Outcome-based student assessment enhances academic performance in basic medical laboratory course

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Abstract

Basic medical laboratory courses (BMLCs) play an important role in medical educational courses helping the student acquire three important skills of surgical operating, collaborative learning, and problem solving. The outcome-based student assessment (OBSA) is a learning evaluation method that establishes specific evaluation points based on performance of students in three aspects: surgical operating, collaborative learning, and problem solving in the BMLC curriculum practices. The purpose of the present randomized controlled trial study is to explore the efficiency of OBSA program in BMLCs. The 233 students attending BMLCs were randomly divided into 2 groups, 118 in the OBSA group and 115 in the control group. We conducted multiple-choice examination questions (MCQs) test and two questionnaires with the method of two-sample t test for statistics. The results of MCQs in total eight BMLC blocks showed that the academic performance of the OBSA group was significantly better than that of the control group (P < 0.05). In addition, the average scores of direct observation of procedural skills (DOPS) and mini-experimental evaluation exercise in OBSA group were significantly higher than those in control group (P < 0.05). The majority of the medical students preferred the OBSA and considered OBSA could effectively improve their surgical operating skills (83.9%), collaborative learning skills (92.1%), and problem-solving skills (91.1%). From the above, OBSA is an effective evaluation method for the implementation of the BMLC curriculum.

INTRODUCTION

Basic medical laboratory courses (BMLCs) play an important role in medical educational courses, which help the student acquire three important skills, that is surgical operating skills, collaborative learning skills, and problem solving (1). In China, medical students receive BMLCs in the junior year of their medical training to learn to associate and to translate basic science information into clinical relevance (2). Medical educators believe motivation in BMLC teaching modality is the key element for professional outcomes of students.

Previously, the teaching modality of BMLCs has been mainly divided into two parts: first, lectures provided by teachers, and then student independent experiments. In the first part, teachers give a short lecture to teach the principles before the experiments, such as modulation of blood pressure and distribution of pharmacological agents in the body, etc., which strictly complies with the Air Force Medical University (AFMU) laboratory manual. Then, in the second part, students are divided into small groups with the number of four to six and follow the instructions in the manual to perform the medical exercises step by step. The second part occupies more than 70% course duration. Therefore, the latter part in BMLCs is the most important for medical students to improve their core capacities. However, all students complete their laboratory course without any outcome-based assessment, so that students are unable to make sufficient progress in their learning and experimental process.

The outcome-based student assessment (OBSA) is a program of AFMU in China to introduce medical students in BMLCs to every key process in all eight laboratory experiments, ranging from hands-on their operational capacities, such as “Endotracheal intubation,” “Venous cannula,” and “Artery intubation.” We observed the OBSA program can motivate students to adopt a deep learning. In China’s experimental teaching reform, there are similar models, such as a student-centered teaching (3) and self-efficacy as a goal-oriented motivation to enhance students’ confidence and motivation in the learning process (4). The advantage of the OBSA teaching model is that it combines the characteristics of a variety of teaching methods (3, 4) and focuses on improving individual learning motivation (5) and interest-based positive psychology (6). It takes clear task points as the main line of experimental evaluation system, which makes

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students think the importance of task actively, so as to improve the learning effect of practical operation skills. The purpose of this study is to explain how the OBSA is designed and its advantages in improving students’ abilities of surgical operating, collaborative learning, and problem solving. The innovation of this objective was to explore perceptions of medical students and teachers about outcome-based assessment as a program for medical learning and teaching within the BMLC in Chinese medical universities to adapt and further develop the blended teaching modality.

## METHODS

### Study Participants

The study was conducted by the School of Basic Medical Sciences at AFMU. The participating students were in their junior year majoring in Clinical Medicine when they started the basic medical laboratory course (BMLC) curriculum. The 233 students were randomly divided into 2 groups, 118 in the OBSA group and 115 in the control group. Their main characteristics are summarized in Table 1. Their first teaching part was exactly the same. In the second part of the BMLC, the experimental course stage, four to six students perform experimental operations in one small group. All of the procedures in this study were approved by Instructional Steering Committee for Medical Education of AFMU, and informed consent was obtained from the students. The students were assured that the results would be treated confidentially and could stop participating at any time.

