research Ed.)*, 331(7523), 1002. <https://doi.org/10.1136/bmj.38636.582546.7C>
- Thompson, K. L., Gendreau, J. L., Strickling, J. E., & Young, H. E. (2019). Cadaveric Dissection in Relation to Problem-Based Learning Case Sequencing: A Report of Medical Student Musculoskeletal Examination Performances and Self-Confidence. *ANATOMICAL SCIENCES EDUCATION*, 12(6), 619–626. <https://doi.org/10.1002/ase.1891>
- Tian, J.-H., Yang, K.-H., & Liu, A.-P. (2012). Problem-based learning in evidence-based medicine courses at Lanzhou University. In *Medical teacher* (Vol. 34, Issue 4, p. 341). <https://doi.org/10.3109/0142159X.2011.531169>
- Tousignant, M., & DesMarchais, J. E. (2002). Accuracy of student self-assessment ability compared to their own performance in a problem-based learning medical program: A correlation study. *ADVANCES IN HEALTH SCIENCES EDUCATION*, 7(1), 19–27. <https://doi.org/10.1023/A:1014516206120>
- Trevena, L. J., & Clarke, R. M. (2002). Self-directed learning in population health. a clinically relevant approach for medical students. *American Journal of Preventive Medicine*, 22(1), 59–65. [https://doi.org/10.1016/s0749-3797\(01\)00395-6](https://doi.org/10.1016/s0749-3797(01)00395-6)
- Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. (2018). PRISMA extensión for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine*. <https://doi.org/10.7326/M18-0850>.
- Tsou, K.-I., Cho, S.-L., Lin, C.-S., Sy, L. B., Yang, L.-K., Chou, T.-Y., & Chiang, H.-S. (2009). SHORT-TERM OUTCOMES OF A NEAR-FULL PBL CURRICULUM IN A NEW TAIWAN MEDICAL SCHOOL. *KAOHSIUNG JOURNAL OF MEDICAL SCIENCES*, 25(5), 282–292. [https://doi.org/10.1016/S1607-551X\(09\)70075-0](https://doi.org/10.1016/S1607-551X(09)70075-0)
- Tshitenge, S. T., Ndhlovu, C. E., & Ogundipe, R. (2017). Evaluation of problem-based learning curriculum implementation in a clerkship rotation of a newly established African medical training institution: lessons from the University of Botswana. *The Pan African medical journal*, 27, 13. <https://doi.org/10.11604/pamj.2017.27.13.10623>
- Tufts, M. A., & Higgins-Opitz, S. B. (2009). What makes the learning of physiology in a PBL medical curriculum challenging? Student perceptions. *ADVANCES IN PHYSIOLOGY EDUCATION*, 33(3), 187–195. <https://doi.org/10.1152/advan.90214.2008>
- Urrutia Aguilar, M. E., Hamui-Sutton, A., Castaneda Figueiras, S., van der Goes, T. I., & Guevara-Guzman, R. (2011). Impact of problem-based learning on the cognitive processes of medical students. *GACETA MEDICA DE MEXICO*, 147(5), 385–393.
- USHERWOOD, T., JOESBURY, H., & HANNAY, D. (1991). STUDENT-DIRECTED PROBLEM-BASED LEARNING IN GENERAL-PRACTICE AND PUBLIC-HEALTH MEDICINE. *MEDICAL EDUCATION*, 25(5), 421–429. <https://doi.org/10.1111/j.1365-2923.1991.tb00090.x>
- Vernon, D. T. A., & Hosokawa, M. C. (1996). Faculty attitudes and opinions about problem-based learning. *ACADEMIC MEDICINE*, 71(11), 1233–1238. <https://doi.org/10.1097/00001888-199611000-00020>
- Villamor, M. C. A. (2001). Problem-based learning (PBL) as an approach in the teaching of biochemistry of the endocrine system at the Angeles University College of Medicine. *ANNALS ACADEMY OF MEDICINE SINGAPORE*, 30(4), 382–386.
- Vincelette, J., Lalande, R., Delorme, P., Goudreau, J., Lalonde, V., & Jean, P. (1997). A pilot course as a model for implementing a PBL curriculum. *ACADEMIC MEDICINE*, 72(8), 698–701. <https://doi.org/10.1097/00001888-199708000-00015>
- Walters, M. R. (2001). Problem-based learning within endocrine physiology lectures. *Advances in Physiology Education*, 25(1–4), 225–227. <https://doi.org/10.1152/advances.2001.25.4.225>
- Wang, J., Zhang, W., Qin, L., Zhao, J., Zhang, S., Gu, J., & Zhou, C. (2010). Problem-Based Learning in Regional Anatomy Education at Peking University. *ANATOMICAL SCIENCES EDUCATION*, 3(3), 121–126. <https://doi.org/10.1002/ase.151>
- Wenk, M., Waurick, R., Schotes, D., Wenk, M., Gerdes, C., Van Aken, H. K., & Pöpping, D. M. (2009). Simulation-based medical education is no better than problem-based discussions and induces misjudgment in self-assessment. *Advances in Health Sciences Education: Theory and Practice*, 14(2), 159–171. <https://doi.org/10.1007/s10459-008-9098-2>
- Whitfield, C. R., Manger, E. A., Zwicker, J., & Lehman, E. B. (2002). Differences between students in problem-based and lecture-based curricula measured by clerkship performance ratings at the beginning of the third year. *TEACHING AND LEARNING IN MEDICINE*, 14(4), 211–217. https://doi.org/10.1207/S15328015TLM1404_2
- Yadav, R. L., Piryani, R. M., Deo, G. P., Shah, D. K., Yadav, L. K., & Islam, M. N. (2018). Attitude and perception of undergraduate medical students toward the problem-based learning in Chitwan Medical College, Nepal. *ADVANCES IN MEDICAL EDUCATION AND PRACTICE*, 9, 317–322. <https://doi.org/10.2147/AMEPS160814>
- Yanamadala, M., Kaprielian, V. S., O'Connor Grochowski, C., Reed, T., & Heflin, M. T. (2018). A problem-based learning curriculum in geriatrics for medical students. *Gerontology & Geriatrics Education*, 39(2), 122–131. <https://doi.org/10.1080/02701960.2016.1152268>

