Benefit of Writing Laboratory Previews for Anatomy Learning in Medical Students

Ming-Fong Chang[1], *Meng-Lin Liao*[1], *Sung-Tsang Hsieh*[1,2], *Shu-Huei Wang*[1], *Li-Jen Lee*[1], *Hsiu-Ni Kung*[1], *Kuo-Shyan Lu*[1], *Yuh-Lien Chen*[1] & *June-Horng Lue*[1]

Purpose: The teaching of human anatomy for medical students requires remarkable teaching hours on the dissection of cadavers. Most medical schools are facing the challenges of teaching anatomy with limited teaching time. Innovative teaching methods are needed to help students establish anatomical knowledge. This study was aimed to evaluate the benefits of writing laboratory previews in anatomy dissection courses. **Methods:** Our data were collected from 135 medical students who studied human anatomy. The data included times of laboratory previews and scores of lecture and laboratory examinations. Students' examination performance was divided into three groups: low (≤ 25 percentile), middle (25 percentile < score < 75 percentile), and high performance (≥ 75 percentile). We then conducted statistical analysis to understand whether more times of laboratory previews could improve academic performance. **Results:** There was a significant improvement between the groups of eight previews (49.2 ± 4.2) and six previews (37.6 ± 4.5) in low academic performance students (P = 0.04). Furthermore, there was a significant improvement in the group of eight previews in comparison with the group of seven previews (69.9 ± 3.3 vs. 58.0 ± 3.5; P = 0.01) in the academic performance of between 25 and 75 percentile group, which majority of the medical students belonged. **Conclusions:** Writing laboratory previews for anatomy dissection courses was beneficial for students. Our data indicated that laboratory previews improved laboratory performance in the majority of students. The quality of laboratory previews could be added as another parameter to assess the impacts of laboratory previews on learning anatomy.

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[1] Department of Anatomy and Cell Biology, College of Medicine, National Taiwan University, Taipei 10051, Taiwan; [2] Department of Neurology, National Taiwan University Hospital, Taipei 10051, Taiwan
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Correspondence to: June-Horng Lue, Department of Anatomy and Cell Biology, College of Medicine, National Taiwan University, No.1, Section 1, Jen-Ai Road, Taipei 10051, Taiwan.
E-mail: thomas@ntu.edu.tw

INTRODUCTION

The demand for medical services is growing because of the increase in the elderly population and chronic diseases.[1,2] Increasing the demand for medical services also raises the demand for qualified medical personnel, thus creating the need to enhance medical education resources. The teaching resources of medical education are mainly to increase the demand for core courses such as anatomy, physiology, pharmacology, and pathology.

Anatomy is the traditional core curriculum of medical education, and medical students gain anatomical knowledge as the basis of their medical careers. Anatomical knowledge helps medical students establish concepts for diagnosis and therapy. It is also a good starting point for medical students to learn how to communicate with patients in the context of diagnosis and discovery.[3] Anatomy courses that include teaching lectures and complete dissection of human bodies are important for medical students.[4,5] These allow them to understand the human body structures by carefully dissecting the cadavers. Therefore, anatomy teaching requires a sufficient number of instructors to closely supervise students.[6] However, medical schools around the world are facing the problem of lacking qualified anatomists.[7,8] Because of their shortage in medical schools, the teaching time for anatomy will be reduced.[6,9] To improve the students' learning of anatomy in this situation, the anatomy teachers had made some modifications: the addition of special learning modules, the integration of anatomy in problem-based learning, and the use of indicted specimens, computer-generated images, plastic models, and other tools.[10,11] However, using 2D or 3D virtual software applications and computer-assisted learning programs, instead of real human dissection, remains controversial. Although the use of teaching tools could promote student to learn anatomy via lectures, dissecting cadavers still remains a necessary step for medical students.[12]