### Formative Assessments

Traditional formative assessments in our BMLC includes four aspects: multiple-choice examinations (MCQs; as shown in Supplemental Table S1 at [https://doi.org/10.6084/m9.figshare.14221640]), average finished time, the average scores of both direct observation of procedural skills (DOPS; as shown in Supplemental Table S2 at [https://doi.org/10.6084/m9.figshare.14221640]), and mini-experimental evaluation exercise (Mini-EEX, as shown in Supplemental Table S3 at [https://doi.org/10.6084/m9.figshare.14221640]). At the end of each block, students were administered a practice mini-quiz consisting of 10–20 multiple-choice examination questions (MCQs) in a simulated test-taking environment.

The MCQ quiz is designed to contain core concepts and terminology relating to the physiology content for that corresponding block. A total of eight assessments were administered over the BMLC. The mini-quiz MCQs were developed based on difficult concepts as identified from student feedback, as well as personal experience and observations as a student, peer-tutor, and professor. Selected answer choices were analyzed, and assessments of knowledge base and preparatory effectiveness were made.

Average finished time means the average completion time of each experimental unit (4 to 6 students) in the control or intervention group. The average completion time reflects the students’ familiarity with the operation process.

DOPS is a student-centered assessment method that promotes self-directed learning because the student has to identify his learning needs (7). The DOPS in our BMLC is a nine-point rating scale organized in four performance levels of unqualified (≤6), qualified (≥6), good (7–8), and excellent (>9).

The present Mini-EEX is modified from the mini-clinical evaluation exercise (Mini-CEX) (8) and provided for teachers to first evaluate the performance of students in the laboratory and then to give the students a feedback for further improvement (the detailed items of Mini-EEX are described in Supplemental Table S3 at [https://doi.org/10.6084/m9.figshare.14221640]). The Mini-EEX is a 10-point rating scale organized in 4 performance levels of unqualified (≤6), qualified (≥6), good (7–8), and excellent (9–10).

### Traditional BMLCs and the Experimental Setup

In traditional BMLCs, students independently complete the same assigned reading before class (background and theoretical knowledge about the experiment, overview of the experiment, and step-by-step instructions). Phase 1 of the program is conducted at the first 4 wk, followed by phase 2 in 8 wk. The following subjects were being taught during phase 1: 1) how to begin scientific research, 2) how to write a scientific review, 3) how to write a research article, and 4) a brief introduction to preclinical animal models. During phase 2, students apply concepts from physiology, biochemistry, pathology, pharmacology, and microbiology. The whole second-part curriculum is divided into eight blocks (teaching unit), and each block of class hours varies from 3 to 5 with a total duration of 8 wk. Eight basic medical laboratory courses taught in every block are shown in Table 2. In this part, we use traditional formative assessment to evaluate students’ performance. In the control group, we still used traditional assessment methods. In the experimental group, we added the OBSA program during the animal experiments and administered a questionnaire to investigate the satisfaction and effectiveness of the method. The flow chart of the study is presented in Fig. 1.

### Design of the Outcome-Based Student Assessment

To strengthen core skills of medical students and specifically address the lack of surgical guidance and instructions in BMLCs, an OBSA program that comprised more than 10 evaluation points on 3 skills of surgical operating, collaborative learning, and problem solving, OBSA was introduced in 2019 as an extremely important learning approach. We further adapted and expanded the outcome-based student assessment to four subdivisions of Assessment on Anesthesia, Operation, Team Work, and Techniques in the research framework. One sample of OBSA on block 4 of chemical factors regulating cardiac activities with frog is shown in Table 3.
The outcome-based student assessment takes up 70% of the total value. In the past, this part was determined by teachers’ subjective evaluation in the traditional evaluation method. The remaining 30% are DOPS/Mini-EEX/MCQs, each accounting for 10%.

