Evaluating learning among undergraduate medical students in schools with traditional and problem-based curricula

Sultan Ayoub Meo
Department of Physiology, College of Medicine, King Saud University, Riyadh, Saudi Arabia

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IN RECENT DECADES, knowledge in medicine and allied health sciences has changed dramatically; once established educational strategies, scientific philosophies have been replaced by additional sophisticated concepts. Moreover, quite new disciplines have appeared, and parallel changes have occurred in medical practice and healthcare delivery system as well. In the 21st century, the change in educational restructurings reached its height, but the issue that continues to challenge in medical schools is determining the suitable curriculum that encourages high-level skills, critical thinking, and self-directed learning that best prepares physicians for professional practice in a rapidly changing healthcare environment (4). Moreover, due to the universal public, health, and educational challenges, there is an increased demand for problem-solving knowledge and skills to work in complex sociomedical situations. This can be accomplished by making changes in traditional educational strategies (29). Considering these sweeping changes in medicine and allied health sciences, globally, a large number of medical schools have accepted new trends in medical education to respond to such rapid changes in medicine. Bearing in mind these new realities, in the Kingdom of Saudi Arabia, a few medical schools have adopted new tools for teaching and learning [problem-based learning (PBL)] or hybrid PBL (integrated) within their curricula with the goal of enhancing knowledge and professional skills of the students. Although the literature shows the strengths and weakness of both of these approaches in different regional environments (31, 27), PBL is being adopted in some Saudi Arabian medical schools without any available regional evidence in favor of this approach. Keeping in view the global changes in medical education, the aim of the present study was to assess knowledge and skills in a respiratory physiology course in traditional learning versus PBL in an undergraduate medical curriculum in two different medical schools.

METHODS

Study settings. The present cross-sectional study was conducted within the Department of Physiology (respiratory physiology laboratory) of the College of Medicine of King Saud University (Riyadh, Saudi Arabia).

Selection of students. Students were selected based on their voluntary participation, apparently healthy status, same age, sex, nationality, regional and cultural background, and almost similar performance in previous grades. Both PBL and traditional [lecture-based learning (LBL)] medical schools were located in the same region. There was a homogeneous admission criterion to both medical schools, and students were admitted based on regional distributions of the available seats. Within the selection of the students, it was kept in mind that students would have the same enthusiasm and motivation for their studies.

Exclusion criteria. Students who suffered from gross anemia and diabetes mellitus were excluded from the study, as these diseases impair cognitive functions such as attention, understanding, and producing (8, 11). Moreover, students who were outliers (either outstanding or failure in their previous examination) were also excluded to minimize differences of knowledge and skills.

Considering the study inclusion and exclusion criteria, uniform admission process, and regional and cultural traditions, we initially selected 70 students (35 male students from each medical school). After reviewing their previous grades, 10 students (5 students from each medical school) were excluded from the study as their grades were not comparable. Finally, we selected 60 individuals (30 male students from each medical school). Students were fully informed about the research methodology and objectives, and their formal written consent was obtained. Students were also informed that their participation was entirely voluntary and that the results of the present study would not be a part of their degree awarding examination, there were no potential benefits or harms of the study, and their test results would be confidential.

Traditional medical school (control group). From the traditional curriculum-based medical school, 30 male, volunteer, first-year medical students were selected to participate in the study. Students were taught specific contents in respiratory physiology for the period of 2 wk using traditional methods of education (i.e., lectures, tutorials, and
lung function laboratory practical sessions). This group was assigned as a control group.

PBL medical school (study group). From the PBL medical school, 30 male, volunteer, first-year medical students were selected to participate in this study. In the PBL group, the various problems, case scenarios, and lung function laboratory practical sessions were conducted in respiratory physiology by faculty members as per the respiratory physiology block required learning objective and outcomes. In PBL sessions, problems were given to the students, such as “I am still coughing,” and “shortness of breath.” For example, in the “I am still coughing” problem given to students, the learning objectives were based on the normal structure of the different parts of the respiratory tract, especially the bronchial tree, and students had to correlate them with their function. This revealed the anatomy of the muscles involved in normal breathing and those used during respiratory distress, the cough reflex and its physiological significance, and physiological and pathological causes of cough. Chronic obstructive lung disease, its causes, and its pathophysiology were explained. In addition, students were given tasks to perform, interpret, and explain the pulmonary function test, spirogram, and various parameters [including forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1), FEV1-to-FCV ratio, and peak expiratory flow] based on the lung function test. Thus, students learned how to differentiate between obstructive and restrictive lung diseases and drugs used in the treatment of chronic obstructive lung disease.