The anatomy course of the National Taiwan University (NTU) in medical students includes traditional teacher teaching and then dissecting the body after lecture teaching. Our anatomy courses have been similar in the last decade. The course allocates 110 to 115 h a year for lectures and 155 to 160 h per year for laboratory dissection. In terms of time allocation, dissection is the main learning mode of anatomy, which consumes about 60% of the teaching time (260-270 h per year). In addition, the anatomy course at other universities assigned 73 ± 18 h per year for lecture teaching and 100 ± 28 h per year for laboratory dissection. The anatomy course at NTU allocates more time than other universities in Taiwan. But compared with international universities, the total teaching time for anatomy at NTU is relatively less.[13] Therefore, medical students in Taiwan face obstacles in dissecting cadavers within a limited time. Shortening the teaching time of anatomy courses has become a trend in the world.[6,9] The challenge for anatomical teachers is how to improve the study of general anatomy, especially the dissection of the cadavers, within a limited teaching time. Therefore, it is necessary to develop a good strategy to help medical students study anatomy.

In this study, we evaluated the benefits of laboratory previews. To understand whether writing laboratory previews can improve the performance of students in learning anatomy, we analyzed the relationship between the number of submissions and the scores. The purpose of this study was to demonstrate the benefits of writing laboratory previews in anatomy learning.

METHODS

The academic year of the NTU School of Medicine is divided into two semesters: September to January and February to June. Third-year medical students study systematic anatomy each year from September to October. The systematic anatomy course contains an overview of the skeletal, muscular, cardiovascular, and nervous systems. After completing the systematic anatomy course, students need to take an exam to assess their knowledge of the basic concepts of the human body.

During the period from November to June, students begin to study regional anatomy, which is a course that includes gross anatomy lectures and human body dissection. Regional anatomy is divided into five units including the upper limb (November), thorax and abdomen (December), pelvis and perineum (January), head and neck (March to May), and lower limb (June). The related systems (respiratory, digestive, and reproductive systems) are introduced in detail in each corresponding area. During dissection, students are divided into 12-13 groups based on the size of the population and the number of cadavers available. After studying the gross anatomy, the students enter the gross anatomy laboratory for dissection. During the period from November to June, students attend dissection courses two to three times a week. According to the course arrangement, the students are grouped into four to six people to dissect. The groups take turns to conduct dissection, and each student has eight opportunities to dissect the cadaver per semester. In addition, teachers require students, who were the actual operators of dissection, to provide a preview before dissection. The students write laboratory previews of the anatomy experiment according to the anatomy manual, handouts, and books. Laboratory previews should include sketch diagrams, anatomical terms, anatomical steps, and anatomical landmarks. The anatomy teachers check the students' laboratory previews and record their number of submissions. We required students to make laboratory previews for the anatomical area before the experiment. If the students completed the preview after the start of the dissection, then we will not accept it. Students will have a record of missing assignment, and the number of submissions is less than eight times. During the period from November to January, students will complete the dissection of the upper limbs, thorax, abdomen, pelvis, and perineum. At the end of the first semester, students will take exams, including lectures and experiments. The lecture score evaluates the learning performance of the anatomy course, whereas the laboratory score measures students' learning of human anatomy through dissection. In the second semester, students will use the same approach to learn the gross anatomy of the head, back, neck, and lower limbs.

The method of laboratory previews was conducted as follows:

(1) At the beginning of the gross anatomy laboratory class, all students were assigned to 12-13 groups, and each group had a cadaver for dissection. Anatomical experiments were conducted 4-12 h per week, and each student has the opportunity to dissect a cadaver in each region.
(2) All students in the classroom listened to the lectures and then dissected a cadaver with the same area in the gross anatomy laboratory.
(3) One week before the class, the lecture notes for the course were sent to the students. Students used these resources (such as handouts and books) to write laboratory previews that were required from them. Before the anatomical

experiment, the teacher examined and recorded the students' laboratory previews in the gross anatomy laboratory.

(4) To guarantee an average participation in the dissection, each group followed a schedule to ensure that each student had the same number and time of operation. While the students were not dissecting, they observed the structures being dissected by actual operators or read books. At the end of each anatomical unit, the actual operators needed to complete the keywords on the checklist and to introduce them to other students.