A Pilot Phase for OBSA

A pilot phase from August 2019 to September 2019 provided insight into shortcomings of the OBSA teaching modality by applying the teachers’ evaluations on the teachers themselves who have performed all BMLC experiments in advance. The most significant change was an increase in evaluations on activity with specialized equipment, followed by a change in the quizzes on application of basic science concepts, which was highly requested by BMLC teachers.

Questionnaire Survey and Exit Survey

Two surveys were distributed to students in the experimental group using a modification of the procedure reported (9). The demographic method was used to collect information about all of the students. The first student questionnaire survey (Pre-OBSA Questionnaire Survey, shown in Table 4) was mainly used to evaluate the students’ opinions on OBSA in BMLCs. The second survey (Post-OBSA Questionnaire Survey, shown in Table 4) was used to mainly evaluate overall responses of all OBSA students on the three skills of surgical operating, collaborative learning, and problem solving. Objective and subjective indicators that showed in OBSA items are used to determine the overall effectiveness of OBSA participation. The questionnaire was distributed to all students in OBSA group, and their anonymity was preserved. The distributions of the answers were analyzed as percentages of the total number of students in the 118-student section. The questionnaire was completely anonymous. Likert-style ratings (strongly agree, agree, neutral, disagree, and strongly disagree) were used.

Statistical Analysis

By referring to the scores of previous students, we set 59% as the benchmark score for the test. The average scores on the formative assessments in the control group (n = 115) and OBSA group (n = 118) in every block of BMLCs were analyzed by an independent-sample t-test and P < 0.05 was considered statistically significant. All statistical

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**Table 2. Eight blocks of basic medical laboratory courses**

| No. | Topic                                           | Length of Class | Learning Objectives                                                                 | Methodologies Implemented                                                                 | Expected Outcomes                                                                 |
|-----|-------------------------------------------------|-----------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 1   | Hypoxia animal model and its mechanisms (with rat) | 3 class hours (120 min) | Partial pressure of oxygen, Oxygen binding capacity | To replicate the animal model of hypoxic hypoxia and normoxic hypoxia. | To understand the causes of hypoxia.                                               |
| 2   | Blood pressure and its regulation (with rabbit)  | 4 class hours (160 min) | Neural regulation, Humoral regulation, Heart failure | To observe the role of nerve and humoral regulation in cardiovascular activities. | To think out the significance of drugs to prevent hypoxia.                          |
| 3   | Half-life of phenolsulfonphthalein and its distribution in the body (with rabbit) | 3 class hours (120 min) | First-order elimination kinetics, Half-life of eliminate | To master the technique of carotid artery intubation in rabbit. | To understand the pathogenesis of hemorrhagic shock.                               |
| 4   | Chemical factors regulating cardiac activities (with frog) | 3 class hours (120 min) | Excitability, Autoregulation, Conductility, Contractility | To grasp the isolation and perfusion methods of frog heart. | To understand the classification of shock.                                           |
| 5   | Pharmacological effect on cardiac rhythms (with rabbit) | 5 class hours (200 min) | Heart failure, Epinephrine and norepinephrine | To establish a rabbit model of acute heart failure. | To evaluate internal chemical factors in maintaining cardiac rhythms.               |

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**Figure 1.** The flow chart of the study is presented. MCQs, multiple-choice examination questions; OBSA, outcome-based student assessment.
### RESULTS

#### Academic Performance

The evaluation on academic performance of the students was mainly used to test the effectiveness of OBSA on the students in BMLCs. Figure 2 shows average scores on the MCQ examinations of the students in the control group (n = 115) and OBSA group (n = 118) after every block of BMLCs, analyzed by an independent-sample t test. After the first block, the scores of the students in the control group (60.1 ± 1.1) and OBSA group (60.2 ± 1.0) were not statistically different. Then, after the second block, the scores of the students in the control group increased to 63.3 ± 1.0 and the scores in OBSA group also increased to 63.8 ± 1.1, suggesting there was no significance between two groups. However, the academic performance of students began to change significantly from the third block. Figure 2 shows that the students in OBSA group were significantly better at performance from block 3 until to the last block than the students in the control group. In an example of block 8, the OBSA method helped students get average scores >80.0 ± 1.2, while the scores in the control group were maintained at <80.0 (71.0 ± 1.2).