Students were referred to sources of information with no limitations on their use. In the next session, after the problem was introduced to each student, different aspects of the problem were debated. Students attended PBL sessions for the same period (2 wk) as the LBL group of students. Both groups of students were equally experienced in objective structured practical examination (OSPE) performance.

Faculty involvement. Faculty members were involved to deliver the same content-based lectures and conducted the lung function laboratory sessions for the LBL group of students. Similarly, trained tutors were involved in the tutorial sessions for PBL students, and tutors facilitated the discussion. PBL students used the provided problems to seek, synthesize, and integrate information. Moreover, practical sessions on lung function for PBL students were also conducted in a similar pattern. Faculty members were briefed about the study protocol, and a peer from the Department of Physiology also ensured that the teaching faculty member was well aware about the LBL and PBL system. In addition, a nonaligned faculty member was involved to ensure the best delivery of the program. There were no differences between the suggested reading materials and major course contents in respiratory physiology. The educational environment, including the lecture theater, small-group session rooms, tutorial, laboratory, and library facilities, were similar. Before the start of the program, students were informed about the course contents, teaching faculty members, time, venue, and assessment methods.

Assessment of knowledge. At the completion of the 2-wk period of LBL and PBL sessions, knowledge was assessed based on a single best multiple-choice question (MCQ) examination in respiratory physiology. The MCQ examination consisted of 20 MCQs with 5 subtests and was used to test knowledge in respiratory physiology. Based on the objectives of the respiratory physiology course contents, the MCQ examination was prepared by a neutral faculty member who was not involved in the respiratory physiology teaching and lung function laboratory sessions. The involvement of an impartial faculty member to prepare the MCQ examination and OSPE minimized the chances of favor of one curriculum or another. Considering the six levels of Bloom’s taxonomy, the MCQs were divided into two parts: the first part (50% of MCQs) was based on Bloom’s taxonomy levels 1 and 2 (recalling and comprehension) and the second part (50% of MCQs) was based on levels 3–6 (application, analysis, synthesis, and evaluation).

Assessment of skills. The OSPE was conducted to assess skills on the lung function test. Ten stations were spread out in an examination hall with all the necessary facilities. Each station lasted for 6 min. Students were given exercises to perform in the presence of an examiner. The main objectives assessed were interviewing skills (including history taking relevant to the lung function tests), spirometry, obtaining anthropometric variables, training the patient on how to perform the test adequately, identification of the calibration syringe, how to calibrate the electronic spirometer, explaining to the subject about how to perform the spirometry, ability to perform the appropriate lung function tests, interpretation of findings, interpretation of the spirogram, and capability for diagnosis and differentiation between obstructive and restrictive lung diseases. However, communication skills were assessed at all stations. There was an examiner and an observer at each station to watch the student’s performance and mark the check list as the student progressed through the exam. The examiner and observer did not know whether the students were from the PBL or LBL curricula. The entire evaluative tools are well acknowledged in the literature and were administered in an unbiased manner.

Statistical analysis. For knowledge, the marks obtained by the individual students in the MCQ examination were entered into a computer. Data were recorded and analyzed with SPSS (version 15.0) for Windows. Means ± SD were computed for both LBL and PBL groups. For the assessment of skills, a check list was used to determine the skills of the students. A Student’s t-test was applied for the quantitative data. The level of significance was achieved at P < 0.05.

Ethical approval. The Institutional Review Board of the College of Medicine, King Saud University, approved this study.