(5) From November to June, each anatomy teacher spent 8-10 h checking and recording the students' laboratory previews.

In this study, we collected the number of times students submitted laboratory previews from regional anatomy, including the upper limbs, thorax, abdomen, and pelvis. To understand the benefits of laboratory previews for gross anatomy learning, we analyzed the relationship between the number of laboratory preview submissions, lecture exam scores, and laboratory exam scores (below the 25 percentile, between the 25 and 75 percentiles, and above the 75 percentile). The results of each group were presented in a scatter plot, and a statistical *t*-test was performed to see if the number of laboratory previews improved anatomical learning. If a student had an absent record, the student's data are excluded. The number of students with no recorded absences was 135 in the present study. Statistical *t*-tests provided a significant difference analysis between each group of medical students in gross anatomy.

RESULTS

The Correlation Analysis between Lecture and Laboratory Scores in Gross Anatomy

After anatomical examinations, the students' lecture and laboratory scores were depicted in scatter plots (Figure 1). The correlation analysis between lecture and laboratory scores showed a Pearson's correlation coefficient of 0.73 (> 0.7; $p < 0.0001$). The result showed that students' lecture scores were significantly correlated with laboratory scores.

What is the Difference between Scores and Times of Laboratory Previews of the Same Class?

Medical students did anatomy examinations after writing laboratory previews. After introducing the writing laboratory previews, the average performance of lectures had no significant difference from the different groups based on the times of the laboratory previews (Figure 2A and Table 1). Also, there was no significant difference among these groups in the laboratory performance analysis (Figure 2B and Table 1).

Statistical Analysis of the Relationship between Scores and the Number of Writing Laboratory Previews among Students with Different Academic Performances

To understand whether writing laboratory previews could improve the learning anatomy of medical students, we divided students' examination scores into three groups: low ($\leq$ 25 percentile), middle (25 percentile $<$ score $<$ 75 percentile), and high performance ($\geq$ 75 percentile). Each group was further divided into several subgroups

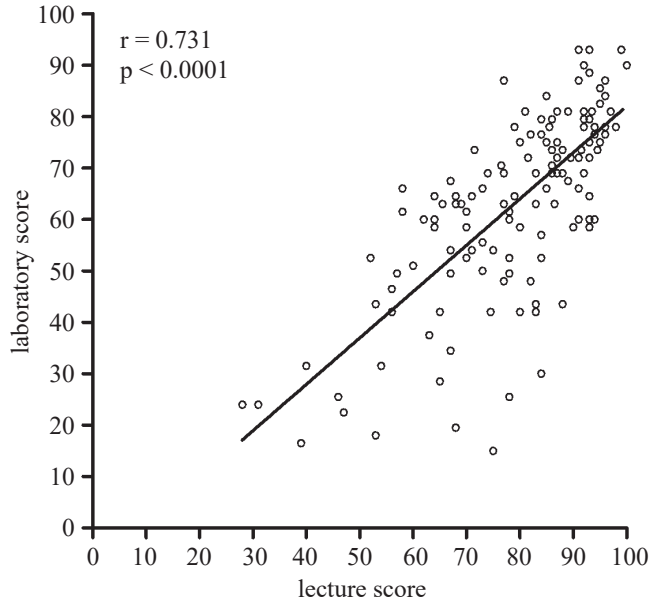

Figure 1. The scatter plot between lecture and laboratory scores in gross anatomy. The scatter plot of students' lecture score (x-axis) and laboratory score (y-axis) fit with linear regression. There was a significant correlation between lecture and laboratory scores in students' academic performance.

according to the different times of laboratory previews to study the beneficial effects of laboratory previews in anatomy learning.

