

ORIGINAL PAPER  
ΕΡΕΥΝΗΤΙΚΗ ΕΡΓΑΣΙΑ

**The comparison of knowledge score between lecture-based learning and the combination of problem-based (learning) and lecture-based learning among internal medicine students**  
**A meta-analysis of randomized controlled trials**

**OBJECTIVE** To assess the knowledge score between lecture-based learning (LBL) alone and the combination of problem-based learning (PBL) and LBL in internal medicine students. **METHOD** A meta-analysis was conducted by collecting articles in Scopus, PubMed, and Embase. The required information was extracted from each study. The comparison of knowledge score between LBL alone and the combination of PBL and LBL was assessed using the Mantel-Haenszel method. **RESULTS** A total of eight articles consisting of 510 students using PBL and LBL and 489 students using LBL alone was analyzed. Our study found that the highest knowledge score was observed in the combination of PBL and LBL with the mean difference being 7.00 compared to PBL alone. **CONCLUSIONS** Our study identified that the combination of PBL and LBL has better efficacy than LBL alone for the teaching method of internal medicine students.

The curriculum of medical students has developed drastically in the last several decades.<sup>1</sup> In the historical perspective, the first medical students teaching method was based more on the experience than on book learning. In this teaching method, books were used but only as adjuncts. Subsequently, the apprenticeship teaching system was applied in formal school of medicine with regular course.<sup>2</sup> Furthermore, William Osler, with his famous quotes “to study the phenomena of disease without books is to sail an uncharted sea whilst to study books without patients is not to go to sea at all”, introduced bed-side teaching as the method of medical education.<sup>3</sup> Over time, medical education continued to grow rapidly where a rapid increase in medical students had occurred. At this time, lecture-based learning (LBL) method began to be applied where this

learning method was effective for large group learning.<sup>4</sup> However, a study had reported that the efficacy of teaching methods might differ among different departments, for example: the efficacy of teaching methods in internal medicine students might differ to surgery students.<sup>5</sup> In the context of internal medicine students, various teaching methods have been implemented such as LBL, problem-based learning (PBL), and case-based learning (CBL). Of them, PBL was expected to be the best teaching method due to PBL involved students in the active discussion.<sup>6</sup>

PBL was first initiated by Célestin Freinet at 1920s after World War I, and formally, this teaching method had been used and introduced at McMaster University, Canada, in the late 1960s.<sup>7</sup> This teaching method involved an active form of learning or self-directed learning, and in this teaching

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Σύγκριση της βαθμολογίας γνώσης μεταξύ της μάθησης βάσει διαλέξεων και του συνδυασμού μάθησης βάσει προβλημάτων και μάθησης βάσει διαλέξεων μεταξύ φοιτητών Παθολογίας: Μια μετα-ανάλυση τυχαιοποιημένων ελεγχόμενων δοκιμών

Περίληψη στο τέλος του άρθρου

**Key words**

Internal medicine  
Knowledge score  
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method, the shifts in the role of the teacher to the student (student-centered) had occurred. This method focused on active discussion that adhered to clinical conditions, communities, and scientific problems.<sup>7,8</sup> Thereafter, this teaching method was expected to be able to alleviate the knowledge of internal medicine students. However, studies have reported that PBL teaching method had no sufficient efficacy in the improvement of internal medicine the knowledge of internal medicine students.<sup>9,10</sup> Moreover, a study had revealed one of the disadvantages of PBL teaching method is that students do not have adequate knowledge on the fundamental theory for solving the problems.<sup>11</sup> On the other hand, one of the advantages of LBL is that students may have adequate knowledge about theory.<sup>12</sup> Taking into account that what PBL lacks can be adjusted by LBL, a study by assessing the combination of PBL and LBL might be required. Several previous studies have investigated the efficacy of PBL and LBL in internal medicine students. However, the findings across studies were conflicting. Therefore, a meta-analysis study was required to assess the cumulative efficacy of PBL and LBL in internal medicine students.

