



The Benefits of Problem-Based Learning as Active Learning in Theoretical Physiology of Autonomic Nervous System Course for Medical Students

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Abstract

Background: Traditional teaching methods such as lectures alone cannot meet educational needs in the medical sciences. It is necessary to supplement lectures with additional methods in order to prepare the students for problem solving in real situations.

Objectives: The present study aimed at employing the problem-based learning (PBL) method in the theoretical physiology of autonomic nervous system (ANS) course for medical students and comparing the results with the customary method of lectures.

Methods: In 2014, first-year medical students enrolled in the neurology curricular block at Tehran University of Medical Sciences were randomly assigned to two groups. One group participated in classes with lectures, while the other group was divided into subgroups of 10 for PBL sessions. In the first session of PBL, a scenario pertaining to ANS was presented, and then the students were asked to expand the scenario and discuss it using brainstorming method. The first session was held on introducing a reference for studying. In the second session, students in each group presented the results of their individual studies, and a representative from each group gave a report in line with the educational objectives of the class. Finally, a short-answer final test and survey were administered. Data were analyzed using independent samples t-test and Levene's test.

Results: Based on results, mean scores of students in the PBL group (15.20 ± 3.31) were significantly higher than those of students in the lecture group (12.38 ± 4.49) ($P < 0.001$). Based on the survey, students preferred PBL to lectures.

Conclusions: PBL promotes motivation, self-confidence, and communication skills, all of which contribute to the better learning of the students who attended the theoretical physiology of ANS course.

Keywords: Lectures, Problem-Based Learning, Physiology, Autonomic Nervous System, Students of Medicine

1. Background

Learning is an active process whereby learners acquire a new knowledge based on their previous experiences, present knowledge, and general worldview. Teacher-centered lecture with the passive position of learners is the most prevalent method of teaching worldwide, while the lecturers do not promote the students to acquire problem-solving skills. Learning is effective only when it involves self-direction. As an active, learner-centered, learning method, the problem-based learning (PBL) employs this feature (1).

PBL was first employed at Canada's McMaster University in the 1960s in the form of student-centered group learning. In this method, students participate in solving complex problems designed to be as unclear, vague, limitless, and non-specific as well as real-world problems. The PBL approach is an effective learning method that promotes critical thinking and may encourage students to

achieve further knowledge and skills.

Physiology is a fundamental component of a medical school curriculum. It covers the natural function of different organs, and if taught effectively, students complete it with an understanding of issues regarding diseases in various real-life clinical situations. Traditionally, medical schools teach physiology by lectures based on body systems. More recently, medical schools have introduced alternative methods such as PBL, which is based on case studies (2, 3).

Based on evidence regarding the effectiveness of passive teaching methods such as lectures, lectures alone do not tend to fulfill the educational objectives for this physiology course. Since 2011, Tehran University of Medical Sciences has adopted a curriculum merged with basic sciences for its medical students. The success of this course largely depends on using active learning and cooperation on the part of students. Based on studies (4) demonstrat-

ing that PBL successfully keeps learning active, the present study—the first of its kind in Iran—designed PBL for teaching the theoretical physiology of autonomic nervous system (ANS) course at Tehran University of Medical Sciences.

2. Methods

Sessions were held based on the Maastricht University's seven-jump approach. This includes clarifying the problem scenario, defining the problem by the participation of students, brainstorming to explain the case observed in the problem scenario, concluding, formulating learning objectives in groups, working independently to acquire knowledge, and discussing in groups the newly acquired knowledge for problem-solving (5).

Group sessions were held to determine the PBL method and to train the facilitators, who were selected from graduate students specializing in physiology. These students facilitated the interactions, questions, and curiosities of small, student-based groups. In addition to having the content knowledge of the ANS, facilitators needed skills beyond how to deliver lectures. Facilitators were trained for the following skills and qualifications: the ability to listen, limit the answers in a way to promote the students to use their own process of learning, examine group activities, know when to intervene, the willingness to confess their own lack of knowledge, offer appropriate feedback to groups when they are perplexed or hopeless, the willingness to give students freedom instead of controlling them all the time, promote group independence, use manage class time effectively, propose variables outcomes or appropriate alternatives, solve problems, and provide an opportunity for students to draw conclusions after class discussions.

Scenarios were designed based on educational objectives in which students delineated the physiology of the ANS for explaining the function of this system in times of fear and escape. Educational objectives included knowledge of the basic neurotransmitters of the ANS, the effects of the ANS on different viscera, and autonomic reflexes.

