Original Article

Blended Teaching Practices for Active Learning in Higher Pharmacy Education

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ABSTRACT

Background: Blended adoption of active learning practices improves student achievement on average in college. Nevertheless, there have been few studies to date on the effects of detailed factors on learning outcomes. **Objectives:** The aim of this study was to develop a blended teaching strategy by incorporating methods of team-based learning (TBL) and e-learning into a Pharmaceutical Analysis course for student active learning, and to explore how the practice impacts student learning outcomes. **Materials and Methods:** Two blended teaching programs with different blending ratios of TBL and e-learning methods were developed and compared in this study. Students from four experimental classes enrolled in three majors were recruited. Student outcomes related to active learning goals were evaluated using formative and summative evaluation methods. A survey administered after the study was completed. **Results:** Student e-learning performance was positively correlated with the final scores, suggesting that exercises and tests provided by the e-learning platform made a positive contribution to student knowledge achievement. On surveys a large majority of students reported that working on instructor-posed questions in a TBL setting improved their higher-order cognitive skills, social cohesion and, through that, feelings of accountability. Final scores showed significant differences among students from different majors, which implied that the effectiveness of active learning depends on the characteristics of students and their activities outside of class. **Conclusion:** The blended teaching strategy developed in this study was effective in improving student achievement in either formative or summative assessments, which provides an accessible and informative entry point for implementing active learning in higher pharmacy education.

Key words: Higher pharmacy education, Blended teaching, Active learning, E-learning, Team-based learning.

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INTRODUCTION

Lecturing in the classroom has been the most common teaching method at higher education institutions since the emergence of universities in Europe more than 900 years ago. The features of this teaching mode are 'teacher-centered' and face-to-face communication between students and teachers as well as between students and students. In modern times, 'student-centered' pedagogy, which advocates guiding students to learn actively, has developed and gradually become the dominant direction of learning and teaching research.[1,2] Thus, the development of new and optimized classroom interventions has been called for by agencies concerned with undergraduate education to promote active participation by students in teaching activities. It has been reported that active learning practices, where active learning is defined as when students are actively working on problems or questions in class,[3] improve student achievement on average in college science, technology, engineering and mathematics courses compared with traditional lectures. Baylor College of Medicine first tried team-based learning

(TBL) in medical teaching, in which the role of the student moved from "listener" to "knowledge seeker" while the role of the teacher moved from instructor-centered to more active learning-based instruction.[4] In the following years, active learning and evidence-based teaching practices that develop student learning have become the expected teaching methods across college campuses.[5-7]

Currently, with the development of internet technology, taking part in courses carried out with the use of e-learning platforms is fast becoming a new learning method.[8,9] The features of e-learning are that learning is not limited by time and region. Learners can choose their learning contents according to their own interests and personalized needs, and perform learning and practices online repeatedly. E-learning has become an important tool for the continuing education of pharmacists as part of the healthcare training of professionals in Europe, USA, Australia and Canada.[10] Many universities in China have begun to try internet-based learning practices in undergraduate education.[11,12]

However, both the teaching methods and student active learning are complex processes that occur both inside and outside the classroom. Blended adoption of some form of research-based teaching methods for active learning at the college level is rapidly expanding.[13] Nevertheless, research on detailed factors, such as the blending ratio of the components, impacts of learning resources and formative evaluation methods, remains very limited.

Pharmaceutical Analysis (PA) is a core professional course set up in the junior year for undergraduate students in pharmacy-related majors at China Pharmaceutical University. The goals of the course are to cultivate students' capacity to employ analytical techniques to address drug quality control and therapeutic drug monitoring (TDM) in the pharmaceutical industry and clinical service. In our previous work, we built a PA massive open online course (MOOC) in a national online platform of China.[14,15] However, how best to make use of PA MOOC as a part of undergraduate courses, or as an adjunct to traditional learning activities for pharmacy students, was still not clear. Herein, we propose a blended teaching strategy to incorporate methods of TBL and e-learning into a PA course for student active learning, and explore how the practice impacts student learning outcomes in the PA course.

MATERIALS AND METHODS

Protocol

In order to explore how the teaching practices of TBL and e-learning impact student learning outcomes in a PA course, two teaching programs, MOD 1 and MOD 2, were designed in this study (Figure 1). The total teaching hours for both MOD 1 and MOD 2 were 34 class hours, but the ratios of large lecture hours versus TBL hours were different. The proportion of lecture hours versus TBL hours was 26:8 for MOD 1 (TBL approximately equal to 25% of total hours) and 18:16 for MOD 2 (TBL approximately equal to 50% of total hours).