**RESULTS**

Table 1 shows the assessment of knowledge and skills based on the marks obtained in the MCQ examination and OSPE in respiratory physiology among undergraduate medical students in the traditional versus PBL curriculum. Total marks for the MCQs were 50; of these, 25 marks were allocated for MCQs that were based on Bloom’s taxonomy levels 1 and 2 and 25 marks were based on Bloom’s taxonomy levels 3–6. Students who belonged to the PBL curriculum obtained higher scores in the MCQ examination based on Bloom’s taxonomy levels 1 and 2 (P = 0.04) and Bloom’s taxonomy levels 3–6 (P = 0.001) compared with those who belonged to the traditional

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lecture-Based Curriculum</th>
<th>Problem-Based Curriculum</th>
<th>P Value</th>
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</thead>
<tbody>
<tr>
<td>MCQ examination</td>
<td></td>
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<tr>
<td>Part 1 (out of 25 marks, Bloom’s taxonomy levels 1 and 2)</td>
<td>21.16 ± 3.33</td>
<td>22.58 ± 3.04</td>
<td>0.04</td>
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<tr>
<td>Part 2 (out of 25 marks, Bloom’s taxonomy levels 3–6)</td>
<td>18.16 ± 3.41</td>
<td>21.83 ± 3.07</td>
<td>0.001</td>
</tr>
<tr>
<td>Total (parts 1 and 2, out of 50 total marks)</td>
<td>39.36 ± 5.69</td>
<td>44.33 ± 5.52</td>
<td>0.001</td>
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<tr>
<td>OSPE (out of 50 marks)</td>
<td>27.63 ± 6.25</td>
<td>41.03 ± 3.16</td>
<td>0.0001</td>
</tr>
<tr>
<td>Total marks in both MCQ examination and OSPE (out of 100 total marks)</td>
<td>67.00 ± 9.16</td>
<td>85.36 ± 6.84</td>
<td>0.0001</td>
</tr>
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Values are means ± SD; n = 30 students/group, MCQ examination, multiple-choice question examination; OSPE, objective structured practical examination.
(LBL) curriculum. Students who belonged to the PBL curriculum obtained overall higher scores in the MCQ examination \( (P = 0.001) \) compared with those who belonged to the traditional curriculum group. Table 1 also shows the assessment of skills based on the marks obtained in the OSPE in the lung function laboratory for respiratory physiology among undergraduate medical students in the traditional versus PBL curriculum. Students who belonged to the PBL group obtained higher scores in the OSPE \( (P = 0.0001) \) compared with those who belonged to the traditional curriculum. Students who belonged to the PBL curriculum obtained higher combined scores in the MCQ examination and OSPE \( (85.36 \pm 6.84, P = 0.0001) \) compared with those who belonged to the traditional \( (67.00 \pm 9.16, P = 0.001) \) curriculum.

**DISCUSSION**

The undergraduate medical education scene requires ongoing improvement to keep cadence with the changing demands of the 21st century, especially in medical practice. The older medical schools are reviewing their curriculum while new schools are developing their programs following current trends in medical education, particularly PBL and integrated curriculum. While medical schools are moving from traditional to PBL curricula, in this situation, it must be kept in mind that before shifting from one curriculum to another, there is a need to conduct a series of studies in their own educational environment to have an idea of the selection of the appropriate tool for teaching and learning. Keeping in view all these facts, we conducted a study to assess knowledge and skills in a respiratory physiology course in the traditional versus PBL undergraduate medical curriculum in two different types of medical schools. In this study, students belonging to the PBL curriculum obtained higher scores in the MCQ examination and OSPE compared with traditional students.

This is one of the few studies that shows a positive effect of PBL on learning in basic medical science. Shahabudin (24) demonstrated that PBL students showed better factual recall than traditionally educated students. Interestingly, Kaufman et al. (15) reported that PBL students scored higher on the National Board of Medical Examiners part 2 clinical science examination. Concurrently, Burford et al. (6) directed a randomized multicenter study in pharmacology using PBL and traditional curricula and demonstrated higher scores on knowledge testing for the former PBL approach. Our data, as well as those of the other authors referenced here, support our hypothesis that medical knowledge is certainly better retained if originally learned using PBL compared with traditional (lecture) methods.

The findings of the present study are in contrast to studies that reported that undergraduate students in a PBL group had lower knowledge acquisition compared with those who received the lecture method (3, 12, 16). The literature shows that PBL produced no statistically significant differences in knowledge acquisition compared with the traditional lecture-based method for graduate nursing students (19). Furthermore, Rideout et al. (22) found that undergraduate students taught by the PBL method had no statistically significant differences in theoretical knowledge in pathophysiology and professional knowledge compared with students taught by the lecture method. The most probable reason for this contradiction is the difference in research methodology, as their study was based on a self-reporting questionnaire. However, in the present study, we assessed knowledge based on single best MCQs. MCQs were based on both lower level as well as higher order of Bloom’s taxonomy, including recalling, comprehension, application, analysis, synthesis, and evaluation.