Yoo, D. M., Cho, A. R., & Kim, S. (2019). Satisfaction with and suitability of the problem-based learning program at the Catholic University of Korea College of Medicine. *JOURNAL OF EDUCATIONAL EVALUATION FOR HEALTH PROFESSIONS*, 16. <https://doi.org/10.3352/jeehp.2019.16.20>

Zhang, S., Xu, J., Wang, H., Zhang, D., Zhang, Q., & Zou, L. (2018). Effects of problem-based learning in Chinese radiology education: A systematic review and meta-analysis. *Medicine*, 97(9), e0069. <https://doi.org/10.1097/MD.00000000000010069>

Zhao, W., He, L., Deng, W., Zhu, J., Su, A., & Zhang, Y. (2020). The effectiveness of the combined problem-based learning (PBL) and case-based learning (CBL) teaching method in the clinical practical teaching of thyroid disease. *BMC MEDICAL EDUCATION*, 20(1). <https://doi.org/10.1186/s12909-020-02306-y>

Tables

Table 1
Characteristics of the 124 publications included in the scoping review

Characteristic of the publication		Number (percentage)
Year of publication	1990–1999	27 (22%)
	2000–2009	46 (37%)
	2010–2021	51 (41%)
Continents and countries ^a	Asia	45 (36.3%)
	China (16), Saudi Arabia (12), Egypt, India, Nepal and United Arab Emirates (2) and other ^b nine countries (1)	
	North America	39 (31.5%)
	United States of America (27) and Canada (12)	
	Europe	22 (17.7%)
	Turkey (5), Germany and United Kingdom (4), Spain (3), France (2) and other ^c four countries (1)	
	Africa	7 (5.6%)
	South Africa (4), Botswana, Ghana and Uganda (1)	
	Oceania	6 (4.8%)
	Australia (5) and New Zealand (1)	
	South America	5 (4.0%)
	México (2), Argentina, Chile and Trinidad & Tobago (1)	
Study population	Students	94 (75.8%)
	Students and tutors	16 (12.9%)
	Tutors	6 (4.8%)
	Not specified	8 (6.5%)
Study design	Survey or questionnaire	45 (36.3%)
	Comparative non-randomized study	32 (25.8%)
	Descriptive experience	21 (16.9%)
	Comparative and randomized study	16 (12.9%)
	Expert opinion, editorial or comment	5 (4.0%)
	Systematic review and meta-analysis	4 (3.2%)
	Narrative review	1 (0.8%)
Comparator	Without comparison	66 (53.2%)
	With traditional or lecture-based learning	56 (45.2%)
	With simulation	2 (1.6%)
Main Outcome ^d	Performance	55 (44.4%)
	Student satisfaction	33 (26.6%)
	Knowledge retention	15 (12.1%)
	Not specified	12 (9.7%)
	Tutor satisfaction	5 (4.0%)
	Other	4 (3.2%)
^a The number of publications of each country appears in parentheses. ^b Including: Bahrain, Iran, South Korea, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan and Vietnam. ^c Including: Belgium, Georgia, Netherlands and Sweden. ^d Forty-five studies included secondary outcomes: including student satisfaction (23), tutor satisfaction (7), knowledge retention (5), social and/or communication skills (5), reasoning (1) and other outcomes (4).		

