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Adaptations in Anatomy Education during COVID-19

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ABSTRACT

Background: The impact of coronavirus disease 2019 (COVID-19) has profoundly affected education, with most universities changing face-to-face classes to online formats. To adapt to the COVID-19 pandemic situation, we adopted a blended learning approach to anatomy instruction that included online lectures, pre-recorded laboratory dissection videos, and 3D anatomy applications, with condensed offline cadaver dissection.

Methods: We aimed to examine the learning outcomes of a newly adopted anatomy educational approach by 1) comparing academic achievement between the blended learning group (the 2020 class, 108 students) and the traditional classroom learning group (the 2019 class, 104 students), and 2) an online questionnaire survey on student preference on the learning method and reasons of preference.

Results: The average anatomy examination scores of the 2020 class, who took online lectures and blended dissection laboratories, were significantly higher than those of the 2019 class, who participated in an offline lecture and dissection laboratories. The questionnaire survey revealed that students preferred online lectures over traditional large group lecture-based teaching because it allowed them to acquire increased self-study time, study according to their individual learning styles, and repeatedly review lecture videos.

Conclusion: This study suggests that a blended learning approach is an effective method for anatomy learning, and the advantage may result from increased self-directed study through online learning.

Keywords: Anatomy Education; COVID-19; Blended Learning; Self-directed Learning

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has significantly affected education all over the world. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), COVID-19 has affected 85% of enrolled students worldwide.^{1,2} In most countries, medical education for both lectures and laboratory classes has been transferred from the physical classroom to online.^{3,4} Anatomy education has been presented

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Author Contributions

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with various platforms, with multiple opinions regarding the conducting of online classes, and the sudden conversion to online.⁵⁻⁷ In Korea, anatomy lectures were changed to entirely online at all medical schools, and the dissection laboratories were either replaced virtually or postponed until after the COVID-19 situation improved.

Since the Korean government raised the infectious disease crisis level to “severe,” on February 23,⁸ the spring semester could not begin as usual, and Korea University banned all offline classes from February 28. Korea University College of Medicine (KUCM) began its first-year classes online on March 24, and the anatomy lectures were also conducted online. The rapid increase in COVID-19 infections led the anatomy department of KUCM to close the dissection laboratory. As an alternative, assignments utilizing a video displaying the dissection process and a 3D program explaining anatomical structures were provided to students. On April 21, when the number of confirmed COVID-19 patients in Korea decreased to around ten per day, the anatomy department decided to start an in-person dissection laboratory.

Blended learning is a type of education that combines traditional offline classes with online lectures. It is widely used to incorporate the advantages of offline and online courses.^{9,10} There have been mixed results in previous studies of blended learning in anatomy. In studies comparing blended learning and traditional teaching methods in anatomy courses, students' grades were improved in blended learning groups in some studies,^{11,12} while there was no difference in other studies.^{13,14} Although Pereira et al.¹¹ showed increased student satisfaction with blended learning, other students reported decreased interest in online subjects and negative responses regarding excess workload during the course.¹² When Anatomy Massive Open Online Course (MOOC) lectures supplemented offline lectures, most students opposed the idea of completely replacing the existing offline classes with online ones.¹⁵

Various e-learning materials have been used in the gross anatomy laboratory. Studies using multimedia during anatomy courses showed that adding various materials helped enhance students' knowledge gain in anatomy.^{11,16} 3D computer programs showing the location, positional relationship, and function of anatomical structures have been developed and incorporated into anatomy education.¹⁷⁻²² However, the previous studies reported that replacing the cadaver laboratory entirely with e-learning had a negative impact on the students' anatomy grades.^{17,19}

Due to the COVID-19 pandemic, we resorted to adopting blended learning in the anatomy course, which we had not initially intended or prepared for. Although the students' responses to online anatomy teaching were remarkably positive, the teachers of the anatomy department were skeptical, and concerned about the effectiveness of altered teaching methods in whether the students' performance could reach the intended learning outcomes. Accordingly, this study aimed to examine the educational outcomes of the online and blended learning approach in anatomy. The specific research questions were: 1) Are the students' anatomy achievement scores in a new blended learning approach similar to those achieved with traditional learning methods?; 2) What factors contributed to students' academic achievement?; and 3) What further improvements can be made to the blended learning approach?