In the low academic performance groups with lecture scores below 25 percentile, there was an increasing trend of laboratory scores against the times of writing laboratory previews (Figure 3A and Table 2A). There was a significant difference between the group of eight times of writing previews (49.2 ± 4.2) and the group of six times of writing previews (37.6 ± 4.5; $p = 0.04$; Figure 3A). In the lecture score group, there was no significant difference between the groups with the laboratory score below the 25 percentile (Figure 3B and Table 2B). This observation suggested that writing laboratory previews significantly improved the anatomical laboratory performance in the low lecture performance group.

The academic performance of the majority of medical students is from 25 to 75 percentile. We did the same comparison to understand whether writing laboratory previews could improve the learning anatomy of these students. In the major academic performance groups with lecture scores between 25 and 75 percentiles, there was a significant difference between the group of eight times of writing laboratory previews and the group of seven times of writing laboratory previews (69.9 ± 3.3 vs. 58.0 ± 3.5; $p = 0.01$; Figure 4A). There was no significant difference in lecture scores between the groups with laboratory score within 25 to 75 percentiles (Figure 4B and Table 3B). This finding indicated that writing laboratory previews could significantly improve the anatomical laboratory performance.

In the high academic performance group, there was no significant difference in the lecture score above the 75 percentile (Figure 5A and Table 4A). A similar trend was also observed in laboratory scores above the 75 percentile (Figure

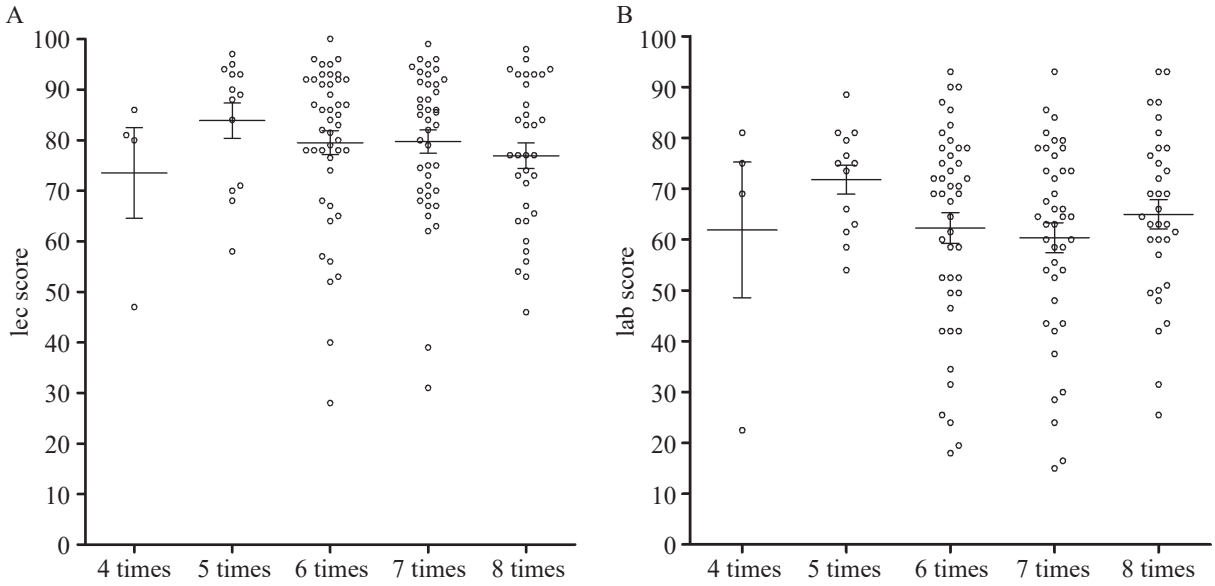

Figure 2. The relationship between scores and times of laboratory previews. (A) The lecture performance (lec score) of medical students was analyzed with the number of laboratory previews. (B) The laboratory performance (lab score) of medical students was plotted against the number of laboratory previews. There was no significance between each group in lecture and laboratory performance.

Table 1. Summary of the scores with the number of laboratory previews LP, laboratory previews; SEM, standard error of mean.