Table 2
Study subject of the 124 publications included in the scoping review

Study subject	Number of publications
Anatomy (one study including cadaveric dissection)	2
Anesthesia	3
Basic medical sciences	1
Biochemistry	2
Cardiopulmonary resuscitation	1
Clinical laboratory	1
Critical care skills	1
Dermatology	1
Emergency medicine	1
Endocrinology (one study focused on thyroid surgery)	5
Epidemiology	1
Evidence-based medicine	2
Family medicine	2
Forensic medicine	1
Geriatrics	1
Hematology	2
Internal Medicine	2
Medical informatics	1
Medical statistics	1
Neurosciences	1
Obstetrics and gynecology	2
Occupational health	1
Ophthalmology	2
Otolaryngology	1
Patient safety education program	1
Pediatrics	4
Pharmacology	1
Physiology	2
Preventive medicine	2
Psychiatry	2
Public health	5
Radiology	4
Renal system	1
Respiratory	1
Surgery	4
Urology	1
More than one discipline	5
The global curriculum	10
Not specified	43

Table 3
Study design according to main and secondary outcomes and continents

		Comparative non-randomized	Comparative AND randomized	Survey or questionnaire	Descriptive experience	Expert opinion, editorial or comment	Systematic review and meta-analysis	Narrative review
Number of studies		32	16	45	21	5	4	1
Sample size*		162 [20-1707]	121 [31-1649]	124 [14-569]	73 [16-561]	-	1652 [1003-2061]	-
Main outcomes	Performance	21	14	10	6	1	3	-
	Knowledge retention	5	2	4	3	-	1	-
	Student satisfaction	6	-	24	3	-	-	-
	Tutor satisfaction	-	-	3	1	1	-	-
	Not specified	-	-	1	7	3	-	1
	Other	-	-	3	1	-	-	-
Secondary outcomes	Knowledge retention	3	-	1	1	-	-	-
	Student satisfaction	6	7	5	4	-	1	-
	Tutor satisfaction	1	-	4	2	-	-	-
	Social and/or communication skills	1	-	3	1	-	-	-
	Reasoning	-	-	-	1	-	-	-
	Other	2	1	-	-	-	1	-
Continent	Asia	6	8	22	5	-	4	-
	North America	16	2	10	9	1	-	1
	Europe	4	5	7	3	3	-	-
	Africa	2	-	3	2	-	-	-
	Oceania	1	1	2	1	1	-	-
	South America	3	-	1	1	-	-	-
*Sample size was available in 99 studies. Results are expressed in median and [range]								

Table 4
Detailed characteristics and main results of the 124 included studies

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
1990	Sokas	United States of America	America (north)	69	Students	Comparative non-randomized study	Traditional or lecture	Occupational health	Performance	Stude satisf
1991	Blosser	United States of America	America (north)	-	Students	Descriptive experience	None	Surgery	Student satisfaction	-
1991	Usherwood	United Kingdom	Europe	53	Students	Survey or questionnaire	None	General practice and public health medicine	Student satisfaction	-
1992	Schwartz	United States of America	America (north)	57	Students	Comparative non-randomized study	Traditional or lecture	Surgery	Knowledge retention	Other
1993	Mennin	United States of America	America (north)	1649	Students	Comparative and randomized study	Traditional or lecture	The global curriculum	Performance	-
1993	Des Marchais	Canada	America (north)	-	Not specified	Descriptive experience	None	The global curriculum	Not specified	-

