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Flipped classroom combined with human anatomy web-based learning system shows promising effects in anatomy education

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Abstract

Flipped classroom has received much attention in medical education. The aim of this study was to evaluate the efficacy of flipped classroom combing with human anatomy web-based learning system in anatomy education.

A total of 89 freshmen in medical specialty were enrolled and randomly allocated into either the experimental group (receiving the flipped classroom with human anatomy web-based learning system, n = 45) or control group (receiving the traditional classroom teaching, n = 44). A pre-quiz and a post-quiz were conducted before and after the classes, respectively. The improvement in scores between groups was compared. A 5-point Likert scale questionnaire was used to evaluate perceptions and experience.

The mean pre-quiz scores of the 2 groups were comparable (all $P > .05$). However, the mean post-quiz score in the experimental group was significantly higher than that in the control group (91.44 ± 6.25 vs 86.13 ± 11.67, $P < .05$). The results of questionnaires showed that 44 (97.8%) students agreed with flipped classroom combined with human anatomy web-based learning system, 43 (95.6%) students obtained improved study interest in anatomy learning, and 42 (93.3%) students felt that the interactive, applied in-class activities during the class greatly enhanced their learning.

Flipped classroom combined with human anatomy web-based learning system can be used as an effective learning tool for anatomy education.

Abbreviations: PPTs = Power Points, SPSS = Statistical Package for the Social Sciences.

Keywords: anatomy, education, flipped classroom, human anatomy web-based learning system

1. Introduction

Anatomy is considered as the foundation of medical sciences, which mainly focuses on morphological structure, occurrence, and development of human tissue and organs.[1,2] Therefore, anatomy is always set as an important basic subject in medical education. Medical students can obtain medical knowledge concerning human morphology and structure and learn the basic language of medicine, diagnostic imaging, and medical specialties by anatomy learning. However, anatomy learning has also been perceived as an onerous and challenging subject in medical education.[3] Moreover, traditional anatomy education techniques including in-person lectures and anatomical dissection have recently encountered significant challenges and received many criticisms currently.[2,4] Meanwhile, the anatomical dissection training is highly demanding of curricular resources as purchasing, utilizing, and disposing of cadavers present as a major challenge. Compounding this problem is the fact that many anatomy-course resources are being reduced, especially for anatomical dissection. Thus, it is important to explore innovative and stimulating, engaging, creative, purposeful, and multimodal means to encourage proactive and deep learning, and to develop long-term memory in students in order to improve student engagement and learning outcomes.

A flipped classroom is defined broadly as an approach to education that "flips" or reverses the traditional method of information presentation and application activities, which has been recently applied to anatomy education and exerted improved student engagement and interaction.[5–7] In medical education, flipped classrooms can replace in-person lectures with

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Informed consent was obtained from all subjects. This study was approved by the Ethics Committee of Wuxi Taihu University.

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individual homework or group activities.[8] It is imperative to develop cardinal skills such as critical thinking, creativity, communications, and collaboration.[9] Meanwhile, virtual and multiple aspects and three-dimensional anatomy learning have been achieved by application of the human anatomy web-based learning system. Integrated multimodal and system-based approach may be a compromising mode for anatomy education by combining multiple pedagogical resources to complement one another.[10,11] Previous studies have shown that application of flipped classroom combined with problem-based learning teaching mode could improve students' various abilities.[5,12,13] However, the application of flipped classroom combined with human anatomy web-based learning system in anatomy education has not been reported.

Herein, we evaluated the efficacy of flipped classroom combined with human anatomy web-based learning system in anatomy education.

2. Materials and methods

2.1. Participants

A total of 89 freshmen in medical specialty from 2 classes in the Wuxi Tai Hu University were enrolled in this study. Both classes simultaneously received anatomy course education for a whole semester from September 2019 to January 2020, with total of 30 class hours. The class receiving the flipped classroom with human anatomy web-based learning system was designed as the experimental group (n=45), whereas the other class receiving the traditional classroom teaching was defined as control group (n=44). Informed consent was obtained from all subjects. This study was approved by the Ethics Committee of Wuxi Taihu University.