To determine the effectiveness of OBSA on academic performance of medical students, average completion time, success in first attempt, and average scores of DOPS, and Mini-EEX in each group were recorded and analyzed. As shown in Fig. 3, taking the block 4 as a representative example, mean time to completion was significantly decreased in OBSA group (140.8 ± 19.3 min) than that in the control group (168.8 ± 20.5 min) (Fig. 3A). The success in first attempt in the OBSA group seemed to improve, but had no significance, compared with that in the control group (Fig. 3B). Moreover, the average scores of both DOPS (7.59 ± 1.74) (Fig. 3C) and Mini-EEX (7.73 ± 1.81) (Fig. 3D) in OBSA group markedly increased, compared with those in the control group (DOPS: 5.81 ± 1.83, P < 0.05; Mini-EEX: 6.34 ± 1.93P < 0.05). These results suggested that OBSA had a positive effect on academic performances of students.

#### Pre-OBSA and post-OBSA Questionnaire Surveys

The first students’ questionnaire survey (Pre-OBSA Questionnaire Survey) was mainly used to evaluate the students’ opinions on OBSA in BMLCs. Of the students in the OBSA group, all returned this questionnaire. Table 4 shows that majority (>50%) of student participants “Neither agree nor disagree” that “Every member of the group actively participated in the preparing for the OBSA programme,” or “OBSA programme helps me gain an in-depth focus on the laboratory procedures,” or “OBSA programme promotes a spirit of teamwork,” or “OBSA programme helps students to retain their moral compass related to academic misconduct.” Only 27.4% of the students agreed that “OBSA programme stimulates my critical thinking of Reduction, Refinement and

### Table 3. One sample of OBSA design in BMLCs

| Topic | Surgical Operating-Based Assessments | Collaborative Learning-Based Assessments | Problem Solving-Based Assessments |
|-------|--------------------------------------|------------------------------------------|-----------------------------------|
|       | Items | Scores | Items | Scores | Items | Scores |
| Chemical factors regulating cardiac activities (with frog) | Grab animal and destroy the spinal cord: | 5% | To show intelligence and emotion: | 30% | To apply integrated knowledge of basic science across disciplines to explain patients’ signs and symptoms: |
|       | To catch the frog according to the standard procedures: | 5% | To be engaged in encouraging the discussion support and facilitate understanding: | 30% | To demonstrate critical thinking skills based on the integrated knowledge to solve medical problems: |
|       | To locate the occipital foramen: | 5% | To analyze the pharmacological regulations: | | To demonstrate deep learning while solving medical problems using integrated knowledge: |
|       | To destroy the spinal cord: | 5% | To solve the problems during the experiment: | | To demonstrate skills in assimilating new medical information: |
|       | Ligation of the right aorta and vena cava: To clearly identify blood vessels: | 5% | To give critical thinking ways: | | |
|       | To ligate skillfully: | 5% | To cultivate the responsibility: | | |
|       | No damage to venous sinuses: | 5% | |
|       | Fixation and thoracotomy: | 20% | |
|       | To fix the frog firmly, to dissect the skin neatly, to expose the heart and arterial trunk completely without obvious bleeding: | 5% | |
|       | Frog heart intubation: | 20% | |
|       | To locate the reasonable incision position for intubation: | 20% | |
|       | To intubate the heart successfully without any damage: | 20% | |
|       | To keep the normal heartbeat: | 20% | |
|       | To fix the heart firmly: | 20% | |
|       | Isolation of heart: | 20% | |
|       | To keep neat incision and clean tissue separation: | 20% | |
|       | To avoid any damage on venous sinus: | 20% | |