Number of LP	4 times	5 times	6 times	7 times	8 times
n	4	13	44	41	33
Mean ± SEM of lecture score	73.5 ± 8.9	83.8 ± 3.5	79.5 ± 2.3	79.7 ± 2.3	76.9 ± 2.5
Mean ± SEM of laboratory score	61.8 ± 13.3	71.7 ± 2.8	62.2 ± 3.0	60.3 ± 2.9	64.9 ± 2.8
P-value of lecture score (vs. 8 times)	0.333	0.069	0.232	0.207	
P-value of laboratory score (vs. 8 times)	0.370	0.087	0.263	0.138	

5B and Table 4B). These results implied that students with high academic performance were not affected by the number of writing laboratory previews.

DISCUSSION

Although anatomy is the core curriculum in medical education, the reduction of teaching time in anatomy courses for medical students is a trend in the world.[6,9] To facilitate medical students to learn anatomy, several innovative teaching strategies have been developed, including problem-based learning, reciprocal peer teaching, and team-based learning.[14-17] However, there was no evidence to examine whether writing

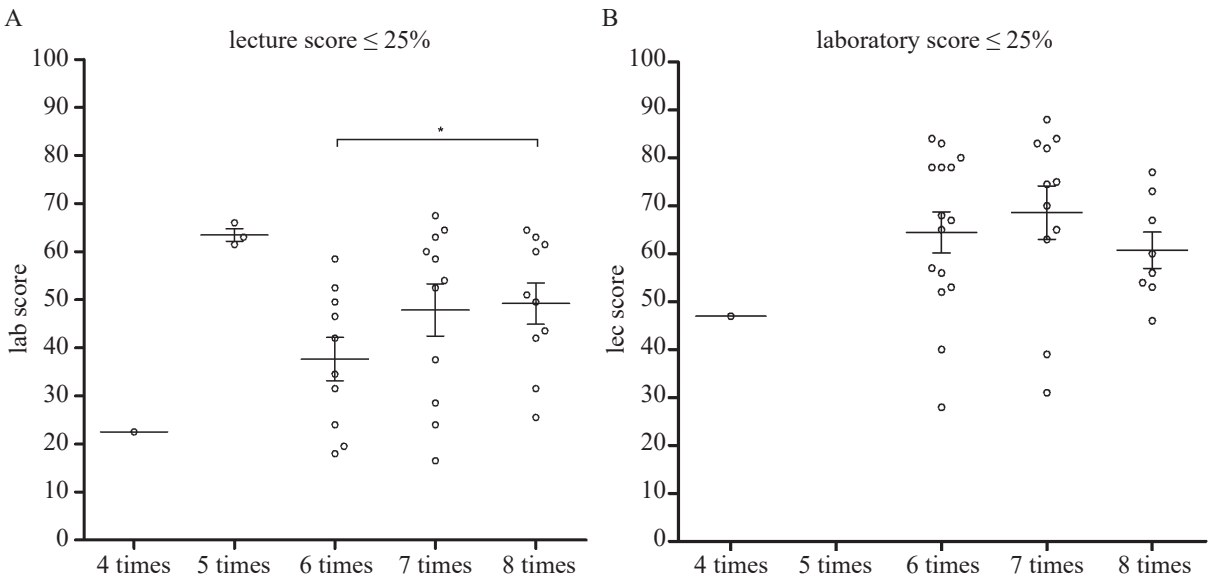

Figure 3. The relationship between scores and times of laboratory previews in the group with low academic performance. The laboratory performance (lab score) of medical students with lecture score ≤ 25 percentile was plotted and analyzed according to the number of laboratory previews. (A) There was a significant difference between the groups of six and eight times of laboratory previews. The lecture performance (lec score) of medical students with lab score ≤ 25 percentile was plotted against the number of laboratory previews. (B) There was no significant difference between each group. *$P < 0.05$.

Table 2. Summary of the scores with the number of laboratory previews in the low academic performance group LPs, laboratory previews; SEM, standard error of mean.