Albano et al. (2) conducted a study on differences in knowledge acquisition in medical colleges using a variety of instructional strategies, including PBL and LBL; they concluded that the differing strategies seem to have only limited influence on the level of knowledge of the graduates. However, in the present study, we assessed knowledge based on marks obtained in the MCQ examination in respiratory physiology among undergraduate medical students in LBL versus PBL curricula and found that students who belonged to PBL curriculum obtained higher scores in the MCQ examination compared with those who belonged to the LBL curriculum. We believe that the most probable reason for this contradiction is that Albano et al. (2) used the Maastricht progress test. The Maastricht progress test is a written test consisting of true/false item questions, and this test may not be suitable to solve the problem of assessment of knowledge of individual students; however, it may be helpful in identifying corresponding cognitive levels. Moreover, in true/false examinations, students have a relatively high probability of guessing the answer (2).

Login et al. (18) conducted a study to determine academic performance on a standardized oral comprehensive exam in students taught basic science in a PBL curriculum and a LBL curriculum. The oral comprehensive exam was administered to the graduating classes of 1991–1994, 6 mo after the completion of their basic science courses. The class of 1991 was taught by LBL, and the classes of 1993 and 1994 were taught by PBL. The science and medical knowledge component score was significantly better for the PBL class of 1994 than for the LBL class of 1991. Similarly, in the present study, we found that students who belonged to the PBL curriculum obtained higher scores in the MCQ examination compared with students who belonged to the traditional curriculum.

Smits et al. (25) reported that there was no consistent evidence showing that PBL in continuing medical education is superior to other educational strategies in increasing a physician’s knowledge but there was moderate evidence showing that it led to higher satisfaction. Smits et al. (26) also investigated the effectiveness of PBL compared with LBL in a postgraduate medical training program concerning the management of mental health problems for occupational health physicians. They observed that, in both groups, knowledge increased equally directly after the program and decreased equally after the followup. They also suggested that both forms of postgraduate medical training are effective. The gain in knowledge remained positive, and the performance indicator scores also increased in both groups, but they increased significantly more in the PBL group. Although in the present project we did not follow up the study findings, our results favor the PBL group, where the gain in knowledge was significantly more compared with the LBL group of students.

Monica et al. (20) reported that a PBL curriculum resulted in significantly better examination performance than did the traditional teaching curriculum, both for MCQs and the viva examination. Students were significantly more successful in
the examinations if they had experienced the PBL style of curriculum. Rich et al. (21) determined the efficacy of PBL pedagogy in preclinical and clinical teaching. Test scores of undergraduate dental students from conventionally taught classes were compared with scores of dental students from PBL classes. Their scores revealed that PBL students performed significantly better than traditional students on midterm and final examinations.

Gurpinar et al. (13) conducted a cross-sectional study among fifth- and sixth-year medical students in Turkey. They prepared 25 MCQs, and the examination was conducted to compare the knowledge of medical students in PBL and traditional curricula on public health topics. The results showed that PBL group scores were significantly higher than those in the traditional group. Similarly, we found that students who belonged to the PBL curriculum obtained higher scores in the MCQ examination compared with students who belonged to the traditional curriculum.

Hwang and Kim (14) studied the effects of PBL with the traditional method on learning in a cardiorespiratory nursing course. They found that the level of knowledge in the PBL group was significantly higher than that of students in the lecture group. The results of the present study are in agreement with those of Hwang and Kim (14).

Koh et al. (17) observed that PBL during medical school has positive effects on physician competencies, especially in cognitive dimensions. Dehkordi and Heydarnajad (9) conducted a study aimed to compare the effect of education through PBL or LBL on knowledge in nursing students. Students underwent a one-semester course using the two methods of education, and Dehkordi and Heydarnajad (9) found that the level of knowledge in the PBL group was significantly higher than that of students in the lecture group.