To implement this method, medical students entering the university in 2014 in the Neurology Block were randomly divided into two groups. One group participated in classes with lectures, while the other group was randomly divided into subgroups of 10 for PBL sessions. At the beginning of the first PBL session, students were provided explanations regarding the method, their own role, and the role of facilitators. Then, Power Point slides presented a problem regarding ANS. Facilitators asked students to read the problem, discuss questions, and identify vague points. Then, students discussed and developed the problem by brainstorming, discussed it. They attempted to find the

best answers to the problems they had identified in their groups under the supervision of facilitators.

Afterwards, as students delineated different aspects of the problem, they formed hypotheses and wrote them down. In the next step, students in each group defined hypotheses in the form of questions that the group's representatives presented. Next, facilitators listed the questions and determined educational objectives with the help of educational topics developed by students. The remaining educational objectives were added by the teacher. In the first session, a reference was introduced to the students in order to find the answers to their questions.

In the second session, each group first discussed the results of their individual studies as well as their acquired knowledge. Then, representatives from each group gave reports, thus sharing new evidence with other groups. Some groups presented material using teaching aids. Facilitators and the instructor kept track of time while intervening as little as possible. Next, the problems were re-analyzed based on new evidence, and the initial hypothesis was refined. Students explained key points and objectives related to the problem. In this way, a coherence was made between materials, and the problem was eventually solved. Remaining points were summarized by the instructor, summaries and studies were completed, and mistakes were corrected.

At the end of the course, students completed an anonymous questionnaire soliciting their opinions regarding PBL compared to lectures. This questionnaire included 20 five-choice questions scored on a Likert scale (from "Not at all" to "Very much"). The content validity of the questionnaire was confirmed by eight specialists using Lawshe's method, with acceptable indices. Reliability (internal consistency) was measured using Cronbach's alpha (0.92), showing the acceptable reliability of the questionnaire.

The final exam, supervised by the department of Medicine's faculty of Medicine, had a short-answer essay format for PBL and lecture groups. This exam had 34 questions deemed standard by the Faculty of Medicine in terms of differentiation and difficulty.

Data were described using measures of descriptive statistics, i.e. mean, SD, and percentage. Levene's test was employed to assess the equality of variances, and the Kolmogorov-Smirnov test was used to check the normality of distributions. Finally, independent samples t-test was run to compare the scores of the two groups. To compare the students' opinions regarding lectures and PBL, Wilcoxon signed-rank test was used since the scores were not normally distributed.

3. Results

Results of the Kolmogorov-Smirnov test showed that the data belonged to a normally-distributed population ($P > 0.050$). Based on results of Levene's test, the variances of the two groups were not equal ($P = 0.404$). Results of independent samples t-test revealed a significant difference between the mean scores of the two groups ($P < 0.001$). Based on results, mean scores of students in the PBL group (15.20 ± 3.31) were significantly higher than those of students in the lecture group (12.38 ± 4.49).

A survey of students' opinions suggested the superiority of PBL to lectures. Results of each item on the questionnaire are presented in [Table 1](#). Based on students' opinions, PBL was superior to lectures in eight points, including "increasing motivation," "promoting self-confidence," "raising awareness of the process of search," "enhancing communication skills," "understanding the method of dealing with a problem," "learning the process of group discussion," "diminishing the role of the instructor," and "gaining the ability to tolerate others' opinions." However, lectures were superior to PBL in maintaining the order of materials as well as the following points: "cooperation by few students," "availability of a pamphlet for final exam," and "availability of ordered materials." No significant difference was observed between the two methods on seven items.

4. Discussion and Conclusion

The present study aimed to compare the effectiveness of lectures and PBL in learning the physiology of ANS course by medical students. Teaching is an educational activity that leads to learning. Learning outcomes include changes in cognition, emotions, and motor skills following teaching. After teaching, teachers expect learners to cognitively understand new issues, use it after analyses, and integrate and evaluate it ([6](#), [7](#)). Results of a meta-analysis showed that PBL increases students' ability in the domains of cognition and skills ([8](#)). Another study indicated that PBL promotes long-term learning in students of dentistry by encouraging them ([9](#)).

The present study utilized scenarios that completely focused on the physiologic conditions of the body. Results showed that PBL can be used for teaching physiology in the fundamental sciences block of medicine curriculum, and clinical scenarios or pathological conditions are not required for teaching this course. Thus, in this block, teaching to first-year students can be more exciting, thereby encouraging them to learn.

