PBL vs. Non-PBL Approach and Assessment in Biomedical and Medical Education: A Recent Update

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Abstract

Both real-life problems and resolution efforts are widely seen as the natural early steps in the learning processes in humans and, therefore, the problem-based learning (PBL) strategy is considered as a more powerful teaching method in Biomedicine. Recent biomedical/medical educational systems incorporate teaching methods, including PBL, which support students' learning by improving their critical thinking, practical skills, knowledge achievement, and continued professional learning. PBL is a self-directed learning and educational approach facilitating the development of learning abilities and skills that are essential for biomedical/medical students, hence there are increasing interest by biomedical and medical schools in developing and adopting PBL approach. The goal of this article is to compare the benefits and limitations of PBL vs. non-PBL approach within biomedical/medical education, describe recent update and improvement of PBL strategy such as hyprid-PBL curriculum and team-based learning method, and review assessment methods for PBL and non-PBL approaches in biomedical/medical education.

Keywords: Biomedicine; PBL; hybrid-PBL; Conventional learning; Team-based learning; Multiple-choice questions; Short-answer questions; Active learning groups; Project-based learning.

Introduction

The influence and importance of instructional guidance on the learning outcome(s) in the biomedical education have long been a *subject of debate*. In the biomedical education, there are mainly teacher-centered (conventional/traditional) non-PBL learning and teaching methods, and student-centered (with minimal guidance) problem-based learning (PBL) methods.

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Problem-based learning (PBL) in Biomedical/ Medical Education

As an active and self-directed strategy of learning, PBL teaching method was first introduced by Barrows and Tamblyn in 1969 and can promote and enhance the abilities of biomedical and medical students at different levels to analyze and integrate both basic science and clinical data and concepts. It can also foster student life-long learning skill development. Many research studies show evidences that the student-centered PBL facilitates the development of learning abilities and skills that are essential for biomedical/medical students and, therefore, is more effective than non-PBL conventional learning strategy for preparing

medical and biomedical practitioners [1,2]. The non-PBL (teacher-centered) conventional/traditional learning includes teacher-centered learning such as lecturers (lecture-based learning; LBL) and short discussions with students.

There are currently 5 key PBL categories, which are self-determination, cooperative learning, problem-solving, information processing, and contextual learning [3]. Both the case quality and preparatory materials are essential for the success of PBL approach, which becomes a popular medical education model worldwide [4]. Each PBL case dependents on five important characteristics, that are the case relevance, feasibility, engagement, instruction and challenge [4-5].

The application and effectiveness of PBL in different medical programs are well-investigated. A comparison of perceptions of medical education between PBL and non-PBL (conventional/ traditional) approaches shows that students with PBL methods have better education and interpersonal skills [6]. However, some early studies comparing students' academic achievements of PBL and conventional medical learners using many measures of knowledge acquisition have concluded that there is no clear advantage of one curriculum over the other [7] or there is a significant trend that favors conventional teaching methods [8].

In both biomedical and medical education, quantitative and qualitative studies aimed to explore the learning satisfaction of PBL vs. non-PBL approaches/learning environment among students show that the PBL students clearly perceive their learning environments to be more positive than their counterpart students in conventional program(s). This uniformly positive view by participating students on the PBL approach is reflected in their comments that PBL is interactive, enjoyable, practical, relevant and holistic. Nevertheless, there are some limitations for the PBL approach such as the interference of the group process issues with student learning, differences between tutors in their expectations of PBL learners, and the need for confirming that essential contents are being learned by the PBL approach [9,10].

Most recently, a study on biomedical students has proposed that an evidence-based approach to PBL case construction is necessary [11]. In this study, they dedicated 6 hr/week for years 1 and 2 biomedical students to a modified format of PBL, which is called active learning groups (ALG) and composed of small student group of 9-10 and 2 faculty facilitators; one basic science and one clinical science. The ALG cases were designed to address concepts from both laboratory and lecture sessions. For the ALG cases, students were instructed to independently prepare materials that are relevant to each case using the available self-identified resources [11]. The results of this study are supportive for developing an evidence-based template for the case review of ALG. This, however, still needs further education of and input from end users, including using metrics for assessing the success of the ALG case such as evaluating student-generated learning objectives and performance on more related exam questions [11].

