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 retention (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; Gurpinar 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. 2011; Tian et al. 2012; Hoover et al. 2012; Li et al. 2013; Ding et al. 2014; Meo 2014; Khoshevisasal 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; Vornon, & Hosokawa 1996; Kaufman & Mann 1998; Kaufman & Mann 1999; Antepohl & Herzig 1999; Dyke et al. 2001; Brewer 2001; Seneviratne et al. 2001; Alleyn 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 (Vornon & 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; Kalai & Mullan 1996; Gresham & Philip 1996; Vincelette 1997; Kaufman & Mann 1999; Antepohl & Herzig 1999; Casassus et al. 1999; Purdy et al. 1999; Farrell et al. 1999; Ghosh & Dawko 2000; Dyke et al. 2001; Walters 2001; Leung et al 2001; Kho 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; Albarrak et al. 2013; Li et al. 2013; Meo 2014; Khosrhevisal et al. 2014; Nosair et al. 2015; Gonçalves et al. 2015; Tshtitenge et al. 2017; Eltony et al. 2017; Yadav et al. 2018; Asad et al. 2019; Al-Malani et al. 2020; Korkmaz & Ozcelik 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-Swailem 2015; Aldaryawish et al. 2017; Yoo et al. 2019; Aldayel et al. 2019; Hu et al. 2019) or negative (DeLowtertal 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; Kho 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; Subramanian et al. 2014; Khan & Al-Swailem 2015; Chang 2016; Yoo et al 2019) and even unfavorable to the PBL methodology in two publications (Griffith et al. 1996; DeLowtertal 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; Balandran & John 2017; Mughal & Shaikh 2018; Yadav et al. 2018; Villamor 2001; Demioren 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 stat 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.

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**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**      |                    |
| Asia                              | 45 (36.3%)         |
| - China (16), Saudi Arabia (12), Egypt, India, Nepal and United Arab Emirates (2) and other (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 (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**                  |                    |
| 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%)           |

*The number of publications of each country appears in parentheses. *Including: Bahrain, Iran, South Korea, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan and Vietnam. *Including: Belgium, Georgia, Netherlands and Sweden. *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).
| 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                     |
|                     | 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                        | 121                        | 124                     | 73                     | -                                   | 1652                                               | -                |
|                     | [20-1707]                  | [31-1649]                  | [14–569]                | [16–561]               | [1003–2061]                        | -                                   |                  |
| **Main outcomes**   |                            |                            |                         |                        |                                     |                                     |                  |
| Performance         | 21                         | 14                         | 10                      | 6                      | 1                                   | 3                                   | -                |
| Knowledge retention | 5                          | 2                          | 4                       | 3                      | -                                   | 1                                   | -                |
| Student satisfaction|                            |                            | 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                                   | -                |
| Tutor satisfaction  | 1                          |                            | 1                       | 4                      | 2                                   | -                                   | -                |
| Social and/or       |                            |                            | 1                       | 3                      | 1                                   | -                                   | -                |
| communication skills|                            |                            |                         |                        |                                     |                                     |                  |
| Reasoning           |                            |                            |                         |                        |                                     |                                     |                  |
| Other               |                            |                            |                         |                        |                                     |                                     |                  |
| **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                                   | -                                   | -                |
| South America       | 3                          |                            | 1                       | 1                      | -                                   | -                                   | -                |

