Effect of hybrid teaching incorporating problem-based learning on student performance in pathophysiology

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Abstract

Objective: To compare the effectiveness of traditional and hybrid teaching strategies in pathophysiology and to conduct a survey of students’ opinions about the hybrid teaching strategy.

Methods: A hybrid pathophysiology course was developed by combining traditional lectures, case- or problem-based learning, group discussion and several quizzes. A total of 167 students were assigned to the hybrid teaching group and 118 students assigned to the traditional lecture group.

Results: Compared with students who received traditional lectures, no students in the hybrid teaching class failed the final examination. The percentage of students with high scores was significantly higher in the hybrid teaching class. In addition, 73.7% of students in the hybrid teaching class expressed substantial interest in pathophysiology during the course, and 83% of these students felt they had received essential training and acquired the ability to solve clinical case problems.

Conclusion: The hybrid teaching strategy is an advanced approach that encourages students to actively learn teaching materials and solve practical clinical problems, and that promotes student interest in pathophysiology.

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Introduction
Pathophysiology education combines clinical and theoretical instruction. Both theoretical teaching and clinical practice in pathophysiology are needed to develop students’ ability to transform theoretical knowledge into solutions to practical clinical problems. Linking clinical practice to theoretical education also improves students’ decision-making ability, deepens their education and broadens the scope of knowledge of students and teachers.1

Problem-based learning (PBL) is a student-centred pedagogy in which students learn about a subject through the experience of solving an open-ended problem provided in the course materials. Previous studies have shown that PBL is an effective learning and teaching approach, particularly in long-term courses.2 PBL has been used in medical and nursing programs in many different countries and its effectiveness has been demonstrated.3 One study of PBL teaching of hyperthyroidism in an endocrinology internship showed that, compared with a traditional lecture-based classroom group, PBL groups achieved higher scores and performed better on clinical case analysis.3

We aimed to evaluate the effect of a hybrid teaching strategy on students’ responses in laboratory practice compared with traditional pathophysiological teaching (i.e. lectures only, with very little student discussion).

Methods
A total of 285 undergraduate students from one university participated. Of these, 167 students (enrolled in 2015) were assigned to the hybrid teaching group and the remaining 118 students (enrolled in 2013) were assigned to the traditional lecture group. The course was taught by two instructors (one instructor gave 26 lectures and the other instructor gave 28 lectures) and was held during a regular semester of 13.5 weeks. The class met for 40-minute lectures twice per week.

Study design
The study was approved by the ethical committee of our university. Written informed consent was provided by all participating students.

The hybrid teaching class received four sessions comprising lectures based on illness cases, five quizzes (once every 2 or 3 weeks), modified PBL and a final examination. The traditional course consisted of podium lectures and a final examination (Figure 1). Compared with traditional teaching, the additional time for each PBL class was approximately 1 hour.

Use of illness cases to strengthen learning
When new topics were introduced (e.g. pathophysiology of a new body system), students in the hybrid course received lectures and relevant basic information about a typical illness case at the beginning of the class. In this way, tutors gradually introduced clinical knowledge into the theoretical teaching to naturally connect fundamental medicine and clinical medicine through pathophysiology. This process enabled students to actively learn how to
practically apply the abstract theoretical knowledge presented in textbooks, motivating them to study the theory. In addition, the presentation of practical cases developed students’ ability to comprehensively analyse and solve the problems. Students were asked to prepare questions before class and could ask the tutor questions at any point during the class. In addition, teachers also encouraged student discussion of the cases.

**Class quizzes and final exam**

Every 2 or 3 weeks, students completed a 10-minute quiz. The quiz questions were randomly chosen from a pool of questions to minimize cheating. The quiz scores accounted for 50% of the final grade (10% per quiz). The final exam consisted of a traditional written exam and accounted for 50% of the final grade. The students’ final grades were used as quantitative data to assess their performance in the courses. An excellent student was defined as one who achieved a final score of 90. Both quiz and final exams were conducted in class.

The following quiz questions were used: (1) What kinds of acid–base disturbances are most probably caused by pyrexia? Why? (2) Is the dehydration cause by watery diarrhoea and the dehydration caused by severe vomiting the same? Why? (3) After rescue from haemorrhagic shock, the blood pressure of some kinds of animals will return to normal after blood transfusion, whereas the blood pressure of others will not return to normal even after full blood transfusion to replace all the lost blood. Why? (4) Please explain the reasons for haemorrhage during disseminated intravascular coagulation (DIC) and the related mechanism, as well as the relationship between the pathological changes that occur during DIC. (5) Through what mechanisms do open pneumothorax and severe closed pneumothorax cause acute respiratory failure?

**Application of PBL**

The analysis of cases was conducted over two sessions. The first session consisted of the main case presentation and clinical
symptoms, and the second session consisted of scrutiny of the results.