BMLCs, basic medical laboratory courses; OBSA, outcome-based student assessment.
Table 4. Pre-OBSA and Post-OBSA Questionnaire Survey to evaluate the students’ opinions on OBSA in BMLCs

| Question/Questionnaire Survey                                                                 | Strongly Disagree, n, % | Disagree, n, % | Neither Agree nor Disagree, n, % | Agree, n, % | Strongly Agree, n, % |
|-----------------------------------------------------------------------------------------------|------------------------|---------------|-------------------------------|------------|-----------------------|
| Every member of the group takes part in the team-work actively with the OBSA program.         | 4, 3.4%               | 13, 11.0%     | 81, 68.6%                     | 17, 14.4%  | 3, 2.5%               |
| Pre-OBSA                                                                                      | 1, 0.8%               | 2, 1.6%       | 8, 6.8%                       | 27, 22.9%  | 80, 67.8%            |
| Post-OBSA                                                                                     |                        |               |                               |            |                       |
| OBSA program helps me gain an in-depth focus on the laboratory procedures.                     | 3, 2.5%               | 23, 19.5%     | 70, 59.3%                     | 20, 16.9%  | 2, 1.7%               |
| Pre-OBSA                                                                                      | 0, 0                   | 1, 0.8%       | 3, 2.5%                       | 24, 20.3%  | 90, 76.3%            |
| Post-OBSA                                                                                     |                        |               |                               |            |                       |
| OBSA program stimulate my critical thinking of Reduction, Refinement and Replacement in the Principles of Humane Experimental Technique. | 4, 3.4%               | 25, 21.2%     | 59, 50.0%                     | 26, 22.0%  | 4, 3.4%               |
| Pre-OBSA                                                                                      | 0, 0                   | 4, 3.4%       | 20, 16.9%                     | 27, 22.9%  | 67, 56.8%            |
| Post-OBSA                                                                                     |                        |               |                               |            |                       |
| Collaborative learning in OBSA program urged me to seriously prepare for every BMLC block.    | 4, 3.4%               | 29, 24.6%     | 49, 41.5%                     | 31, 26.3%  | 5, 4.2%               |
| Pre-OBSA                                                                                      | 0, 0                   | 5, 4.2%       | 14, 11.9%                     | 29, 24.6%  | 70, 59.3%            |
| Post-OBSA                                                                                     |                        |               |                               |            |                       |
| OBSA program provides me a more active environment to develop me to grasp the skill of surgical operating. | 4, 3.4%               | 29, 24.6%     | 49, 41.5%                     | 31, 26.3%  | 5, 4.2%               |
| Pre-OBSA                                                                                      | 0, 0                   | 5, 4.2%       | 14, 11.9%                     | 29, 24.6%  | 70, 59.3%            |
| Post-OBSA                                                                                     |                        |               |                               |            |                       |
| OBSA program gives me more profound understanding of interrelations among basic science subjects | 7, 5.9%               | 13, 11.0%     | 43, 36.4%                     | 51, 43.2%  | 4, 3.4%               |
| Pre-OBSA                                                                                      | 0, 0                   | 3, 2.5%       | 12, 10.2%                     | 28, 23.7%  | 75, 63.6%            |
| Post-OBSA                                                                                     |                        |               |                               |            |                       |
| OBSA program helps me appreciate the importance of basic science subjects in clinical practice. | 9, 7.6%               | 50, 42.4%     | 53, 44.9%                     | 1, 0.8%    | 5, 4.2%               |
| Pre-OBSA                                                                                      | 0, 0                   | 11, 9.3%      | 18, 15.3%                     | 28, 23.7%  | 61, 51.7%            |
| Post-OBSA                                                                                     |                        |               |                               |            |                       |
| OBSA program promotes a spirit of teamwork.                                                   | 8, 6.8%               | 34, 28.8%     | 70, 59.3%                     | 6, 5.1%    | 0, 0                  |
| Pre-OBSA                                                                                      | 0, 0                   | 0, 0          | 2, 1.7%                       | 18, 15.3%  | 98, 83.1%            |
| Post-OBSA                                                                                     |                        |               |                               |            |                       |
| OBSA program promotes the critical thinking skills based on the integrated knowledge to solve medical problems. | 11, 9.3%              | 28, 23.7%     | 59, 50.0%                     | 14, 11.9%  | 6, 5.1%               |
| Pre-OBSA                                                                                      | 1, 0.8%               | 2, 1.7%       | 3, 2.5%                       | 13, 11.0%  | 99, 83.9%            |
| Post-OBSA                                                                                     |                        |               |                               |            |                       |
| OBSA program helps students to retain their moral compass related to academic misconduct.     | 8, 6.8%               | 28, 23.7%     | 64, 54.2%                     | 11, 9.3%   | 7, 5.9%               |
| Pre-OBSA                                                                                      | 1, 0.8%               | 6, 5.1%       | 13, 11.0%                     | 7, 5.9%    | 91, 77.1%            |
| Post-OBSA                                                                                     |                        |               |                               |            |                       |