METHODS

Adaptations of anatomy lectures in response to COVID-19

KUMC is a 6-year medical college which consists of pre-medical studies (years 1 and 2), preclinical (years 3 and 4), and clinical clerkship rotations (years 5 and 6). The annual number of matriculant students is 106. The anatomy course consists of large group lectures and traditional cadaver dissection laboratories held in the spring semester of year 3. However, due to COVID-19, anatomy teaching was inevitably replaced by online education, synchronously or asynchronously through a learning management system (LMS) called the Black Board Collaborate (BBC). Limb, back, thorax, abdomen and pelvis lectures were taught asynchronously, and head and neck lectures were delivered synchronously. Interactions between professors and students were made available through chats in real-time online classes. For the pre-recorded lectures, a discussion space was provided at the BBC to promote inquiry from students and answers from professors, and students could repeatedly review and study over the videos until each examination date. Additional change during the 2020 anatomy course was providing all lecture materials to students in advance of each class, whereas in 2019, only lecture handouts for limbs and thorax were provided to students before the class. The lecturers for all areas, except for the back, were the same in the 2019 and the 2020 class.

Adaptations of cadaver dissection laboratories in response to COVID-19

In the 2019 class, the cadaver dissection laboratory immediately followed the anatomy lecture of the same subject. The laboratory was conducted 3–4 times a week, for about 4 hours each time, following a brief explanation of the contents and how to proceed with the dissection. One cadaver was assigned to every five to six students. We provided the checklists of the structures to observe during the dissection and the e-Anatomy® (Panmun Education, Seoul, Korea) videos, which is a series of videos on the dissection sequence and methods. Watching e-Anatomy® before dissection laboratories was optional, not mandatory in 2019. However, in 2020, while the anatomy course was done entirely online at home, students were required to study and submit assignments using the e-Anatomy® videos and Complete Anatomy® (Elsevier, Amsterdam, Netherlands), illustrating the location and shape of anatomical structures in three dimensions.

Since the end of April, when the number of COVID-19 infections had become sufficiently reduced in Korea, a face-to-face cadaver dissection was recommenced; 10 hours a day, 1–2 times per week. At this time, the amount equivalent to three times the previous laboratory was done in one day. Before starting the dissection laboratory, the infection prevention measures guidelines provided by the Korea Disease Control and Prevention Agency (KDCA) were applied to students. After screening symptoms and body temperature measures, the personal protective equipment (i.e., surgical gowns, masks, face shields, wristlets, and gloves) were distributed, worn during dissection, and discarded after each class. In addition, the negative pressure system inside the dissection room was operated to ensure safe air circulation.

Contents and class hours of anatomy lectures and cadaver dissection laboratories

The anatomy lecture and laboratory were both divided into the following topics: limbs, back, thorax, abdomen and pelvis, and head and neck. The lecture hours for each organ were the same in the 2019 and 2020 classes, while the dissection hours were slightly reduced in the 2020 class, especially for the limbs, back, and thorax topics. The same learning outcomes were provided to the students at the beginning of class in 2019 and 2020 (Table 1).

Table 1. The course content and the class hours of anatomy lectures and dissection laboratory

Variables	Class 2020	Class 2019
Intended learning outcomes	The same learning outcomes were provided to the students at the beginning of class in 2019 and 2020	
Domain		
Lecture hours ^a , hr		
Limbs	18	18
Back	5	5
Thorax	8	8
Abdomen and pelvis	16	16
Head and neck	21	21
Dissection laboratory hours ^b , hr		
Limb	20	27
Back	5	6
Thorax	9	12
Abdomen and pelvis	21	21
Head and neck	30	30

^aLecture hours done offline for class 2019, online for class 2020; ^bLaboratory hours done offline in both class 2019 and 2020.