Callis et al. (7) conducted a study to determine knowledge and skills in a hybrid PBL curriculum compared with a traditional LBL curriculum. They found that students who belonged to the hybrid PBL group were better at applying basic science knowledge to a clinical case and demonstrated greater skills in the areas of hypothesis generation and communication. Similarly, in the present study, PBL students achieved better scores in the MCQ examination and OSPE compared with those who belong to the LBL curriculum.

Szegedi et al. (28) conducted a study using a cardiopulmonary resuscitation (CPR) examination and collected data on final CPR exam grades both from PBL and traditionally trained students. Students who attended PBL classes had better CPR examination grades and demonstrated better resuscitation skills when their knowledge and skills were assessed compared with their traditionally trained peers. Similarly, in the present study, we found that students who belonged to the PBL group demonstrated better knowledge in respiratory physiology and lung function skills compared with their counterparts.

Abou-Elhamd et al. (1) introduced PBL techniques into the ear-nose-throat (ENT) course taught to fifth-year medical students, and conventional methods were used to teach audiology and ENT radiology. They concluded that the application of PBL to ENT teaching resulted in a substantial increase in students’ knowledge and skills. Similarly, in the present study, we found that students who belonged to the PBL group achieved higher scores when knowledge was tested based on the MCQ examination and skills in the lung function test were tested based on the OSPE.

Schwartz et al. (23) demonstrated that PBL students scored significantly better on the formulation of differential diagnoses and interpretation of clinical data, demonstrated a strong trend to perform better on ordering of appropriate laboratory and diagnostic studies, and scored significantly better on the National Board of Medical Examiners-II subtest. Similarly, in the present study, we found that students who belonged to the PBL group achieved better scores in the OSPE when skills were assessed in performing and interpreting spirometry/lung function test data. Rich et al. (21) reported that a preclinical and clinical program using PBL methodology resulted in student performance of nonsurgical periodontic skills at a level equal to or greater than that of a conventional approach.

In correlation with the results of the present study, Smits et al. (25) reported that there is evidence showing that PBL increases a physician’s skills. Similarly, Dochy et al. (10) suggested a strong positive effect of PBL on skills of students. Moreover, Bader and Syed (5) reported that the PBL system helps in developing student skills, particularly problem-solving and analytic skills. Thomas et al. (30) compared the performance of obstetrics and gynecology residents who were trained using a PBL curriculum during medical school with those who were trained in a traditional curriculum. They found that there was a significant difference between the mean scores of the two study groups for United States Medical Licensing Examination step 2. In the present study, our data, as well as those of the other authors referenced here, support the concept that skill in medical students is certainly better retained if students learn in a PBL style of teaching and learning. We believe that PBL students used the problems to seek, synthesize, reasoning, and integrate the information and also to better understand, process, and retrieve the information. Moreover, the PBL tool of teaching and learning enhances students’ basic knowledge and problem-solving skills, and PBL students also have more chances of group discussion. This pedagogy alters the students’ learning strategies. Therefore, in the present study, students’ knowledge and skills were better in PBL compared with LBL.

**Study limitations.** There are few limitations to the present study. These include the small study sample size and duration, based on a 2-wk course in respiratory physiology and lung function laboratory and the fact that only male students were invited to participate. In Saudi Arabia, we have separate faculties as well as college campuses, where male faculty members teach only male students and female faculty members teach female students only. Therefore, in the present study, we had the limitation of inviting only male students to participate.

**Conclusions and suggestions.** The results of the present study show that students who belonged to a PBL curriculum obtained significantly higher knowledge and skills scores compared with students who belonged to traditional styles of medical school. This study contributes to the understanding of the relationship between different educational approaches and student outcomes. Although we believe that the results of the present study based on only respiratory physiology and a lung function laboratory may provide some evidence in the selection of an appropriate method for teaching and learning, we need multicenter, large-scale, longer time period studies on multiple body systems to obtain more valid and reliable conclusions needed to support decision making about curriculum changes.
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DISCLOSURES
No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS
Author contributions: S.A.M. conception and design of research; S.A.M. performed experiments; S.A.M. analyzed data; S.A.M. interpreted results of experiments; S.A.M. drafted manuscript; S.A.M. edited and revised manuscript; S.A.M. approved final version of manuscript.

REFERENCES