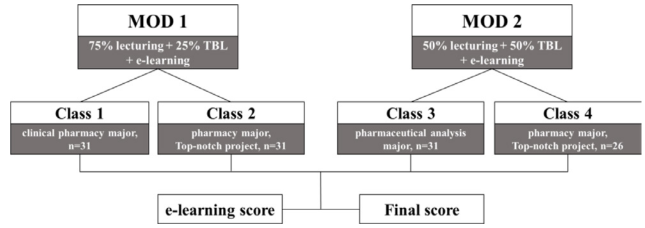

Figure 1: Teaching programs flow chart.

The same faculty team carried out both teaching practices for a term of three months in each semester. This teaching study was approved by the Academic Affairs Office of the China Pharmaceutical University (Nanjing, Jiangsu, China). At the beginning of each term, a PA lesson plan including teaching week, teaching hours and teaching method (lecture, TBL or e-learning), teaching topics and an outline of contents was developed by the faculty team and distributed to participants (Appendix 1).

Participants

Students in four experimental classes enrolled in three majors were recruited in the learning of the PA course (Course No. 1111071018, 2 credit-hours) in different semesters. They were class 1 (31 students, clinical pharmacy major, grade 2015), class 2 (31 students, pharmacy major, top-notch project, grade 2016), class 3 (32 students, pharmaceutical analysis major, grade 2016) and class 4 (26 students, pharmacy major, top-notch project, grade 2017). The participants were not informed about the study prior to its commencement.

Measures

In terms of e-learning, students were asked to register online and take part in PA MOOC outside the classroom. They could make use of the resources online to obtain background information prior to class, re-watch lecture materials to review the class lecture and associated discussion and do exercises and tests to supplement their learning, or as a means of preparing for the final examination. Due dates were set up for those exercises and tests. Participants were required to complete and submit their assigned work online before an explicitly delineated time. A student's performance in e-learning,

Appendix 1: National first-class undergraduate course application course teaching calendar.

Course name: Pharmaceutical analysis
Course leader: Wenyuan Liu

Week	Class hour min	Content of courses key point	Course type (Each chapter shares an e-learning part on MOOC)
1	2h (90)	Introduction: Properties and Tasks of the Pharmaceutical Analysis Course	Lecture
		Introduction: The Relationship between Human Life and Medicine	
2	1h (45)	Chapter 1: Overview of Drug Quality Research and Pharmacopoeia	Lecture
	1h (45)	Chapter 1: Comparison of Chinese Pharmacopoeia Development and Foreign Pharmacopoeia	TBL
3	1h (45)	Chapter 2: Drug Identification Tests and Methods	Lecture
	1h (45)	Chapter 2: Advances in the Application of Modern Analytical Technology (NIR) in Drug Identification	TBL
4	1h (45)	Chapter 3: Detection of Genotoxic Impurities and Typical Cases; Inspection Methods for Related Substances	Lecture
	1h (45)	Chapter 3: Analytical Methods for Other Types of Impurities	TBL
5	1h (45)	Chapter 4: Determination of Drug Content and Validation	Lecture
	1h (45)	Chapter 4: Detection Technology and Progress of Illegal Addition of Drugs	TBL
6	1h (45)	Chapter 5: Biopharmaceutical Analysis	Lecture
	1h (45)	Chapter 5: Analysis and Monitoring Techniques for Rational Use of Clinical Medicine	TBL
7	1h (45)	Chapter 6: Analysis of Aromatic Nonsteroidal Anti-inflammatory Drugs	Lecture
	1h (45)	Chapter 6: Typical Cases of Aromatic Acid Analysis	TBL
8	1h (45)	Chapter 6: Analysis of Phenethylamine-like Epinephrine Drugs	Lecture
	1h (45)	Chapter 6: Typical Cases of Clinical Analysis of Phenylethylamines	TBL
9	1h (45)	Chapter 6: Analysis of Parabens and Aniline Local Anesthetics	Lecture
	1h (45)	Chapter 6: Analysis of Dihydropyridine Calcium Channel Blocking Drugs	Lecture/TBL
10	1h (45)	Chapter 6: Analysis of Barbitur and Benzodiazepine Sedative Hypnotics	Lecture
	1h (45)	Chapter 6: Clinical Rational Use of Barbiturates	TBL
11	1h (45)	Chapter 6: Analysis of Phenothiazine Antipsychotics	Lecture
	1h (45)	Chapter 7: Discovery and Enlightenment of Artemisinin	Lecture/TBL
12	1h (45)	Chapter 8: Analysis of Pinane Anticholinergics	Lecture
	1h (45)	Chapter 8: Comparison of Analysis Methods for Pinanes in Pharmacopoeia at Home and Abroad	Lecture/TBL
13	1h (45)	Chapter 9: Comparison of Analysis Methods for Vitamins A, B, C and E in Pharmacopoeia at Home and Abroad	Lecture
	1h (45)	Chapter 9: Analysis of Multivitamin Preparations	Lecture/TBL
14	1h (45)	Chapter 10: Comparison of analytical methods for steroid hormones *in vivo* and *in vitro*	Lecture
	1h (45)	Chapter 10: Analysis of Clinical Interactions with Hormones	Lecture/TBL
15	1h (45)	Chapter 11: Analysis of Antibiotics	Lecture
	1h (45)	Chapter 11: Analysis of Synthetic Antimicrobials	Lecture/TBL
16	1h (45)	Chapter 12: Introduction to Pharmaceutical Preparation Analysis	Lecture
	1h (45)	Chapter 13: Introduction to Analysis of Chinese Medicinal Materials and Their Preparations	Lecture/TBL
17	1h (45)	Chapter 14: Analysis of Biological Products	Lecture
	1h (45)	Chapter 15: Advances in Modern Analytical Methods in Drug Quality Control	Lecture/TBL