A: Lecture score ≤ 25%

Number of LP	4 times	5 times	6 times	7 times	8 times
n	1	3	10	11	10
Mean ± SEM of laboratory score	22.5 ± 0	63.5 ± 1.3	37.6 ± 4.5	47.8 ± 5.4	49.2 ± 4.2
P-value (vs. 8 times)		0.052	0.040	0.425	

B: Laboratory score ≤ 25%

Number of LP	4 times	5 times	6 times	7 times	8 times
n	1	0	15	11	8
Mean ± SEM of lecture score	47 ± 0		64.4 ± 4.2	68.5 ± 5.5	60.7 ± 3.7
P-value (vs. 8 times)			0.287	0.149	

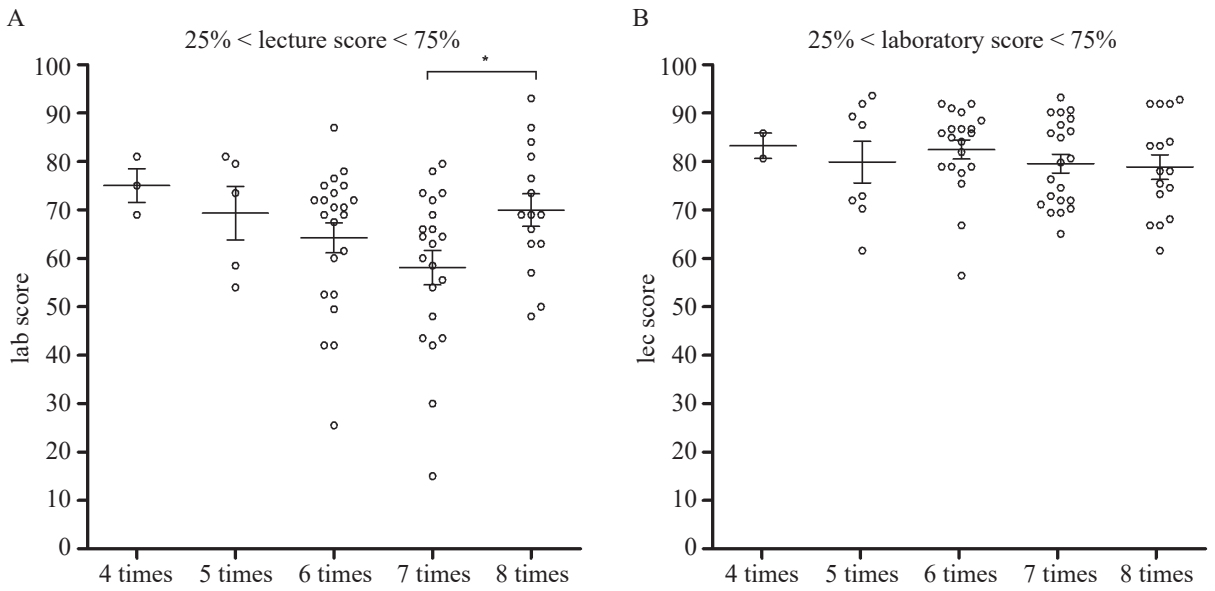

Figure 4. The relationship between times of laboratory previews and major academic performance of medical students in the anatomy course. The laboratory performance (lab score) of medical students with lecture score between 25 and 75 percentiles was plotted against the number of laboratory previews. (A) There was a significant difference between the groups of seven and eight laboratory previews. The lecture performance (lec score) of medical students with the laboratory score between 25 and 75 percentiles was plotted against the number of laboratory previews. (B) There was no significant difference between each group. *$P < 0.05$.

Table 3. Summary of the scores with the number of laboratory previews in the major group of academic performance LP, laboratory previews; SEM, standard error of mean.