BMLCs, basic medical laboratory courses; OBSA, outcome-based student assessment; n = 118 students.

Replacement in the Principles of Humane Experimental Technique.” Even 7.6% of the students strongly disagreed “OBSA programme helps me appreciate the importance of basic science subjects in clinical practice.” It is not an unexpected result that the majority of students before implementation of the OBSA training held negative or skeptical opinion on this program.

Post-OBSA Questionnaire Survey in Table 4 shows students in the OBSA group evaluated their level of improvement with regards to their three skills, including surgical operating, collaborative learning, and problem solving. The median responses for the “strongly agree” or “agree” per the total responses, as well as the sum of all positive responses (agree and strongly agree categories), are shown in Table 4. Table 4 also shows that 83.9% of student participants “agree” and “strongly agree” that completing the program was useful in helping to improve their surgical operating skills. At the same time, 92.1% of student participants “agree” and “strongly agree” that completing the program was useful in helping to improve their collaborative learning skills. Additionally, 91.1% of students found the program helpful in improving their problem-solving skills.

**Discussion**

The present study investigated the impact of an outcome-based student assessment (OBSA) program on student improvement in basic medical laboratory courses (BMLCs) of the third-year medical curriculum especially in terms of improving their surgical operating, collaborative learning, and problem-solving skills. As hypothesized, the OBSA program did enhance the three skills and improve academic performances on multiple-choice examinations (MCQs),
average finished time, the average scores of both direct ob-
servation of procedural skills (DOPS), and mini-experimental
evaluation exercise (Mini-EEX) in BMLCs.

Several studies have proven the utility of small-group
based supplemental instruction programs in increasing stu-
dent academic success in the medical education setting and
reported findings consistent with those from our study (10–
12). Earlier research also confirmed positive effect of a small-
group, active learning, tutorial-based, in-course enrichment
program on student performance in medical physiology at
the Rocky Vista University College of Osteopathic Medicine
(10). Based on the traditional project-based learning teach-
ing, Sydney Medical School has added TB50 teaching, which
has the smaller group size, the preparatory Readiness
Assurance Testing process, facilitation by a clinician, an em-
phasis on basic science concepts, and immediate feedback.
This supplemental instruction program improved students’
ability in four aspects: guided learning, problem solving, col-
laborative learning, and critical reflection (11).

BMLCs began with the simple physiological experiments
and went to more difficult modules related to neurophysiol-
ogy, pharmacology, and cardiovascular systems. Although
students who did not enter the OBSA program and had
increased scores in MCQ examinations with the eight blocks
have gone on, this is mostly because of the much better
understanding of the physiological concepts and more confi-
dence in their ability to pass the course. On the contrary,
with the process of OBSA training in every block, the stu-
dents show better progress in all aspects in the following six
blocks, suggesting that outcome-based skill-building train-
ing was able to enhance student recognition of relevant
course content, identify any ensuing knowledge gaps, and
reinforce the application of difficult and/or important theo-
retical concepts on multiple-choice assessments. Compared
with the control group, the average completion time of the
OBSA group was significantly shorter, which was consistent
with the observed classroom performance in BMLCs, i.e.,
medical students were able to start and complete experi-
ments more quickly under the guidance of the OBSA group.
Although the difference was not statistically significant, it
was also observed that the OBSA group showed an upward
trend in success in first attempt compared with the control
group, which may require a larger sample size to be
confirmed in our further study. Direct observation of proce-
dural skills (DOPS) and Mini-Clinical Evaluation Exercise
(Mini-CEX) were worldwide used as formative assessments
in medical education to evaluate clinical skills, and were cre-
atively introduced as DOPS and mini-experimental evalu-
ation exercise (Mini-EEX) to determine the effectiveness of
OBSA in our study. The average scores of DOPS and Mini-
EEX of OBSA group were both markedly higher than control
group, which furtherly certified the positive effect on aca-
demic performances of medical students in BMLCs.