including times of watching lecture notes or slides, performance in completing exercises or tests and frequency of attending discussion in a forum, could be automatically and quantitatively calculated through the statistical tools provided by the MOOC platform. These data were the basis for formative evaluation of a student's e-learning behavior outside the classroom.

For TBL, students were given discussion topics or questions that required logic or higher-order thinking one week before group working. They needed to retrieve information independently and think through their answers on their own before attending an in-class small-group discussion. In the small-group discussion, each student had to share and explain their answers to the group members. Then the whole group worked together to derive a group idea. One week after the small-group discussion, a whole-class discussion was held. Volunteers representing each group had to explain their responses to selected questions to the whole class at the front of the room, and the instructors could hint at or reveal correct answers. Based on their participation and the correct answer, course points were awarded to participants in the in-class activities.

Data analysis

Based on the existing MOOC platform evaluation system, a formative evaluation method was established. Participants then sat a final exam and their scores were statistically analyzed to make a summative assessment of the effectiveness of the teaching strategy. A regression analysis was conducted using SPSS (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY, USA: IBM Corp). The statistical analysis was conducted using the unpaired Student's *t*-test. Differences were considered statistically significant at $*p < 0.05$, $**p < 0.01$ and $***p < 0.001$. A survey that covered questions on course design, learning achievements and level of satisfaction was conducted to assess student feedback after the study was completed.

RESULTS

Correlation of e-learning and final scores

All students in the four experimental classes completed the study, and the statistical results for their final scores were captured (Appendix 2). Their e-learning scores were collected from the MOOC platform. Regression analysis was performed on the e-learning and final scores of the four classes, and a scatter distribution map shows the results in Figure 2. It is apparent that a class with a higher e-learning score also had a higher corresponding final score, which indicated that there is a positive correlation between student e-learning and final score. We calculated the Pearson correlation coefficient (Figure 2) for each class, all of which were positive values, suggesting that e-learning benefited the final exam results of each class to some degree.

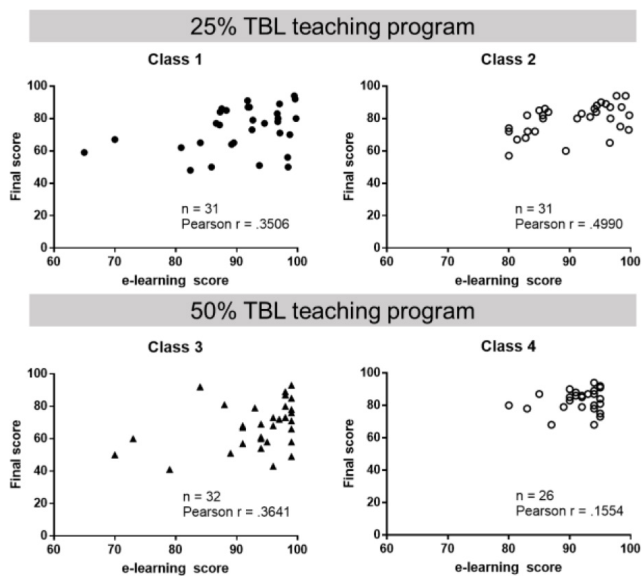

Figure 2: Regression Analysis of e-learning Score and Final Score among Class 1-4 (Pearson correlation coefficient was calculated inserted in each graph).