A: 25% < Lecture score < 75%

Number of LP	4 times	5 times	6 times	7 times	8 times
n	3	5	22	21	15
Mean ± SEM of laboratory score	75.0 ± 3.4	69.3 ± 5.5	64.2 ± 3.1	58.0 ± 3.5	69.9 ± 3.3
P-value (vs. 8 times)	0.262	0.462	0.115	0.012	

B: 25% < Laboratory score < 75%

Number of LP	4 times	5 times	6 times	7 times	8 times
n	2	8	20	21	16
Mean ± SEM of lecture score	83 ± 3	79.1 ± 4.9	82.1 ± 2.2	78.6 ± 2.2	77.9 ± 2.9
Versus 8 times *P*-value (vs. 8 times)		0.413	0.130	0.410	

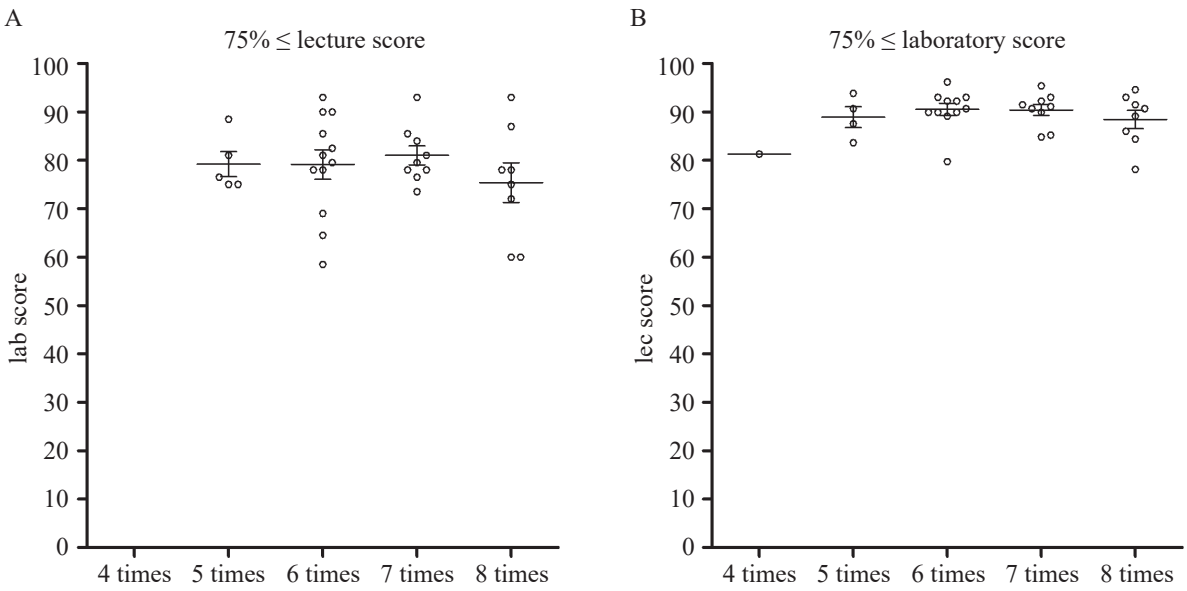

Figure 5. The relationship between scores and times of laboratory previews. (A) The laboratory performance (lab score) of medical students with a lecture score ≥ 75 percentile was analyzed with the number of laboratory previews. The lecture performance (lec score) of medical students with laboratory score ≥ 75 percentile was plotted as a scatter plot against the number of laboratory previews. (B) There was no significant difference between each group in the lecture score and the laboratory score ≥ 75 percentile.

Table 4. Summary of the scores with the number of laboratory previews in the group of high academic performance LP, laboratory previews; SEM, standard error of mean.