A recent improvement of PBL in the biomedical education has been achieved by the development of hybrid-PBL method that merges both PBL and non-PBL (teacher-centered) conventional/traditional learning to advance the biomedical science education. Recent data comparing studies that employ hybrid-PBL vs. pure PBL or conventional non-PBL learning methods in the biomedical education show that applying hybrid-PBL can result in better overall students' perception and performance than other methods [12]. However, more research is still needed to further explore the pedagogical benefits and development of hybrid-PBL over other learning methods.

Another recently developed competing method to PBL and hyprid-PBL curricula, called team-based learning (TBL), has been used in medical education as a student-centered learning method with many positive outcomes. Like PBL, TBL can maintain the small group teaching and learning advantages. However, it does not require large numbers of tutors, in contrast to the PBL curriculum. When comparing students' perceptions of using TBL in place of PBL, Burgess and colleagues [13] found that medical students prefer TBL over PBL, as the optimal teaching approach/strategy. Medical students found the TBL session format and structure more encouraging and conducive to engagement, learning and participation than PBL sessions. However, TBL use still requires an instructional approach, including tutors' directions [13].

Assessment Methods for PBL and non-PBL approaches in Biomedical/Medical Education

Several assessment methods are developed and applied in biomedical/medical education to test and measure the student ability to both acquire and apply knowledge they gained. These methods include oral, written, practical, and multi-source observations. Each method is well-designed to measure and evaluate different learning

outcome(s). Notably, there is no current consensus among academic scholars on which is the best assessment method for testing and evaluating deep vs. superficial learning among students [14].

Comparing the knowledge of biomedical/ medical students enrolled in PBL with that of students in a non-PBL approach can be achieved by evaluating the student scores on the final examination that normally consists of multiple choice or short answer questions, or other appropriate examination question formats. In biomedical/medical schools, examinations are common tools for students' assessment and evaluation. Examination questions have many formats or types such as the selected/objective response format (e.g. multiple-choice questions), and free response format (e.g. short-answer questions, long questions, and the essay). Other question types include true/false, matching, computational and oral questions.

In medical schools, the most common assessment format is the written examination format, in which students respond traditionally using pen and paper, or electronically using electronic assessment methods the written format of examinations freely from what they learnt in their own language, which is referred to as the free response format, or they can transcribe from their textbook(s). The later response method is referred to as the objective, fixed or selected, response format (SRF), in which students can choose their response from a provided/suggested list of options [16]. Despite being the most common assessment format, the written examination format has some disadvantages, including being both time consuming and prone to potential marking errors, and lacking fair assessments due to poor or difficult students handwriting. Moreover, the upfront preparation of the appropriate marking scheme is essential for both improving the reliability of this common assessment format and minimizing the marking bias [17].

In the written examination format, students can respond to multiple choice questions (MCQs), which are used in the assessment of students in medical and medical-related courses for over 50 years since they help instructors and educators with testing a wide range of the curriculum topics. MCQs involve SRF and have several advantages, including asking many questions on a wide range of topics that are covered in the course, and the objective grading for MSCQs in general [18]. Other important advantages of MCQs are their feasibility in large class size and the items of the multiple-choice test can, if well prepared, assess various learning outcome levels, from how students can basically recall the information they studied, to how they apply, analyze and evaluate this information when taking the tests [18,19]. In addition, getting feedbacks for MCQs is timely and easier, sometimes immediately, since the computer-based administration and marking can be used for MCQs tests [20]. Moreover, the analysis of items in MCQs can be properly used for assessing which questions can discriminate between slow and good learning students. The analysis of these items can also show the difficulty index of each question of MCQs [18-21]. Some disadvantages were also reported for MCQs such as the preparation of students to MCQs, which is towards the process of surface learning with opting mainly for crude memorization, and the high chance of students' guessing when using SRF/MCQs [21].