Appendix 2: Statistical Results of PA Final Scores by Students from Experimental Classes.

Total Students	Over 90 points	80–89 points	70–79 points	60–69 points	Below 60 points	Mean (SD)
	A	B	C	D	F	
	N (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	
31 (class 1)	3 (9.7)	9 (29.0)	8 (25.8)	5 (16.1)	6 (19.4)	73.42±23.58
31 (class 2)	3 (9.7)	17 (54.8)	6 (19.4)	4 (12.9)	1 (3.2)	78.46s 2 po
32 (class 3)	2 (6.2)	5 (15.6)	8 (25)	8 (25)	9 (28.1)	67.12s 3 po
26 (class 4)	4 (15.4)	14 (53.8)	6 (23.1)	2 (7.7)	0 (0)	82.81s 4 po

For the two top-notch classes (a top-notch project is a training plan for excellent students in college in China), classes 2 and 4, the Pearson correlation coefficient of class 2 (0.4990) that was subjected to a 25% TBL program was higher than that of class 4 (0.1554) that was subjected to a 50% TBL program by nearly 0.35. This suggested that exposure to more instruction by teachers in large lectures greatly influenced what the students learned, as the students might have more chances to communicate with teachers and classmates in that environment.[16] Meanwhile, compared with that of class 2, the final score of class 4 students remained competitively excellent, which implied that TBL, e-learning or other learning methods such as lab training experiences could also be more beneficial for the students of top-notch classes.

Factors influencing final scores

In order to assess whether the differences in the final scores were related to student majors and/or teaching modes, the final scores of classes with the same majors or teaching modes were compared. As shown in Table 1, there was no significant difference between the final scores of classes 1 and 2, whose students came from the clinical pharmacy major and pharmacy major (top-notch project), respectively, and were subjected to the same 25% TBL teaching program. We concluded that, under this teaching mode, the main factor influencing elements of the students' achievement was the teachers' classroom instruction. Such elements, including the characteristics of the students and student activities outside of class, had a lesser impact on student learning outcomes.

However, we found a highly significant difference between the final scores of students in classes 3 and 4, who came from the pharmaceutical analysis major and pharmacy major (top-notch project), respectively, but were subjected to the same 50% TBL teaching program. The results showed that, under this teaching mode, the effectiveness of active learning depended on how well students performed in TBL, or how much practice they had outside class. These elements could in turn be influenced by student characteristics such as their prior academic preparation and their motivation.

For students from the two top-notch classes, classes 2 and 4, who presented similar student-level characteristics, no significant differences were found between their final scores. Although the students of classes 2 and 4 were administered different blended programs, approximately equal to 25% TBL and 50% TBL, respectively, their learning gains were aligned with each other, revealing that the top-notch class students displayed a strong adaptive capacity.

Feedback from students

We surveyed students' feedback after the study was completed. The feedback forms were collected by category and summarized by percentage. On average, as shown in Table 2, a large majority of students (84.6%) reported they support the introduction of e-learning into the PA course, 77.0% supported the introduction of TBL into the course, and 57.7% of students agreed blended learning increased their learning interest. When asked to define the role of e-learning, 59.4% of students selected e-learning as an auxiliary learning method, 21.9% suggested it was a supplementary tool to enhance learning interest, and 19% selected it as a dominant learning strategy. In addition, when students were asked to rank the effectiveness of the different teaching methods, 35.7% of students ranked lectures, 35.7% ranked TBL, and 28.6% selected e-learning as the most effective. When asked which type of online resource was most helpful for improving learning outcomes, 88.5% of students selected exercises and tests in the e-learning platform.

Table 1: Comparisons of the Final Scores between Class 1-4.