A: Lecture score ≥ 75%

Number of LP	4 times	5 times	6 times	7 times	8 times
n	0	5	12	9	8
Mean ± SEM of laboratory score		79.2 ± 2.5	79.1 ± 3.0	81.0 ± 1.9	75.3 ± 4.1
P-value (vs. 8 times)		0.255	0.232	0.108	

B: Laboratory score ≥ 75%

Number of LP	4 times	5 times	6 times	7 times	8 times
n	1	4	11	9	8
Mean ± SEM of lecture score	81 ± 0	90.7 ± 2.7	92.8 ± 1.5	92.6 ± 1.4	90.1 ± 2.4
P-value (vs. 8 times)		0.439	0.172	0.185	

anatomical laboratory previews could improve anatomy learning. To understand the effects of laboratory previews on learning anatomy, we used the writing laboratory previews method in NTU. The anatomy curriculum contains two stages: systemic anatomy and regional anatomy with the dissection of human cadavers. Students have the basic concepts after completing systemic anatomy. In the regional anatomy section, medical students write the anatomical laboratory previews before dissection based on the basic concept of system anatomy and the handouts of dissection. At the end of the semester, we collected the records of students' laboratory previews and exam scores for data analysis. This study provided the information about the benefits of writing laboratory previews in the anatomy course.

Our study demonstrated the beneficial effects of writing laboratory previews in anatomy courses. Particularly, the main and low lecture score groups had better laboratory scores owing to writing more times of laboratory previews. This suggested that writing laboratory previews could provide benefits for learning anatomy in medical students.

Medical students were divided into several groups for dissecting cadavers. The anatomy learning method in NTU may be similar to team-based learning. Although the students did not discuss in advance as team-based learning did, they discussed at the end of the dissection class.[16] In the previous studies, the academic performance could be improved through peer discussion in problem-based learning and team-based learning.[14-21] However, personality is an important factor to influence learning performance through discussion.[15,16] The extraverted students familiarized themselves into a group for learning and discussing with peers, but the introverted students have insufficient confidence in the discussion, especially for some low academic performance students. This suggested that the anatomy teachers should develop teaching strategies to help these students improve anatomy learning.

In our study, the laboratory preview method not only increased academic performance in low and middle score students but also provided some advantages for students and anatomy teachers. First, although the students were dissectors, writing the laboratory previews while drawing anatomical structures helped dissectors build the guidelines of human body. This allowed dissectors to spend less time for checking atlas or asking guidance from teachers. This benefit could provide a good way for anatomical teachers to overcome the shortage of teaching time and qualified anatomical teachers.[6-9] Second, the students with low academic performance and introverted personality usually feel the lack of confidence in peer discussion. The preparation of laboratory previews may help these students build confidence in communicating with their peers in the discussion section. Third, writing laboratory previews is not affected by different personalities. The laboratory preview method helped students build the fundamental knowledge of human anatomy before dissection and discussion. Therefore, writing laboratory previews could improve the quality of peer discussions. This suggests that the laboratory preview method is suitable for combination with problem-based learning, team-based learning, and reciprocal peer teaching or traditional lecture.

This study had some limitations. First, we used the times of laboratory previews to represent the performance of the laboratory previews from medical students. In addition to the times of laboratory previews, the quality index of laboratory previews should be evaluated. This index could help explain why some students attained high-level scores in examination with fewer times of the laboratory previews. A more

accurate evaluation method of laboratory previews should be established. Second, the statistical power of this study was not enough. The sample size was not enough in the groups of writing fewer previews. Third, feedback from students should be collected. Feedback surveys could provide detailed information to elucidate the motivation and thoughts of the students. In the future, we could eliminate these limitations to assess the benefits of writing laboratory previews in anatomy learning.

In the present study, our results demonstrated that writing laboratory previews significantly improved major medical students to study the dissection of cadavers in the anatomical laboratory. Writing laboratory previews would be a useful strategy for anatomy teachers in the future.

CONCLUSIONS

Our study demonstrated the beneficial effects of writing laboratory previews in anatomy courses. Particularly, the groups with main and low lecture score had better laboratory scores because of writing more laboratory previews. Writing laboratory previews could be a useful strategy for learning anatomy dissection.

COMPETING FINANCIAL INTERESTS

The authors declare no competing financial interests.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Informed consents for data collection were obtained from all participants. The ethical approval was obtained from Research Ethics Committee of NTU.

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