Student assessment

Both in 2019 and 2020, three exams for assessing students' achievement were proctored face-to-face in the large lecture halls. In 2019, the orders of examinations were taken after completing the lectures on limb; back, thorax, abdomen and pelvis, and head and neck classes, consecutively. In 2020, limb, back, and thorax were assessed in the first exam, and abdomen and pelvis were covered in the second one, and head and neck in the third one, respectively. In 2020, all necessary infection prevention measures according to the KDCA guidelines were applied for all examinations, including maintaining the recommended distance of 2 m between students and mandatory facemask wearing. The examination contents and format were not different between 2019 and 2020: the lecture examinations consisted of multiple-choice questions (MCQs) and short-answer questions. Students were asked to write down the names of structures tied or pinned on the cadaver that they had previously dissected during the dissection laboratory exam. The students were divided into three groups, allowing 34–35 students in the examination room at the same time, donning appropriate personal protective equipment, and observing 2 m social distancing guidelines.

The performance scores of cell biology

To determine whether baseline academic performance differences exist between the 2019 and the 2020 class, the grades for cell biology course were compared. Cell biology is a pre-requisite course for anatomy learning and is taught in the second year of the pre-medical course. Both the 2019 and the 2020 class students completed cell biology six months before the anatomy course, that is, the second semester of 2018 and 2019, respectively. In both 2019 and 2020 class, the cell biology lectures were taught by the same lecturers using face-to-face large group lectures, and the total class hours were 42 in 2018 and 36 in 2019. The student assessment, including MCQs and short-answer questions, were compared between the 2019 and the 2020 class.

Participants

Students who took anatomy courses and completed all anatomy exams in 2019 and 2020 were included in the study. Students who retaken the anatomy lesson due to previous failures were excluded. As a result, the scores of 104 students in the 2019 class and 108 students in the 2020 class were analyzed. The ratio of females to males did not reveal a significant difference

between the two groups: 31.7%:78.3% (2019) vs. 37%:63% (2020) ($P = 0.456$). For the survey, only the students who took anatomy classes in 2020 were invited.

Outcome measurement

The anatomy examination scores of the 2020 class, who studied anatomy via blended learning, were compared with those of the 2019 class who were taught in traditional large group lectures and cadaver dissections. The examination scores were compared by the domains (lectures and dissection labs), test types (MCQs and short answer), total scores including lecture and laboratory and MCQ scores by topics. The mean difficulty indices of MCQ total and each topic scores were calculated using the formula: the number of students answering each item correctly divided by the total number of students. The mean discrimination indices were calculated for MCQs total and each topic scores as follows: (the number of students answering each item correctly in the upper 27% group - the number of students answering each item correctly in the lower 27% group)/(the number of students in the upper 27% group + the number of students in the lower 27% group)/2. The mean difficulty indices and discrimination indices of the total and each topic MCQ scores showed similar ranges between 2019 and 2020 (Table 2). The mean difficult index and discrimination index could not be calculated for the short-answer type items, but the content validity of them was verified by a third person from the lectures of anatomy, and he confirmed no significant difference between 2019 and 2020.

An online questionnaire survey was conducted to identify 1) students' preferred learning methods between online and face-to-face classes; 2) the reasons for the students' preferred learning approach; 3) the effect of online classes on learning, including factors that influence students' self-learning, study time, self-directedness and engagement/interaction between teachers and students; and 4) the influence of technical problems on learning. For items 1) and 2), multiple response options were provided. A five-point Likert scale was used to determine the responses for 3) and 4): The Cronbach's alpha for them was 0.695 and 0.848, respectively. An open-ended free text question was asked to solicit any comments and suggestions for improvement in future online anatomy courses. After fully explaining there was no disadvantage to not participating in the survey, students were notified of the questionnaire link. A total of 76 students (70.4%) were surveyed. The survey was conducted anonymously.