## MATERIAL AND METHOD

### Design of study

We carried out a meta-analysis study by assessing the efficacy of PBL and LBL teaching methods to the knowledge score of internal medicine students (PROSPERO registration ID: CRD42023399680). To achieve the purpose of our investigation, the calculation of association and effect estimate was performed by collecting the data of interest retrieved from the relevant articles in Scopus, PubMed, and Embase. Our study was conducted by following the protocols outlined in the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA).<sup>13</sup> The details of PRISMA protocols in our study are outlined in the supplementary file 1.<sup>14</sup>

### Eligibility criteria

Articles were accepted to be included in our study if they fulfilled the following inclusion criteria: (a) to assess the knowledge score of PBL and LBL; (b) to feature the subjects on internal medicine students; (c) to provide the data of interest for the calculation of effect estimates, and (d) to be designed as a randomized controlled trial (RCT). Contrary, the exclusion criteria were: review, letter to the editor, commentary, non-RCT, low-quality article, and duplicate article.

### Article search and data curation

Until 5 February 2023, we performed article search strategy by

collecting the relevant articles in Scopus, Embase, and PubMed. The key words applied in search strategy were adapted from medical subject headings: (“problem-based learning” or “PBL”) and (“lecture-based learning” or “LBL”) and (“knowledge score”) and (“internal medicine students”). We only used the English language to search for the articles. If we found double publication, we only included the article with a larger sample size. We also performed a systematic search in the list of references of related articles. Moreover, the potential data were collected by two independent authors (JKF and SS): (a) author name and year of article; (b) the design of study; (c) location; (d) sample size, and (e) the knowledge score.

### Evaluation of article quality

Before being included in our study, the quality of papers was assessed using the Modified Jadad Scale by two independent authors (JKF and SS). Score 0–2 indicated low quality, score 3–4 indicated moderate quality, and score 5–8 indicated that the paper had high quality.<sup>15</sup> Low-quality papers were excluded from our study. Details of the assessment of Modified Jadad Scale in our study are presented in the supplementary file 2.<sup>14</sup>

### Study variables

The main outcome was the knowledge score of internal medicine students. The predictor covariates were PBL and LBL teaching methods.

### Statistical analysis

The analysis of publication bias and heterogeneity among studies were performed before we determined the analysis of association and effect size. The bias of publication was evaluated using an Egger test, and the  $p \leq 0.05$  indicated that the likelihood of publication bias existed. The analysis of heterogeneity among studies was calculated by using a Q test. The  $p \leq 0.10$  and the I-squared  $> 50\%$  indicated that heterogeneity among studies existed, and the data was assessed by using random effects. Alternatively, we used a fixed-effect model. Furthermore, the association between teaching methods either using PBL or LBL and the knowledge score among internal medicine students was carried out using a Z test. The  $p \leq 0.05$  suggested the significant association, and the effect size was presented using mean difference in forest plot. A software of Comprehensive Meta-Analysis (CMA, New Jersey, USA), version 2.1 was adopted to analyze our data.

## RESULTS

### Studies selection

From the database and the reference list of relevant systematic reviews, we collected a total of 13,383 and 165 papers, respectively. Of them, we excluded 13,364 papers because they had irrelevant topics and duplication. Sub-

sequently, we included 184 papers for further review in full-text. Among those, we excluded 176 papers because of review and inadequate data. Finally, eight papers were included to calculate the likelihood of the association between teaching methods either using PBL or LBL and the knowledge score among internal medicine students.<sup>16-23</sup> All articles had high quality following the assessment of Modified Jadad Scale (supplementary file 2).<sup>14</sup> The article collection in our meta-analysis is described in figure 1, and their characteristics are outlined in table 1.

The efficacy of problem-based learning and lecture-based learning on the knowledge score of internal medicine students

We collected eight papers assessing the association between the knowledge score and the combination of PBL and LBL teaching methods in internal medicine students. Our analysis revealed that the combination of PBL and LBL had a higher knowledge score compared to LBL alone with the MD was 7.00 scores ( $p=0.0090$ ).

Potential of heterogeneity and publication bias among articles

Heterogeneity among articles was found ( $p<0.0001$  and I-squared 98.5%), and therefore, the random-effect model was used. For assessing the likelihood of publication bias among studies, Egger's test was used. Publication bias was not detected in our review based on Egger's test ( $p=0.4868$ ).