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
1995	Chang	Canada	America (north)	-	Students	Narrative review	Traditional or lecture	Surgery	Not specified	-
1995	Berntein	Canada	America (north)	265	Students and tutors	Comparative non-randomized study	Traditional or lecture	Not specified	Student satisfaction	Tutor satisf
1996	Kaufman	Canada	America (north)	168	Students	Comparative non-randomized study	Traditional or lecture	The global curriculum	Student satisfaction	-
1996	Richards	United States of America	America (north)	452	Students	Comparative non-randomized study	Traditional or lecture	Internal Medicine	Performance	-
1996	Kalaian	United States of America	America (north)	172	Students	Survey or questionnaire	None	Infectious Diseases and Cardiovascular	Student satisfaction	-
1996	Gresham	United States of America	America (north)	64	Students	Descriptive experience	None	Not specified	Performance	Stude satisf
1996	Griffith	United States of America	America (north)	53	Tutors	Survey or questionnaire	None	Internal Medicine	Tutor satisfaction	-

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
1996	De Lowerntal	South Africa	Africa	-	Students and tutors	Descriptive experience	None	Not specified	Tutor satisfaction	Stude satisf
1996	Vernon	United States of America	America (north)	494	Tutors	Survey or questionnaire	None	Not specified	Performance	Know retent
1997	Vincelette	Canada	America (north)	-	Students and tutors	Descriptive experience	None	The global curriculum	Student satisfaction	Tutor satisf
1998	Kaufman	Canada	America (north)	243	Students	Comparative non-randomized study	Traditional or lecture	The global curriculum	Performance	-
1998	Hill	Australia	Oceania	139	Students	Comparative non-randomized study	Traditional or lecture	Not specified	Performance	-
1998	Blake	United States of America	America (north)	41	Tutors	Survey or questionnaire	None	Not specified	Performance	-

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
1998	Hmelo	United States of America	America (north)	76	Students	Comparative non-randomized study	Traditional or lecture	Not specified	Knowledge retention	
1999	Kaufman	Canada	America (north)	243	Students	Comparative non-randomized study	Traditional or lecture	The global curriculum	Performance	Stude satisf
1999	Antepohl	Germany	Europe	123	Students	Comparative and randomized study	Traditional or lecture	Pharmacology	Performance	Stude satisf
1999	Finch	Canada	America (north)	47	Students	Comparative non-randomized study	Traditional or lecture	Pediatric	Performance	Know retent
1999	McGrew	United States of America	America (north)	-	Students and tutors	Survey or questionnaire	None	Family Medicine	Not specified	-
1999	Casassus	France	Europe	68	Students	Comparative non-randomized study	Traditional or lecture	Hematology	Performance	Stude satisf
1999	Purdy	Canada	America (north)	-	Students	Descriptive experience	None	Neurosciences	Performance	Stude satisf
1999	Farrell	United States of America	America (north)	75	Students	Survey or questionnaire	None	Ophthalmology	Performance	Stude satisf

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2000	Kelly	Australia	Oceania	-	Students	Descriptive experience	None	Emergency Medicine	Not specified	-
2000	Doig	United States of America	America (north)	-	Not specified	Descriptive experience	None	The global curriculum	Not specified	-
2000	Ghosh	Nepal	Asia	100	Students	Survey or questionnaire	None	Physiology	Student satisfaction	-
2001	Bui-Mansfield	United States of America	America (north)	76	Students and tutors	Descriptive experience	None	Radiology	Not specified	-
2001	Dyke	Australia	Oceania	136	Students	Comparative and randomized study	Traditional or lecture	Epidemiology	Performance	Stude satisf
2001	Brewer	United States of America	America (north)	-	Students	Descriptive experience	Traditional or lecture	Endocrinology	Performance	-
2001	Walters	United States of America	America (north)	-	Students	Survey or questionnaire	None	Endocrinology	Student satisfaction	-
2001	Leung	China	Asia	320	Students	Survey or questionnaire	None	Public Health	Student satisfaction	-
2001	Curtis	United States of America	America (north)	639	Students	Comparative non-randomized study	Traditional or lecture	Pediatric	Knowledge retention	Stude satisf
2001	Seneviratne	Sri Lanka	Asia	188	Students	Survey or questionnaire	None	Not specified	Performance	Comn skills