Statistical analysis

The examination scores were converted into 100 points for each test type, problem type, and part, and the results were compared using the Mann-Whitney U test using IBM SPSS 24 for Windows (IBM Corp., Armonk, NY, USA). The overall test scores were calculated with weights for the class time for each portion. The sex difference between groups was tested using the χ^2 test, and a frequency analysis was conducted on the survey results.

Table 2. Difficulty index and discrimination index for the MCQ items

MCQ ^a items	Difficulty index		Discrimination index	
	Class 2020	Class 2019	Class 2020	Class 2019
Total scores	0.87	0.82	0.21	0.29
Limbs	0.88	0.80	0.29	0.45
Back	0.84	0.83	0.24	0.21
Thorax	0.94	0.92	0.15	0.19
Abdomen and pelvis	0.84	0.81	0.20	0.28
Head and neck	0.87	0.81	0.22	0.33

MCQ= multiple-choice question.

^aOne single best answer.

Ethics statement

This study was approved by the Korea University Institutional Review Board (Study approval No. KUIRB-2020-0117-01). Only students who agreed to participate and submitted informed consent were surveyed.

RESULTS

Academic achievements

Anatomy examination scores, including lecture and dissection laboratory, of the 2019 and 2020 classes were compared. The total mean examination scores, including the lecture and dissection laboratory, were significantly higher in the 2020 class than in the 2019 class. In the lecture examination, the 2020 class had significantly higher mean scores in the short-answer type than the 2019 class, while there was no difference in the multiple-choice type questions. The mean test scores of MCQ type questions in the thorax, abdomen and pelvis, and the head and neck topics of the 2020 class were higher than those of the 2019 class, but no differences were found in the limbs and back topics (Table 3). On the other hand, the average score of cell biology in the 2020 class was slightly higher than that in the 2019 class, but it was not statistically significant (Table 4).

Survey results

The majority of students who participated in the survey preferred online lectures over offline lectures (online, 78.9%; offline, 21.1%) (Fig. 1A). Most of the students answered that they could save more time during online classes (strongly agree, 65.8%; agree, 23.7%) (Fig. 1B), and they used this saved time for self-directed learning (strongly agree, 35.5%; agree, 39.5%) (Fig. 1B). There were several reasons for preferring the online class: The two most frequent

Table 3. Comparison of the examination scores between the 2020 and 2019 classes

Variables	Class 2020	Class 2019	P value
Domain			
Lecture	82.35 ± 9.66	76.36 ± 13.01	< 0.001
Dissection laboratory	68.44 ± 10.41	63.78 ± 12.41	0.005
Total scores	76.79 ± 9.47	71.33 ± 12.19	< 0.001
Test type			
MCQs ^a	86.09 ± 8.17	83.71 ± 10.81	0.136
Short-answer	80.14 ± 10.73	71.88 ± 15.04	< 0.001
MCQs ^a items by topics			
Limbs	80.89 ± 13.60	81.20 ± 14.47	0.603
Back	85.07 ± 12.90	84.57 ± 8.36	0.139
Thorax	95.02 ± 10.36	92.88 ± 9.59	0.001
Abdomen and pelvis	85.74 ± 6.95	82.31 ± 11.69	0.043
Head and neck	87.67 ± 8.78	83.24 ± 13.07	0.009

Data are presented as mean ± standard deviation.

MCQs = multiple-choice questions.

^aOne single best answer.

Table 4. Comparison of cell biology examination scores between the 2020 and 2019 classes

Variables	Class 2020	Class 2019	P value
MCQs ^a	91.78 ± 7.41	92.67 ± 11.40	0.057
Short-answer	72.02 ± 19.22	71.86 ± 17.66	0.773
Total	86.22 ± 10.44	83.43 ± 12.79	0.064

Data are presented as mean ± standard deviation.

MCQs = multiple-choice questions.

^aOne single best answer.