## DISCUSSION

In our study was found that the combination of PBL and LBL was associated with higher knowledge scores among internal medicine students. Our current study was the first meta-analysis comparing the knowledge score between LBL alone and the combination of PBL and LBL in the population of internal medicine students. However, previous similar studies had been reported in the population of medical students.<sup>24-28</sup> Their findings were consistent with what we reported. They also found that the combination of PBL and LBL had a promising impact to improve the

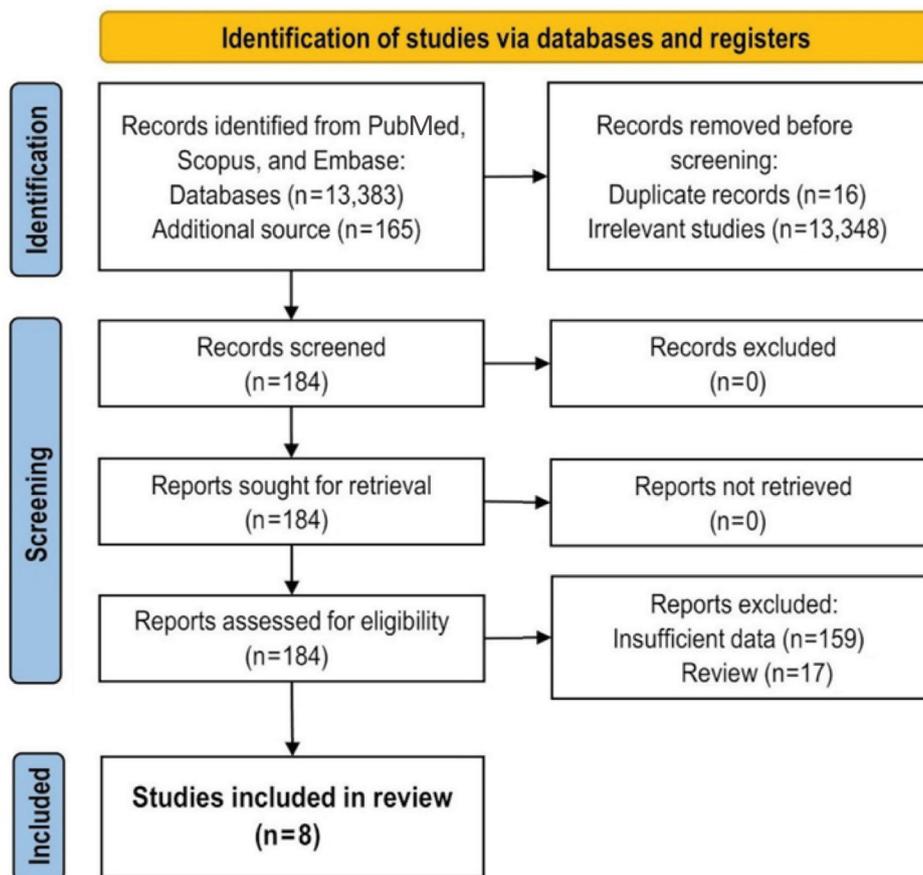


Figure 1. A flowchart of article selection in our study.