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2001	Khoo	Singapore	Asia	-	Students and tutors	Survey or questionnaire	None	Not specified	Student satisfaction	Tutor satisf
2001	Villamor	Philippines	Asia	68	Students	Survey or questionnaire	None	Biochemistry of the endocrine system	Student satisfaction	-
2002	Trevena	Australia	Oceania	130	Students	Survey or questionnaire	None	Public Health	Performance	Stude satisf
2002	Alleyne	Trinidad and Tobago	America (south)	129	Students	Comparative non-randomized study	Traditional or lecture	Medicine, Surgery and Obstetrics and Gynecology	Performance	-
2002	Brynildsen	Sweden	Europe	208	Students and tutors	Survey or questionnaire	None	Not specified	Other	-
2002	Astin	United Kingdom	Europe	-	Students	Opinion, editorial, comment	None	Medical Statistics	Performance	-
2002	Whitfield	United States of America	America (north)	617	Students	Comparative non-randomized study	Traditional or lecture	Not specified	Performance	Know retent
2002	Tousignant	Canada	America (north)	70	Students	Survey or questionnaire	None	Not specified	Other	-

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2003	Carrera	Argentina	America (south)	-	Not specified	Descriptive experience	None	Not specified	Not specified	-
2004	Chang	China	Asia	137	Students	Comparative non-randomized study	Traditional or lecture	Anesthesia	Student satisfaction	-
2004	McParland	United Kingdom	Europe	379	Students	Comparative non-randomized study	Traditional or lecture	Psychiatry	Performance	-
2004	Subramaniam	New Zealand	Oceania	-	Tutors	Survey or questionnaire	None	Radiology	Tutor satisfaction	-
2004	McLean	South Africa	Africa	20	Students	Comparative non-randomized study	Traditional or lecture	Not specified	Student satisfaction	-
2005	Casey	United States of America	America (north)	162	Students	Comparative non-randomized study	Traditional or lecture	Obstetrics and gynecology	Performance	Stude satisf
2005	Gurpinar	Turkey	Europe	134	Students	Comparative non-randomized study	Traditional or lecture	Public Health	Knowledge retention	

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2005	Tamblyn	Canada	America (north)	751	Students	Comparative non-randomized study	Traditional or lecture	Preventive Care	Performance	-
2005	Abu-Hijleh	Bahrain	Asia	131	Students	Survey or questionnaire	None	Surgery	Performance	Stude satisf
2005	Kemahli	Turkey	Europe	-	Not specified	Opinion, editorial, comment	None	Hematology	Not specified	-
2005	Salinas Sánchez	Spain	Europe	-	Not specified	Opinion, editorial, comment	None	Urology	Not specified	-
2005	Distlehorst	United States of America	America (north)	648	Students	Comparative non-randomized study	Traditional or lecture	The global curriculum	Performance	Know retent
2005	Grkoviaë	Australia	Oceania	-	Not specified	Opinion, editorial, comment	None	Not specified	Not specified	-
2006	Lucas	Spain	Europe	-	Students	Survey or questionnaire	None	Anesthesia	Student satisfaction	-

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2006	Burgun	France	Europe	177	Students	Survey or questionnaire	None	Medical informatics	Student satisfaction	-
2006	Steadman	United States of America	America (north)	31	Students	Comparative and randomized study	Simulation	Critical care skills	Performance	-
2006	Hoffman	United States of America	America (north)	-	Students	Comparative non-randomized study	Traditional or lecture	The global curriculum	Performance	-
2008	Norman	Canada	America (north)	1166	Students	Comparative non-randomized study	Traditional or lecture	Not specified	Performance	-
2008	Cohen-Schotanus	Netherlands	Europe	344	Students	Comparative and randomized study	Traditional or lecture	Not specified	Performance	Other
2009	Wenk	Germany	Europe	33	Students	Comparative and randomized study	Simulation	Anesthesia	Performance	-
2009	Kong	China	Asia	90	Students	Comparative and randomized study	Traditional or lecture	Ophthalmology	Performance	-