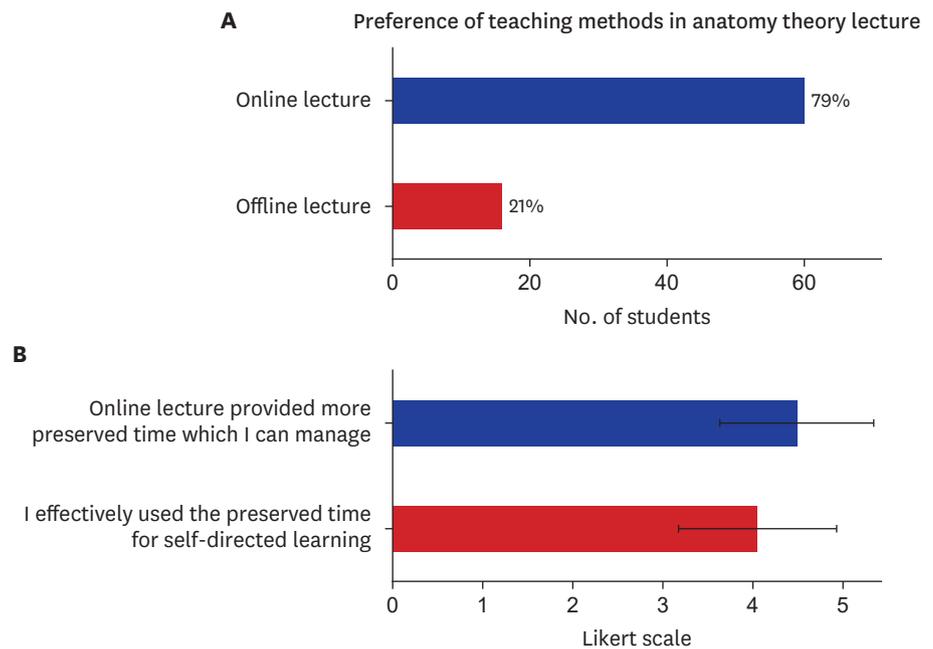


Fig. 1. The survey results on student preferences in learning and influences. **(A)** The students' preferences in learning and **(B)** influence on their saved time and self-directed learning. Likert scale for **(B)**; 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree.

responses were studying the recorded lecture videos repeatedly (76.3%) and reserving more free time (60.5%). Additional reasons are documented in **Fig. 2A**. The students who preferred face-to-face lectures regarded its advantages as improved concentration (93.8%) and better accessibility of asking questions to teachers (56.3%) (**Fig. 2B**).

Similar positive responses to online anatomy learning appeared in the open-ended free-text response. Students mentioned that online learning gave them opportunities to repeatedly review the recorded lecture videos and tailor their learning at an individual pace to enhance their self-directed studies ultimately. The students also stated that the lecture notes provided in advance of classes helped them better understand and learn lecture contents.

Improvements suggested for the online class

Technical issues were the biggest challenge: 61.9% of the respondents reported Internet network problems during online lectures. Fortunately, the network connection problems did not significantly hinder students' concentration on the lecture contents: Only 32.9% of students said that they could not concentrate due to network problems. In addition, we observed less communication and interaction between teachers and students than expected. Less than 50% of students reported that they used either the chat window for the synchronous online lectures or a Q/A discussion space for asynchronous online lectures during the entire anatomy course.

DISCUSSION

In the authors' medical school, the anatomy course was forced to change from traditional large group lectures and cadaveric dissection laboratories to blended anatomy courses, including online lectures and flipped dissection laboratories due to the COVID-19 pandemic.