**Table 1.** Baseline characteristics of articles included in our study.

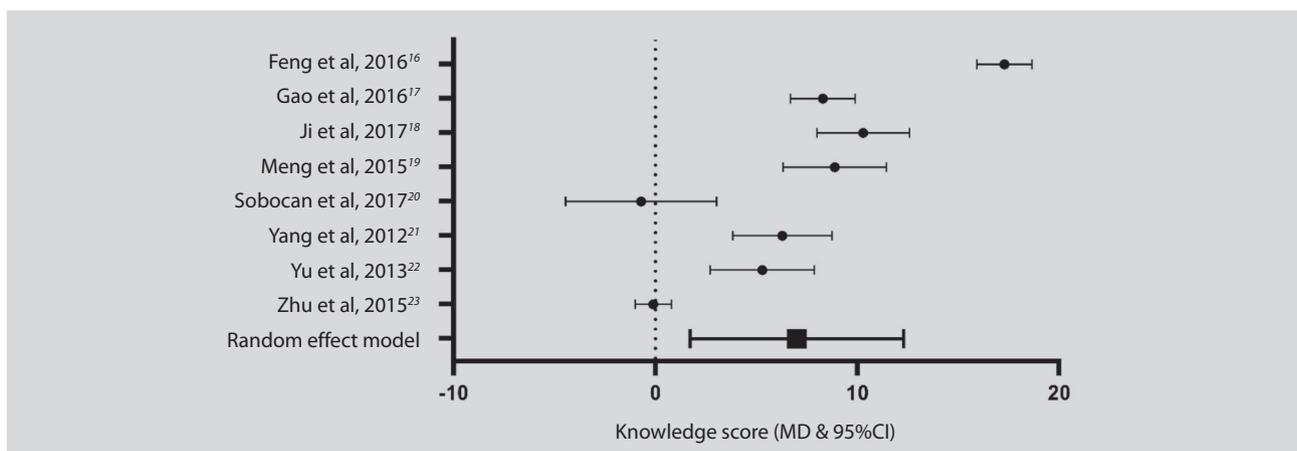
Author and year	Design	Location	Sample size, n		Grade	Outcomes	Main findings	Quality assessment
			PBL + LBL	LBL				
Feng et al, 2016 <sup>16</sup>	RCT	China	38	38	NA	KS, TS	In terms of the knowledge score, PBL and LBL demonstrated superiority over LBL alone	High
Gao et al, 2016 <sup>17</sup>	RCT	China	55	54	Senior	KS	The combination of PBL and LBL provided a better knowledge score compared to LBL alone	High
Ji et al, 2017 <sup>18</sup>	RCT	China	42	42	Junior	KS	PBL and LBL demonstrated a higher knowledge score compared to LBL alone	High
Meng et al, 2015 <sup>19</sup>	RCT	China	14	14	Senior	KS	The knowledge score achieved by combining PBL and LBL exceeded that of LBL alone	High
Sobocan et al, 2017 <sup>20</sup>	RCT	Slovenia	17	17	NA	KS	In terms of efficacy, the combination of PBL and LBL demonstrated comparable results to LBL alone	High
Yang et al, 2012 <sup>21</sup>	RCT	China	256	238	Junior	KS	The combination of PBL and LBL exhibited greater superiority when compared to LBL alone	High
Yu et al, 2013 <sup>22</sup>	RCT	China	30	28	Senior	KS	The impact of PBL and LBL was more prominent compared to LBL alone	High
Zhu et al, 2015 <sup>23</sup>	RCT	China	58	58	NA	KS, SS, CAS	There was no substantial disparity in the knowledge score between LBL and the combination of PBL and LBL	High

RCT: Randomized controlled trial, PBL: Problem-based learning, LBL: Lecture-based learning, NA: Not available, KS: Knowledge score, TS: Teaching satisfaction, SS: Skill score, CAS: Comprehensive ability score

knowledge score, skills score, and capability score (fig. 2). The similar findings were also reported in the population of pediatric,<sup>29</sup> dental,<sup>30</sup> pharmacy,<sup>31</sup> and nursing students.<sup>32</sup>

The underlying reason for the findings of our study showing that the combination of PBL and LBL had superior impact over LBL alone might be difficult to clarify. However, if we explore the advantages and disadvantages of PBL and LBL, it might provide an overview of the results of the present study. The advantages of PBL are the increase of

the development of long-term knowledge retention, the use of diverse instruction, the continuous engagement, the increase of the development of skills, and the improvement of teamwork and interpersonal skills. The disadvantages of PBL concern: potentially poorer performance on tests, student unpreparedness, teacher unpreparedness, time-consuming assessment, and varying degrees of relevance and applicability.<sup>33</sup> On the other hand, the advantages of LBL are as follows: a large amount of the topics can be covered in a single class period, this method (a) may exclude the use



**Figure 2.** A forest plot of the impact of PBL + LBL versus LBL on the knowledge score among internal medicine students (MD: 7.00; 95% CI: 1.72, 12.26;  $p=0.0090$ ;  $p$  Egger: 0.4868;  $p$  heterogeneity:  $<0.0001$ ; I-squared: 98.5%).

of any equipment, (b) can develop listening skills, and (c) may help to the learning of languages. The disadvantages of LBL concern: lectures are often forgotten by the students soon after the class, language using in the lecture is above the standard of the students, and attention level is not the same while students are listening to the lecture.<sup>34</sup> Of those, we might be able to conclude that the limitation of PBL might be improved by LBL. Therefore, when these two methods were combined, it was possible to provide better outcomes. Additionally, students with learning method LBL alone may tend to get bored and do not have the challenge to process their understanding to solve the problems. Meanwhile, students with learning methods PBL and LBL may have their own challenges to apply what they get from learning to solve a problem. Therefore, this circumstance might cause students with learning methods PBL and LBL to have a better understanding compared to LBL alone.