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2009	Collard	Belgium	Europe	104	Students	Descriptive experience	None	Endocrinology	Knowledge retention	Reasc
2009	Johnston	China	Asia	129	Students	Comparative and randomized study	Traditional or lecture	Evidence-based medicine	Performance	-
2009	Macallan	United Kingdom	Europe	-	Students and tutors	Descriptive experience	None	Not specified	Student satisfaction	Tutor satisf
2009	Gurpinar	Turkey	Europe	323	Students and tutors	Survey or questionnaire	None	Not specified	Student satisfaction	Tutor satisf
2009	Tsou	China	Asia	71	Students	Descriptive experience	None	Not specified	Performance	Know retent

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2009	Lin	China	Asia	-	Students and tutors	Descriptive experience	None	Not specified	Not specified	-
2009	Tufts	South Africa	Africa	569	Students	Survey or questionnaire	None	Physiology	Student satisfaction	-
2010	Suleman	Saudi Arabia	Asia	54	Students	Comparative non-randomized study	Traditional or lecture	Not specified	Student satisfaction	Comn skills
2010	Wang	China	Asia	173	Students	Comparative non-randomized study	Traditional or lecture	Anatomy	Performance	Stude satisf
2011	Abou-Elhamd	Egypt	Asia	-	Not specified	Descriptive experience	None	Otolaryngology	Knowledge retention	
2011	Urrutia	Mexico	America (south)	340	Students	Comparative non-randomized study	Traditional or lecture	Not specified	Knowledge retention	Other

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2012	Nouns	Germany	Europe	240	Students	Comparative and randomized study	Traditional or lecture	Basic medical sciences	Knowledge retention	
2012	Tian	China	Asia	107	Students	Comparative and randomized study	Traditional or lecture	Evidence-based medicine	Performance	Stude satisf
2012	Elzubeir	Saudi Arabia	Asia	20	Students and tutors	Survey or questionnaire	None	Renal system	Student satisfaction	-
2012	Saloojee	South Africa	Africa	1707	Students	Comparative non-randomized study	Traditional or lecture	Psychiatry	Performance	-
2012	Hoover	United States of America	America (north)	16	Students	Descriptive experience	None	Public Health	Performance	-
2013	Li	China	Asia	120	Students	Comparative and randomized study	Traditional or lecture	Dermatology	Performance	Stude satisf
2013	Sulaiman	United Arab Emirates	Asia	217	Students and tutors	Survey or questionnaire	None	Family Medicine	Student satisfaction	-

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2013	Albarrak	Saudi Arabia	Asia	200	Students	Survey or questionnaire	Traditional or lecture	Not specified	Student satisfaction	-
2014	Ding	China	Asia	2061	Students	Systematic review and meta-analysis	Traditional or lecture	Preventive Medicine	Performance	Other
2014	Navarro	Chile	America (south)	14	Tutors	Survey or questionnaire	None	Not specified	Tutor satisfaction	-
2014	Meo	Saudi Arabia	Asia	60	Students	Survey or questionnaire	Traditional or lecture	Respiratory	Knowledge retention	Stude satisf
2014	Khoshnevisasl	Iran	Asia	40	Students	Comparative and randomized study	Traditional or lecture	Pediatric	Performance	Stude satisf
2015	Grisham	Vietnam	Asia	61	Students and tutors	Survey or questionnaire	None	Public Health	Student satisfaction	-

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2015	Aboonq	Saudi Arabia	Asia	110	Tutors	Survey or questionnaire	None	Not specified	Other	-
2015	Al-Drees	Saudi Arabia	Asia	510	Students	Survey or questionnaire	None	Not specified	Knowledge retention	
2015	Al-Shaikh	Saudi Arabia	Asia	52	Students	Survey or questionnaire	None	Not specified	Knowledge retention	Socia comm skills
2015	Khan	Saudi Arabia	Asia	92	Students and tutors	Survey or questionnaire	None	Not specified	Student satisfaction	Tutor satisf
2015	Hande	India	Asia	464	Students	Survey or questionnaire	None	Not specified	Knowledge retention	Socia
2015	Nosair	United Arab Emirates	Asia	250	Students	Survey or questionnaire	None	Not specified	Student satisfaction	-
2015	González	Spain	Europe	204	Students	Survey or questionnaire	Traditional or lecture	Not specified	Performance	Stude satisf