Before OBSA program, the average evaluations of the stu-
dents were not optimistic, especially on the possible out-
come related to the study skill techniques, the ability to
apply difficult physiological concepts, and their overall aca-
demic performance. It is exciting that post-OBSA, the major-
ity of students showed significant progress in three
important skills of surgical operating, collaborative learning,
and problem solving. They would recommend the program
to incoming third-year medical students. These outcomes
were consistent with previous studies that showed that, as
medical students progress through their studies, they
become more receptive toward team work and better appreci-
ate the effectiveness of the competitions (13). Currently,
there exists a sufficient amount of data that support the use
of OBSA learning to supplement medical curriculum at the
basic sciences level, as well as the notion that those OBSA
sessions are meaningful tools to significantly enhance med-
ical student performance in various basic medical subjects.

Figure 2. Average scores on the MCQ examinations of the students in the
control group (n = 115) and OBSA group (n = 118) after every block of BMLCs,
analyzed by an independent-sample t test. Values are means ± SD. *P <
0.05. BMLCs, basic medical laboratory courses; MCQs, multiple-choice ex-
admination questions; OBSA, outcome-based student assessment.

Figure 3. Average completion time, success in first attempt, average
DOPS scores and average Mini-EEX scores of the students in the control
group and OBSA group in block 4 of BMLCs, analyzed by an independ-
ent-sample t test. Values are means ± SD. *P < 0.05. DOPS, direct obser-
vation of procedural skills; Mini-EEX, mini-experimental evaluation
exercise; OBSA, outcome-based student assessment.
OBSA IMPROVES ACADEMIC PERFORMANCE OF MEDICAL STUDENTS

Limitations

The main limitation of this paper is that we only conducted a questionnaire survey in the experimental group but not in the control group. The solution to this problem is that we will seek to establish a standardized evaluation method and make it applicable to a wider range of scenarios.

Conclusions

The OBSA program was designed to focus on improve students’ skills of surgical operating, collaborative learning, and problem solving, which mainly increases comprehension and application of course material to overcome compromised performance on course assessments. Our findings suggest that the small-group, outcome-based assessment OBSA program was an extremely valuable resource for enhancing the ability of students to effectively identify, understand, and apply difficult and/or important physiological concepts and improve performance on multiple-choice assessments, thereby reducing academic failure and enabling students to successfully navigate basic medicine and significantly improve their overall course performance. The conclusions from this study may provide a strong basis for the implementation of similar OBSA programs as an academic support in other medical institutions within China, even worldwide.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

Y.-Y.W. and H.-F.Z. conceived and designed research; K.-F.L., B.-Z.L., F.-F.W., X.-C.S., Y.-S.W., F.T., L.-L.J., N.-N.L., H.-F.Z., and Y.-Y.W. performed experiments; K.-F.L., B.-Z.L., Y.-Y.W., and N.-N.L. analyzed data; K.-F.L., X.-C.S., and L.-L.J. interpreted results of experiments; K.-F.L., B.-Z.L., X.-C.S., and F.T. prepared figures; K.-F.L., B.-Z.L., X.-C.S., F.T., and Y.-Y.W. drafted manuscript; K.-F.L., B.-Z.L., Y.-Y.W., and H.-F.Z. edited and revised manuscript; K.-F.L., B.-Z.L., F.-F.W., X.-C.S., Y.-S.W., F.T., L.-L.J., N.-N.L., H.-F.Z., and Y.-Y.W. approved final version of manuscript.

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