This meta-analysis is the first study assessing the use of PBL and LBL in the population of internal medicine students. The results of our study recommended the use of learning methods PBL and LBL to achieve a better knowledge score for internal medicine students. Our current findings might be used as an initial reference in compiling or improving the educational curriculum for internal medicine students. However, other learning methods may also need to be studied such as CBL, team-based learning (TBL), and flipped

classroom in order to obtain comprehensive information regarding the comparison of each learning method.

Our present study had some important limitations. First, some possible confounding factors which might also affect the final findings were not included. Second, the limited number of studies in our meta-analysis might not have sufficient power to obtain the adequate evidence. Third, in this study, we only assessed the knowledge score. Further studies by assessing other parameters such as skills score, and writing ability might be required. Fourth, in our study, we have heterogeneity in the context of the grade of students, and this factor might also govern the final findings of our study.

In conclusion, our study revealed that the combination of PBL and LBL teaching methods provides a better knowledge score compared to LBL alone among internal medicine students. Our study may serve as an additional reference for revising the curriculum of internal medicine education in the near future. By implementing a combination of PBL and LBL teaching methods, the knowledge acquisition of internal medicine students can be improved. This has the potential to enhance the quality of healthcare provided by these students in the future. It may contribute to better patient outcomes, improved diagnosis and treatment, and overall advancement in the field of internal medicine.

## ΠΕΡΙΛΗΨΗ

**Σύγκριση της βαθμολογίας γνώσης μεταξύ της μάθησης βάσει διαλέξεων και του συνδυασμού μάθησης βάσει προβλημάτων και μάθησης βάσει διαλέξεων μεταξύ φοιτητών Παθολογίας: Μια μετα-ανάλυση τυχαιοποιημένων ελεγχόμενων δοκιμών**

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**ΣΚΟΠΟΣ** Η αξιολόγηση της βαθμολογίας γνώσης μεταξύ της μάθησης βάσει διαλέξεων (LBL) μόνο και του συνδυασμού της μάθησης βάσει προβλημάτων (PBL) και LBL σε φοιτητές Παθολογίας. **ΥΛΙΚΟ-ΜΕΘΟΔΟΣ** Πραγματοποιήθηκε μετα-ανάλυση με τη συλλογή άρθρων από τα Scopus, PubMed και Embase. Από κάθε μελέτη εξήχθησαν οι απαιτούμενες πληροφορίες. Η σύγκριση της βαθμολογίας γνώσης μεταξύ LBL μόνο και του συνδυασμού PBL και LBL αξιολογήθηκε χρησιμοποιώντας τη μέθοδο Mantel-Haenszel. **ΑΠΟΤΕΛΕΣΜΑΤΑ** Αναλύθηκαν συνολικά 8 άρθρα στα οποία είχαν συμμετάσχει 510 μαθητές που χρησιμοποιούσαν PBL και LBL και 489 μαθητές που χρησιμοποιούσαν μόνο LBL. Διαπιστώθηκε ότι η υψηλότερη βαθμολογία γνώσης παρατηρήθηκε στον συνδυασμό PBL και LBL, με τη μέση διαφορά να είναι 7 σε σύγκριση μόνο με το PBL. **ΣΥΜΠΕΡΑΣΜΑΤΑ** Προσδιορίστηκε ότι ο συνδυασμός PBL και LBL έχει καλύτερη αποτελεσματικότητα από το LBL μόνο του για τη μέθοδο διδασκαλίας των φοιτητών Παθολογίας.

**Λέξεις ευρετηρίου:** Βαθμολογία γνώσεων, Μάθηση με βάση τη διάλεξη, Μάθηση με βάση το πρόβλημα, Μέθοδος διδασκαλίας, Παθολογία

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