Results of the present study revealed that PBL is more effective than lectures in various aspects while teaching

the Physiology of ANS course. PBL provides an opportunity for practicing, using, and promoting processing skills such as problem solving. In PBL, students' critical and analytical thinking accompanies learning. This leads students to use higher levels of thinking, e.g. the ability to apply what is learned, analysis, and synthesis. It also encourages students toward active, creative, and thoughtful learning. However, not all aspects of PBL proved better than the traditional method of lectures; lectures were more effective than PBL in maintaining the order of materials, level of cooperation, and availability of ordered materials. Also, no difference was found between lectures and PBL in, among others, ignoring less important points in class, discussing the requirements of each lesson, and eliminating confusion regarding the educational topic. Therefore, it seems that students' awareness of PBL should be raised prior to implementing this method, thereby promoting their cooperation. Results of a study at UCLA showed that the early introduction of instruction on how to search for and source medical literature enhances the quality of references cited by students in their first curricular blocks using PBL ([10](#)).

Contrary to the advantages of PBL shown in the present study, some studies have reported no difference between PBL and lectures. There are, however, studies in which PBL proved more effective than the traditional method of lectures ([11](#), [12](#)). Results of a study by Pourshanazari et al. on medical students at Kerman University of Medical Sciences in Iran showed no significant difference between the mean final exam scores of PBL and lecture groups. However, a four-year follow-up exam investigating the long-term learning of students showed significantly higher scores for the PBL group for a Physiology of Respiration course. Pourshanazari et al. recommended the use of this method from the beginning of university education in the fundamental sciences block as it is a better method for promoting long-term learning ([13](#)). The differences in these studies can be attributed to educational topics, number of sessions, environmental and physical factors, content and cognitive level of exams, major, number of students, or methods of assessment. Therefore, PBL is not superior to lectures in all educational topics, and lectures may prove more effective in certain topics. Similarly, Baghaie and Atrkar concluded that lectures are more effective than PBL for students of nursing in terms of their level of learning ([14](#)).

One of the limitations of the present study was that it evaluated students' level of learning using a short-answer final exam. This exam alone may not have fully assessed all the cognitive levels of students. It has been recommended that the effectiveness of the learning process be assessed using appropriate tools compatible with the teaching method, including multiple-choice, essay-type,

Table 1. Comparison of the Student Satisfaction with PBL Versus Lecture

Number	Items	Median		Z Statistic	P Value ^a
		Lectures	PBL		
1	Increasing motivation	2	4	3.27	0.001
2	Increasing self-confidence	2	4	3.44	< 0.001
3	Raising awareness of the process of change	2	4	4.26	0.001
4	Clear and fast understanding of materials	3	3	0.33	0.890
5	Enhancing communication skills	2	4	3.71	< 0.001
6	Understanding the method of dealing with problems	2	4	3.79	< 0.001
7	Learning the process of group discussion	2	4	3.71	< 0.001
8	Diminishing the role of the instructor	1	2	2.69	0.007
9	Ignoring less important issues in class	4	4	1.75	0.080
10	Mentioning the requirements of each lesson	4	4	1.93	0.050
11	Highlighting the requirements of each lesson	3	4	1.31	0.190
12	Occurrence of independent learning	2	3	1.22	0.220
13	Gaining the ability to tolerate others' opinions	2	4	3.68	0.001
14	Effect on learning	3	4	1.73	0.080
15	Following the order of materials	4	2	2.91	0.004
16	Lack of confusion regarding the topic	4	4	0.79	0.430
17	Availability of a pamphlet for final exam	5	2	3.45	0.01
18	Cooperation by few students	4	3	2.84	0.005
19	Availability of materials to study for the mid-term exam	4	5/3	2.70	0.007
20	Availability of ordered materials	4	2	4.23	0.001

Abbreviation: PBL, Problem-Based Learning.

^aBased on the Wilcoxon test.

and matching items (15, 16). Of course, the effects of PBL on the students' level of learning must be assessed independently of the assessment method. Results of a similar study showed that small-group discussions can lead to comparative reasoning, formulate hypotheses, understanding the problem, and generating questions for better learning (17).

Based on various results, it seems that PBL leads to better learning of the Theoretical Physiology of ANS among students of medicine by enhancing their motivation, self-confidence, and communication skills. Thus, it can be considered as a teaching method in the fundamental sciences curricular block for students of medicine, and learning can be improved through active learning and increased cooperation.

Supplementary Material

Supplementary material(s) is available [here](#) [To read supplementary materials, please refer to the journal website and open PDF/HTML].

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