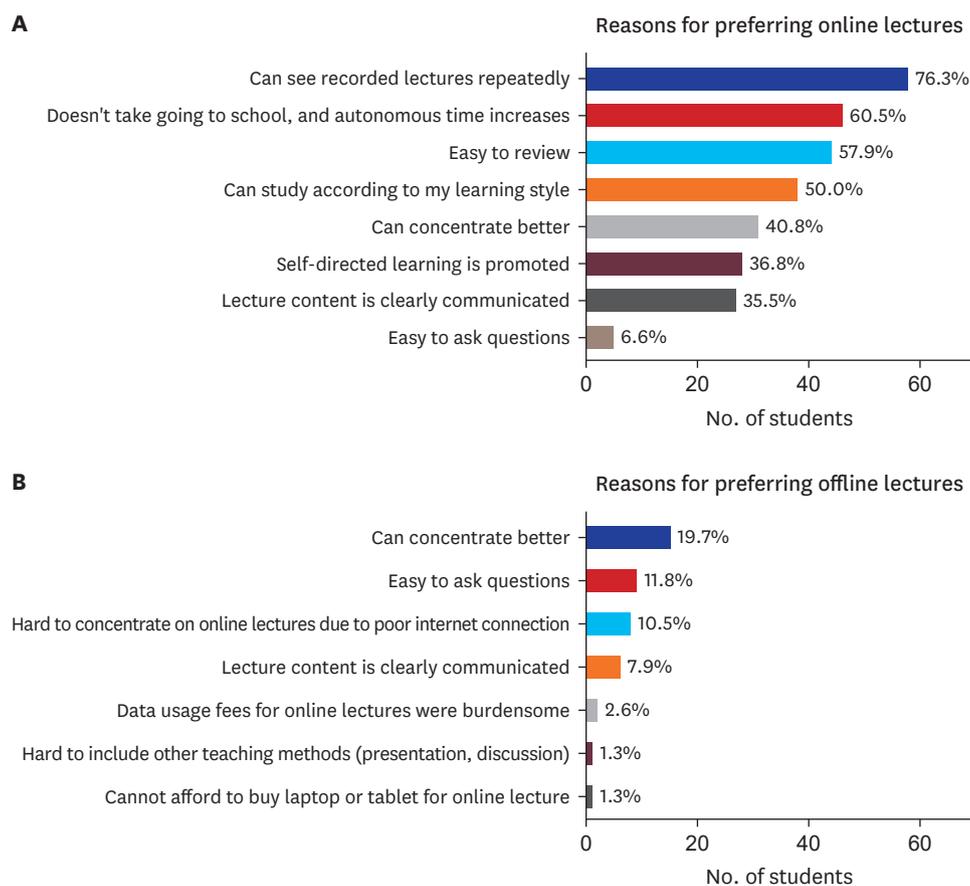


Fig. 2. Reasons for preferred teaching methods. (A) Online; (B) Offline. Multiple answers were allowed.

However, the course outcomes were higher than expected in student assessment and the students' overall satisfaction on the course was also positive.

Our study results revealed that the anatomy achievement scores of the blended learning group (the 2020 class) were higher than those of the traditional lecture one (2019 class). This finding was consistent with some studies in anatomy that reported that the educational effect of blended learning revealed higher or similar outcomes than conventional methods.¹¹⁻¹³ In the detailed analysis of the examination scores, we discovered interesting outcomes. The 2020 class students showed a significant increase in examination scores of the short-answer questions than in the MCQs. It is known that correctly solving short-answer questions requires a better understanding of the contents than the MCQs.^{23,24} Therefore, we may assume that the 2020 class students acquainted a deeper understanding of the learning contents.

Another interesting finding was that the blended learning group demonstrated significantly higher scores in the abdomen and pelvis, and head and neck topics compared to the 2019 classes. In our school, the previous students considered these organs notoriously difficult to understand and learn, and they showed lower performance in these topics than in other topics. Therefore, we may interpret that online or blended learning approaches positively impact the students' performance in these topics. However, this difference in student achievement may be derived from the reduced dissection laboratory hours in limb, back, and thorax and the longer interval between lectures and dissection laboratory classes and

examination in limb and back in the 2020 class. The other factor that might have affected the different examination scores in topics of the abdomen and pelvis or head and neck was the fact that lecture handouts were given in advance to the students in 2020 but not in 2019.