Type	Class	Final score	*p* value	Significance
25% TBL	Class 1	73.42±13.58	.051	NS
	Class 2	78.46± 9.38		
50% TBL	Class 3	67.12±13.93	<.001	***
	Class 4	82.81± 6.84		
Top-notch class	Class 2	78.46± 9.38	.121	NS
	Class 4	82.81± 6.84		

Student's T test was conducted between each class in one type
Data presented as mean final score and standard deviation

Table 2: Survey of Students' Feedback on the Blended Teaching Strategy (*n* = 90).

Survey Questions	Agree Percent (%)	Neutral Percent (%)	Disagree Percent (%)
Do you support e-learning incorporated into PA course	84.6	11.6	3.8
Do you support TBL incorporated into PA course	77.0	19.2	3.8
Does the blended teaching strategy increase your learning outcome on PA	57.7	23.1	19.2

DISCUSSION

In this study, TBL and e-learning methods were incorporated into a PA course to develop a blended teaching strategy. This approach was based on our early work in teaching research. Previously, we built a PA MOOC in a national online platform named I course in China. The contents of the PA MOOC include teaching materials (lecture notes, videos and lecture slides) for 66 knowledge topics in 15 chapters. The MOOC was constructed to align with the goals of the PA course in our university. In addition, large quantities of practices for those knowledge topics, including exercises, tests and discussion topics, were also formulated with their amounts and qualities validated by our faculty team. Since 2016, the PA MOOC has been offered every term by our faculty team, keeping pace with the PA course.

The framework of the blended strategy was also designed according to the characteristics of the PA course. PA is a core professional course in the pharmacy education curricular system setup in the senior year for undergraduate students at China Pharmaceutical University. The course contents encompass not only basic analytical chemistry methods and principles, but also different types of cases involving drug quality analysis. Nowadays, students have to qualify themselves in the field of drug quality control or TDM in the pharmaceutical industry and clinical service by demonstrating such skills as logical thinking, communication skills, sense of accountability and other applicable skills beyond content knowledge. This need has led to off-loading of course content onto more active learning platforms and refocusing class time on helping students develop these skills.

Due to its impacts on student learning outcomes, TBL was incorporated into the strategy. It has been reported that TBL could improve student attitudes toward a discussion topic,[17] improve social cohesion and feelings of accountability[18] and develop a student's argumentation skills.[19] In our study, two teaching programs with different blending ratios of lecture hours versus TBL hours were designed. The TBL percentages in the two programs were approximately equal to 25% and 50% of total teaching hours for MOD 1 and MOD 2, respectively.

The participants in the study covered three majors of our university, which were the clinical pharmacy major, pharmacy major and pharmaceutical analysis. The two classes of pharmacy major were also recruited into the top-notch project of our country. A top-notch project is a training plan for excellent students. Students in this project are provided with additional opportunities and support to enter the science laboratory for academic training outside class. They have a broader academic vision and stronger active learning ability.

Studies have documented that best practices for implementing active learning cluster along the dimensions of practice, logic development, and accountability and apprehension reduction.[20] In our blended teaching practice, we focused on the first two dimensions to improve our teaching practices for student active learning. By incorporating TBL and e-learning into our teaching strategy, we have developed our blended framework and are devoted to working on effective use of these methods.

It has been proved that student learning is positively correlated with the amount of practice undertaken and repeated practice testing is correlated with both increased learning and metacognition.[21] Thus, the main task at the beginning of construction of the PA MOOC was to establish high-quality exercises and tests, which are the resources for student practice. We have created a certain amount of exercises and tests for each knowledge point. The types of exercises and tests include multiple choice, written answers to questions and true and false questions. The quality of the exercises and tests was also validated by our faculty team to ensure that the practices were similar to the tasks students are expected to perform. Participants were asked to take part in e-learning outside class. They were required to complete the practices and submit them online before an explicitly delineated deadline. It has been shown that mutual evaluation among students may help learners become more aware of their own performance and enable them to devise a plan for enhancement.[22] Therefore, the multiple choice and true and false questions were marked automatically by the platform, while the answers to questions were marked by peer review among students. The results of a questionnaire showed that a large majority of students selected exercises and tests online as the most effective methods of learning achievement. Student e-learning scores were positively correlated with their final scores in our study, implying the benefits of enhancing student achievement by e-learning.

Before e-learning was adopted, many practices and evaluations were carried out in class, which consumed part of allocated teaching hours. Shifting such practices from inside the classroom to outside the classroom makes it possible to address more logic and higher-order thinking practices via TBL.