*Sample size was available in 99 studies. Results are expressed in median and [range]*
| 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                      | Study subject | Outcome |
|------|--------|------------------|-------------------|-------------|------------------|---------------------|------------|---------------|-------------------------------|---------------|---------|
| 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 satisfaction |
| 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 | Student satisfaction |
| 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     | Outcome     |
|------|------------|------------------|------------|-------------|------------------|--------------------|------------|---------------|-------------|-------------|
| 1996 | De Lowental| South Africa     | Africa     | -           | Students and tutors | Descriptive experience | None       | Not specified | Tutor satisfaction | Students satisfaction |
| 1996 | Vernon     | United States of America | America (north) | 494 | Tutors | Survey or questionnaire | None       | Not specified | Performance | Knowledge |
| 1997 | Vincelette | Canada           | America (north) | - | Students and tutors | Descriptive experience | None       | The global curriculum | Student satisfaction | Tutor satisfaction |
| 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       | Outcome       |
|------|--------|---------------|-----------------|-------------|------------------|--------------------|------------|---------------|---------------|---------------|
| 1998 | Hmelo  | United States | America (north) | 76          | Students         | Comparative non-randomized study | Traditional or lecture | None          | Knowledge retention |               |
| 1999 | Kaufman| Canada        | America (north) | 243         | Students         | Comparative non-randomized study | Traditional or lecture | The global curriculum | Performance | Stude satisfi. |
| 1999 | Antepohl| Germany       | Europe          | 123         | Students         | Comparative and randomized study | Traditional or lecture | Pharmacology | Performance | Stude satisfi. |
| 1999 | Finch  | Canada        | America (north) | 47          | Students         | Comparative non-randomized study | Traditional or lecture | Pediatric | Performance | Know retent   |
| 1999 | McGrew | United States | 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 satisfi. |
| 1999 | Purdy  | Canada        | America (north) | -           | Students         | Descriptive experience | None          | Neurosciences | Performance | Stude satisfi. |
| 1999 | Farrell| United States | America (north) | 75          | Students         | Survey or questionnaire | None          | Ophthalmology | Performance | Stude satisfi. |
| Year | Author       | Country         | Continent | Sample Size | Study Population | Design/Methodology                                      | Comparator | Study Subject       | Outcome                              | Outcome          |
|------|--------------|-----------------|-----------|-------------|------------------|---------------------------------------------------------|------------|---------------------|--------------------------------------|------------------|
| 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 satisfaction           | Student 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              | Comm skills       |
| Year | Author   | Country            | Continent       | Sample size | Study population         | Design /Methodology | Comparator | Study subject                                                                 | Outcome | Outcome |
|------|----------|--------------------|-----------------|-------------|--------------------------|---------------------|------------|--------------------------------------------------------------------------------|---------|---------|
| 2001 | Khoo     | Singapore         | Asia            | -           | Students and tutors       | Survey or questionnaire | None       | Not specified                                                                  | Student satisfaction | Tutor satisfaction |
| 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 | Student satisfaction |
| 2002 | Alleyne  | Trinidad and Tobago| America (south) | 129         | Students                 | Comparative non-randomized study | Traditional or lecture | Medicine, Surgery and Obstetrics and Gynecology | Performance | -       |
| 2002 | Brynhildsen | 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 | Knowledge |
| 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         | Outcome Notes |
|------|------------|------------------|-----------------|-------------|------------------|--------------------|------------|---------------|----------------|----------------|
| 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 |               |
| 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       | Outcome   |
|------|-----------------|----------------|-----------------|-------------|------------------|---------------------------------------------|---------------------|---------------|---------------|-----------|
| 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 sati: |
| 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  | America (north) | 648         | Students         | Comparative non-randomized study            | Traditional or lecture | The global curriculum | Performance | Know retent |
| 2005 | Grkoviæ         | 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                  |
|------|-----------------|-----------------|--------------|-------------|------------------|---------------------|-----------------|----------------|--------------------------|
| 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 | Outcome |
|------|--------|-----------|-----------|-------------|------------------|--------------------|------------|--------------|---------|---------|
| 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 satisfaction |
| 2009 | Gurpinar| Turkey    | Europe    | 323         | Students and tutors | Survey or questionnaire | None       | Not specified | Student satisfaction | Tutor satisfaction |
| 2009 | Tsou   | China     | Asia      | 71          | Students         | Descriptive experience | None       | Not specified | Performance | Knowledge retention |
| Year | Author     | Country          | Continent | Sample size | Study population     | Design /Methodology | Comparator | Study subject     | Outcome                      |
|------|------------|------------------|-----------|-------------|----------------------|---------------------|------------|-------------------|------------------------------|
| 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 | Communication skills         | -                            |
| 2010 | Wang       | China            | Asia      | 173         | Students             | Comparative non-randomized study | Traditional or lecture | Anatomy          | Performance                  | Student satisfaction         | -                            |
| 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                  |
|------|--------|---------------|-----------|-------------|-------------------|----------------------|------------|------------------------|--------------------------|
| 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              |
| 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              |
| 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                  | Outcom |
|------|--------------|------------|-------------------|-------------|------------------|------------------------------------------|------------------|---------------|--------------------------|--------|
| 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       |
|------|--------------|-------------------|-----------|-------------|------------------|---------------------|------------|---------------|---------------|
| 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, Social skills |
| 2015 | Khan         | Saudi Arabia      | Asia      | 92          | Students and tutors | Survey or questionnaire | None       | Not specified | Student satisfaction, Tutor satisfaction |
| 2015 | Hande        | India             | Asia      | 464         | Students         | Survey or questionnaire | None       | Not specified | Knowledge retention, Social skills |
| 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 |

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| Year | Author          | Country            | Continent | Sample size | Study population | Design /Methodology                  | Comparator | Study subject                          | Outcome            | Outcome          |
|------|-----------------|--------------------|-----------|-------------|------------------|--------------------------------------|------------|----------------------------------------|--------------------|------------------|
| 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 | Student satisfaction | -    |
| Year | Author   | Country   | Continent    | Sample size | Study population | Design /Methodology                  | Comparator | Study subject | Outcome | Outcome | 
|------|----------|-----------|--------------|-------------|------------------|--------------------------------------|------------|--------------|---------|---------|
| 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 | Social  |         |
| 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 satisfaction |         |
| Year | Author  | Country   | Continent | Sample size | Study population | Design /Methodology                      | Comparator       | Study subject                  | Outcome | Outcome |
|------|---------|-----------|-----------|-------------|------------------|-----------------------------------------|------------------|---------------------------------|---------|---------|
| 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 | Student satisfaction |
| 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 | Student satisfaction |
| 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                  | Outcome                      |
|------|------------|-----------------------|-------------------|-------------|------------------|-------------------------------------|------------|----------------------|---------------------------|----------------------------|
| 2020 | Liu        | China                 | Asia              | 1817        | Students         | Systematic review and meta-analysis | Traditional or lecture | Variable             | Knowledge retention       | Study satisfaction          |
| 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](image)

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