Students in the hybrid teaching group were randomly divided into 12 discussion groups, each consisting of 10 participants. The PBL task was divided into three steps that lasted for a total of 320 minutes, with a 2-day gap between steps to give students time to conduct the research necessary to complete the PBL task. During the PBL task, the main task of the tutors (one tutor for each discussion group) was to guide the discussion to ensure the smooth flow of the session and avoid digressions. Each student was evaluated on their participation, presentation effectiveness, teamwork and communication, material preparation, and leadership and empathy.

The tutors were validated internally and externally to ensure that they could adequately operationalize the teaching concepts.

**Statistical analysis**

Quantitative data were analysed descriptively and data for the two groups were compared using the chi-squared test. The results were considered statistically significant at the \( P < 0.05 \) level. Analyses were conducted using SPSS for Windows, Version 16.0 (SPSS Inc., Chicago, IL, USA).

### Results

Students’ ages ranged from 20 to 23 years. There were 119 male students and 166 female students (Table 1). All students majored in clinical medicine and were in their third year in our college. The pathophysiological course started on the first semester of students’ third year. None of the students had previously been taught related materials prior to their participation in this study.

None of the students in the hybrid teaching class failed the final examination (Table 2). The hybrid teaching group contained 9.21% more students rated as excellent compared with the traditional lecture group (0.1695 vs. 0.0714, \( \chi^2 = 6.708, P < 0.05 \), Figure 2a). As shown in Figure 2b, the overall performance of the hybrid teaching group was better than that of the traditional lecture group.

An anonymous student survey conducted after the students received their exam results showed that 86.3% of students preferred the hybrid teaching to the traditional teaching, 73.7% of students in the hybrid teaching group reported being interested in the pathophysiology course material and 83% of students felt that hybrid teaching had developed their ability to solve learning problems. Students in the hybrid group achieved better grades than students in the traditional lecture group.

We also found that participation, presentation effectiveness, teamwork and

| Group                   | Male (n) | Female (n) | Total | Age range (years) |
|-------------------------|----------|------------|-------|-------------------|
| Traditional lecture     | 62       | 105        | 167   | 20–23             |
| Hybrid teaching         | 57       | 61         | 118   | 20–23             |

### Table 2. Test results for the hybrid teaching group at each time point.

| Time point | First quiz | Second quiz | Third quiz | Fourth quiz | Fifth quiz | Final exam |
|------------|------------|-------------|------------|-------------|------------|------------|
| Mean score | 7.79       | 6.77        | 7.90       | 6.68        | 6.80       | 42.21      |
communication, material preparation, and leadership and empathy were better in the hybrid group than in the traditional teaching group.

**Discussion**

PBL is a student-centred education model that facilitates student learning and helps students to solve problems themselves. In the process, students not only practice applying their theoretical knowledge to clinical cases, but also improve their self-awareness and ability to self-motivate. They also become able to shift their focus from the question, “What do we know?” to the question, “How do we know?” In the present study, students who received hybrid teaching received higher scores than students in the traditional teaching group, indicating the effectiveness of PBL and hybrid education. Learning new knowledge requires students’ attention and participation, which are greatly affected by their interest. Hybrid teaching can inspire students’ interest in the teaching materials and increase their desire to express their own understanding of the information. This can help to improve various abilities, such as presentation skills, teamwork and communication, material preparation, and leadership and empathy.

An important advantage of PBL is that it provides the opportunity to engage in clinical reasoning within a problem-solving activity. In the PBL session, students developed their professional skills, such as communication skills. For example, they practised obtaining useful information from patients and engaging in a discussion with patients. More importantly, in the PBL approach, teachers integrate scientific knowledge into practical teaching to cultivate critical skills that students can use in

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**Figure 2.** Performance of students in the hybrid teaching group vs. the traditional lecture group. (a) Ratings of excellence for both student groups (chi-squared results, \( p < 0.05 \)). (b) Grade distributions for both student groups.
professional practice.\textsuperscript{5} Compared with traditional teaching, the use of PBL in lecture courses on pathophysiology results in higher student grades.\textsuperscript{6}

Moreover, the use of case discussions allows PBL to be linked with actual clinical issues, improving students’ comprehensive understanding of pathogenesis.\textsuperscript{7} Additionally, class quizzes encourage daily revision and provide a source of continuous assessment that contributes to the final grade.\textsuperscript{7} Thus, we found that all students in the hybrid teaching group passed the final exam and scored higher than students in the traditional teaching group.

**Conclusion**

The hybrid teaching strategy can be used to encourage students to actively learn teaching materials and solve practical clinical problems, and promotes their interest in pathophysiology. However, the follow-up period was too short to assess the effects of hybrid PBL teaching on students’ learning and problem-solving skills. Currently, we are still following these students and plan to analyse the follow-up data in future studies. In addition, we did not conduct an in-depth exploration of the mechanisms of hybrid teaching; for example, using magnetic resonance imaging to detect changes in brain activity while students were reflecting on a pathophysiological problem. We hope to conduct such explorations in the future to determine the mechanisms underlying hybrid teaching.

**Declaration of conflicting interest**

The authors declare that there is no conflict of interest.

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