Most of the students who participated in the survey preferred online lectures for several reasons. The online class made it possible for students to tailor their learning, save more time for self-studying, easily access the course materials, and repeatedly study at their own pace. Students replied that studying in their own desired learning environment helped them enhance their concentration in the study. A previous study reported similar findings: There was a positive correlation between the lecture video review rate and grades.²⁵ The 2020 class's better achievements in anatomy compared to the 2019 class can be interpreted by the increased opportunities for individualized tailored and self-directed learning through online lectures and advanced distribution of course materials.

As the face-to-face anatomy laboratory was suspended, students were given assignments according to the online lectures' progress, to study the dissection method using e-Anatomy[®], and the key structures using Complete Anatomy[®]. When the offline cadaver dissection laboratory recommenced as new cases of COVID-19 reduced, students could use the knowledge acquired through the assignment, and it helped students' hands-on anatomy dissection laboratory skills and understanding of structures. Although we provided e-Anatomy[®] in 2019 as well, the students rarely watched the videos before the dissection laboratory. Although the authors did not intentionally design this sequence of learning, a flipped learning effect was inadvertently occurring. Our students independently studied anatomy by using multimedia homework during stage level 3 social distancing and then conducted an offline anatomy laboratory in a condensed manner. The in-advance self-study seemed to be helpful in understanding the anatomic structures and more effectively engaging in the dissection laboratory.

There has been debate over the educational implications of cadaver dissection. With regard to the acquisition of anatomy learning, previous studies have suggested various methods to assist or replace cadaver-based learning.^{6,26,27} In contrast, other studies asserted that the experience and knowledge acquired by hands-on cadaver dissection in anatomy laboratories are invaluable.^{28,29} In addition, the cadaver dissection laboratory is the space where medical students meet their first patient and this significantly affects students' medical professionalism.³⁰⁻³⁴ Furthermore, offline dissection laboratories can provide communication between instructors and students to enhance teamwork among pupils, which can only partly be accomplished in online classes. Our results indicate that flipped learning methods with offline hands-on cadaver dissection have a positive impact on student achievement.

Despite the overall positive outcomes of online anatomy classes, the survey results helped the authors identify several challenges required to improve in the future. Many students pointed out Internet network errors as problems, as reported in a previous study.³⁵ Although Internet bandwidth speed in Korea is the second-fastest in the world,³⁶ network connection problems still exist. The other challenge we should solve was interactivity during class. In online education, three types of interactions occur: learner-content interaction, learner-instructor interaction, and learner-learner interaction.³⁷ The interactions among students and between students and teachers were not active even though chat windows and post-lecture discussion rooms were provided through the LMS. A previous study also reported that student-teacher interactions decreased in an online anatomy class.¹⁴ Because it is essential to facilitate

student-teacher interactions in online classes,³⁸ further efforts to improve interaction and communication in online forums are needed. In some studies, using social network services (SNS) such as Facebook and Twitter was helpful in understanding class content.³⁹⁻⁴¹ Therefore, question-and-answer through SNS or chat room operation will help compensate for the decreased student-teacher and student-student interactions.

There were some limitations to this study. First, this study showed that a blended learning student group achieved significantly higher scores in their anatomy examinations than the traditional learning groups. However, these findings were acquired by a cross-sectional comparison of the two different year cohorts. A randomized controlled comparison using the same year cohort might produce different results from the current ones. Second, the survey questionnaire was not a previously validated instrument. Instead, the authors constructed the questionnaire survey items for our specific purposes to identify the students' perspectives on online learning. Third, mean difficulty indices and mean discrimination indices of short answer type questions or laboratory dissection test were not available. Therefore, we may cautiously interpret the results from the short-answer type items.

In conclusion, a blended anatomy course forced by the COVID-19 pandemic presented its educational outcomes in both academic achievement and students' satisfaction. In addition, our findings provide supportive evidence for online education in promoting individual tailored or self-directed learning. By taking advantage of the experience and lessons gained, online anatomy courses adapting to the COVID-19 pandemic and continuous efforts to reinforce students' self-directed learning in anatomy must be followed.

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