The aim of incorporating TBL into the study was to increase a student's higher-order thinking skills and sense of accountability. To provide students with opportunities to practice their logic development, it was important for teachers to formulate questions that require a higher level of thinking. Based on the development of the pharmaceutical industry in China, we selected typical drug quality control cases and high-level written questions that require logic and critical thinking at higher Bloom levels. Participants were then asked to work on teacher-posed questions with teachers explicitly cuing students to use their prior knowledge to guide their thinking. Before participants joined in small-group or whole-class discussions, an individual time of around one week was provided to allow them to independently think through the questions and come up with their own ideas before the following discussions.

Small-group and whole-class discussion work encouraged a deeper understanding of the material when students shared and explained their answers to other students.[23] When attending the TBL, students were randomly divided into small groups with 6–8 students per group. In small-group discussion, each student was asked to share and explain their answers to the group members, with their effort (or lack thereof) noticed by others. Therefore, course points were awarded according to a peer evaluation among students during small-group discussion. In whole-class discussion, one student who represented a group explained their responses for the answer selected in front of the class. Course points were assigned by teachers based on their participation and correct answer in these activities.[24] With regard to whole-class presentations, many students stated that working in a group created social cohesion among the members of the small group, which increased their sense of accountability.

Blended teaching in this study was designed with the purpose of implementing active learning in the pharmacy education course. The focus of the study was on both classroom practices and student activities outside of class. The length of e-learning time and the requirements were consistent across students of the four experimental classes in our study, but the learning hours by TBL were different. The program with a higher TBL proportion resulted in greater differences in students' learning outcomes. Students of a top-notch project showed greater learning gains from increased group working practices. With a decreasing proportion of TBL, the teacher's instruction played a major role in student learning outcomes and there was no significant difference in the final scores among students of different majors.

This study also had some limitations. First, the sample size was not large enough. Moreover, to reduce the influence of different teaching styles, we only chose the classes taught by Prof. Wenyuan Liu. Second, the blending ratio setting lacked a sufficient gradient. Third, the progress of e-learning for each student was difficult to control because of the openness of the process. Ways to further clarify the effects of e-learning in a blended teaching strategy are worth investigation in the future.

CONCLUSION

In general, we incorporated methods of TBL and e-learning into a PA course teaching practice to develop a blended teaching strategy for student active learning. The strategy changed the classroom environment by introducing more group work, more opportunities for in-class practice on higher-order problems and less explanation by the instructor. Outside-class changes included the addition of online knowledge retrieval and practices using the e-learning platform. With these changes, the student learning achievements and levels of satisfaction increased dramatically.

ACKNOWLEDGEMENT

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ABBREVIATIONS

TBL: Team-based Learning; **PA:** Pharmaceutical Analysis; **MOOC:** Massive Open Online Course.

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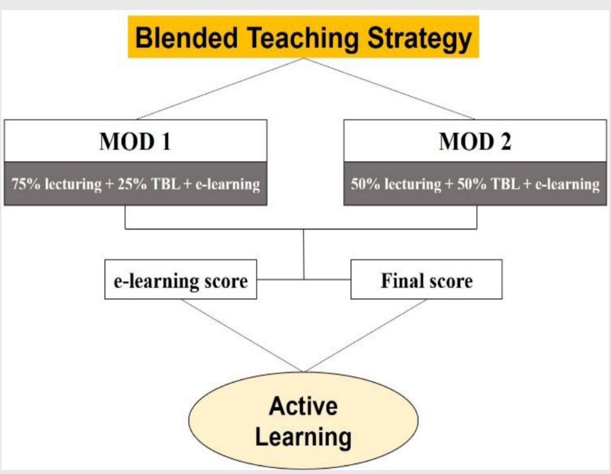
PICTORIAL ABSTRACT



SUMMARY

This study developed a blended teaching strategy for student active learning by incorporating methods of team-based learning (TBL) and e-learning into a Pharmaceutical Analysis course, and explored how the practice impacts student learning outcomes. The blended teaching strategy developed changed the classroom environment by introducing more group work, more opportunities for in-class practice on higher-order problems and less explanation by the instructor, as well as addition of online knowledge retrieval and practices by the outside-class e-learning platform. It proved to be effective in improving student achievement in either formative or summative assessments, which provides an accessible and informative entry point for implementing active learning in higher pharmacy education.

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