A recent study compared the performance of medical students in MCQs (the true or false format) and SAQs (short answer essay questions) in the pre-clinical anatomy exams and uncovered the relationship between the examination final grade of students with the examination formats (SAQs vs. MCQs) and study level [22]. The mood's median test showed that high number of students achieve scores that are greater than median in MCQs scores. Moreover, more students have scores greater than median in SAQs components of the examination, and the final examination scores correlate higher with essay scores compared to its relationship with MCQs score in year 2 [22].

With the widespread application of PBL in many biomedical and medical schools worldwide that reflects a shift from the non-PBL (conventional/ traditional) approaches such as lecture-based curriculum (LBL) to a student-centered program, there is a continuous demand for developing and updating more effective assessment tools and strategies such as MCQs that can reflect the new curriculum philosophy properly. For example, the MCQ educational goals were limited several year ago since they focused on testing factual knowledge rather than a deeper students' use or understanding of information. In addition, many MCQ educational goals focused on testing a small print in textbooks rather than student cognitive skills. The construction and development of new MCQ styles, which can test higher-order thinking skills, have been well-reviewed [4,23].

For creating successful MCQs that test student cognitive skills, question writers should understand the curriculum philosophy and, therefore, write questions that can address specific educational

objectives, test students' understanding, and encourage information integration and application [4,23]. The question writers should also work on factors that affect the questions' validity and pay more attention for both the adjustment of the MCQ question level to the students' needs and preparation of model answers and explanations for each MCQ question [4,23]. In addition, the MCQ question writer should ask his/her colleague(s) to review both the MCQ questions and model answers, give MCQ examples to the students before using these questions in a summative assessment, assess the performance of students on questions, and provide feedback to the students [4,23]. Furthermore, the MCQ question writers should avoid some pitfalls in the design of each MCQ question, including grammatical inconsistencies, imprecise terms or undefined words, double-negative statements in the distractors, clues to the correct answer and grammatical clues, and using abbreviations, eponyms, acronyms, and long items (distractors) with pairs or triplets of reasons [4,23]. The use of these tips will help question writers to write more effective MCQs for both formative and summative assessments in the PBL curriculum.

Finally, it is noteworthy that PBL refers to both the project-based learning and problem-based learning, despite the differences between these two pedagogies that can both promote 21st century biomedical/medical learning. While problem-based learning students learn about a topic by solving a suggested problem(s) that does not often have one correct answer, and generally work in groups to solve this problem(s), project-based learning is a different instructional approach, in which students can learn through the investigation of a complex question, challenge or problem [24]. Project-based learning students can explore real-world problems and define answers to these problems by completing a project, in which they have some control over their work project, including to decide how their project will finish and what is the end product? In addition, problem-based learning students often jointly set the learning goals and share outcomes with their teacher, while the goals of project-based learning are already set and quite structured in the way(s) that the teaching will occur. Moreover, project-based learning is often multidisciplinary, follows general steps and is longer, while problem-based learning is usually a single subject, provides specific steps and is shorter [25]. Thus, while problem-based learning can empower biomedical/medical students to conduct intensive research, with integrating both theory and practice and applying knowledge and skills to develop a feasible solution to a well-defined problem(s), project-based learning can promote both active student learning and more engagement, and allow for higher order student thinking [24,25].

Conclusion

The benefits and limitations of PBL compared to conventional curricula have been continuously studied, mostly using learners from various biomedical and medical programs. The general conscience is that students from PBL curricula are generally better in both their interpersonal communication and clinical performance. In addition, students from PBL curricula usually report a higher satisfaction level and enjoyment with their program than do the conventional non-PBL curriculum learners. However, there is a general conclusion that non-PBL conventional curricula learners perform somewhat better on standard examinations compared to the performance of PBL learners. These findings highlight the dearth for a continuous and future research into the PBL effectiveness in biomedical and medical curricula. In addition, the use of scenario-based MCQs, particularly in PBL curriculum, can motivate biomedical and medical students to combine the fact learning with understanding several skills, including problem solving skills and analytical skills, as well as both the integration and application of knowledge skills.

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