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2015	Amoako-Sakyi	Ghana	Africa	-	Not specified	Descriptive experience	None	The global curriculum	Not specified	-
2016	Yanamadala	United States of America	America (north)	202	Students	Survey or questionnaire	None	Geriatric	Performance	-
2016	Demirören	Turkey	Europe	561	Students	Descriptive experience	None	Not specified	Other	-
2016	Chang	United States of America	America (north)	-	Students and tutors	Opinion, editorial, comment	None	Not specified	Tutor satisfaction	-
2017	Balendran	India	Asia	26	Students	Comparative non-randomized study	Traditional or lecture	Forensic Medicine	Performance	-
2017	Chang	Taiwan	Asia	94	Students	Survey or questionnaire	Traditional or lecture	Obstetrics and gynecology	Performance	-
2017	Tshitenge	Botswana	Africa	81	Students	Survey or questionnaire	None	Family Medicine, Internal Medicine, Pediatrics and Surgery	Student satisfaction	-
2017	Alduraywish	Saudi Arabia	Asia	170	Students	Survey or questionnaire	None	Not specified	Student satisfaction	-
2017	Eltony	Egypt	Asia	71	Students	Descriptive experience	None	Patient safety education program	Knowledge retention	Stude satisf

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2018	Zhang	China	Asia	1487	Students	Systematic review and meta-analysis	Traditional or lecture	Radiology	Performance	-
2018	Hincapié	Mexico	America (south)	100	Students	Comparative non-randomized study	Traditional or lecture	Biochemistry	Performance	-
2018	Mughal	Pakistan	Asia	210	Students	Descriptive experience	None	Not specified	Performance	Socia
2018	Yadav	Nepal	Asia	113	Students	Survey or questionnaire	None	Not specified	Student satisfaction	-
2019	Ma	China	Asia	1003	Students	Systematic review and meta-analysis	Traditional or lecture	Pediatric	Performance	-
2019	Berger	Germany	Europe	112	Students	Comparative and randomized study	Traditional or lecture	Cardiopulmonary resuscitation	Performance	-
2019	Alquliti	Saudi Arabia	Asia	101	Students	Comparative non-randomized study	Traditional or lecture	Not specified	Performance	-
2019	Yoo	Korea, South	Asia	118	Students and tutors	Survey or questionnaire	None	Not specified	Student satisfaction	Tutor satisf

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2019	Asad	Saudi Arabia	Asia	120	Students	Comparative non-randomized study	Traditional or lecture	Not specified	Student satisfaction	-
2019	Hu	China	Asia	74	Students	Comparative and randomized study	Traditional or lecture	Endocrinology	Knowledge retention	Stude satisf
2019	Thompson	Georgia	Europe	213	Students	Comparative non-randomized study	Traditional or lecture	Anatomy (Cadaveric Dissection)	Performance	-
2019	Aldayel	Saudi Arabia	Asia	259	Students	Survey or questionnaire	None	Not specified	Student satisfaction	-
2020	Mpalanyi	Uganda	Africa	18	Students	Survey or questionnaire	None	Radiology	Student satisfaction	-
2020	Li	China	Asia	122	Students	Comparative and randomized study	Traditional or lecture	Clinical laboratory	Performance	Stude satisf
2020	Zhao	China	Asia	354	Students	Comparative and randomized study	Traditional or lecture	Thyroid surgery	Performance	-

Year	Author	Country	Continent	Sample size	Study population	Design /Methodology	Comparator	Study subject	Outcome	Outco
2020	Liu	China	Asia	1817	Students	Systematic review and meta-analysis	Traditional or lecture	Variable	Knowledge retention	Stude satisf
2020	Margolius	United States of America	America (north)	68	Students	Survey or questionnaire	None	Not specified	Performance	-
2020	Korkmaz	Turkey	Europe	354	Students	Survey or questionnaire	None	Not specified	Student satisfaction	-

Figures

Figure 1

Study flow PRISMA diagram. Details the review process through the different stages of the review; includes the number of records identified, included and excluded

Figure 2

Number of articles by year of publication