2.2. Study design

The graphical overview of the study design was shown in Figure 1. The students in control group were taught by using the traditional teaching method. Group discussions were also performed in the control group. The teachers in the experimental group guided students to use textbook, internet resources, and libraries to find information about the content of the curriculum before the class. Before the class, students were also arranged to use the human anatomy web-based learning system to learn related content through computers and conduct self-learning. Students can also watch the videos multiple times to better understand a particular topic.[14,15] In class, teachers encouraged students to express and discuss their opinions. The role of a teacher has changed from an imparter of knowledge to an organizer and guider. They explained the specialty knowledge and commented on the opinions of the students.

2.3. Human anatomy web-based learning system and flipped classroom design

The human anatomy web-based learning system (Nanjing Medical University, China) is a software package using a

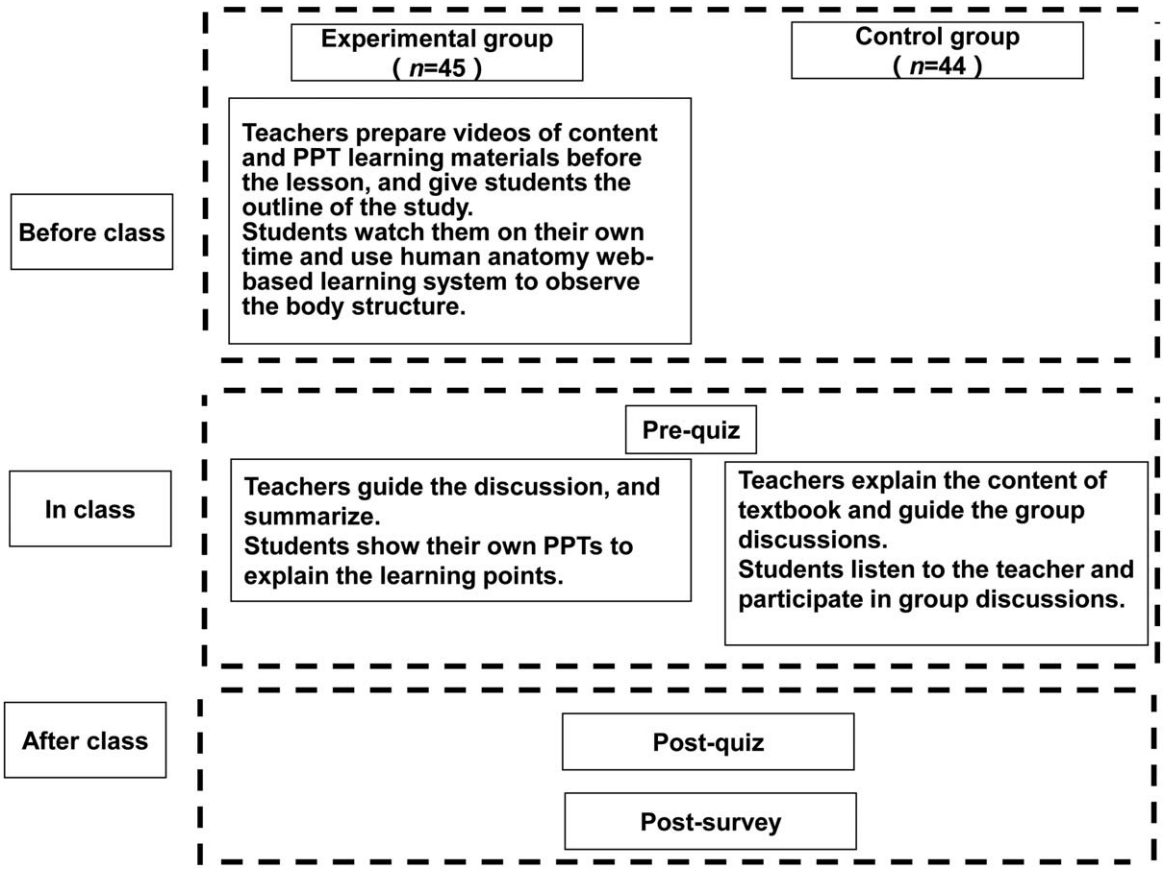

Figure 1. A graphical overview of the study design.

computer to facilitate anatomy learning of 9 major organ systems of the human body. This system includes detail descriptions of each specimen, questions and corresponding reference answers, and basic anatomy concepts.

The human anatomy web-based learning system was used throughout the teaching of flipped classrooms. The implementation methods were as follows. The application process of flipped classrooms was divided into 2 stages, which were before and during the class learning.

1) The pre-class learning stage included self-study and group discussion learning. Students learned the teaching content before class. Teachers provided students with their own courseware and videos, listed learning outlines for students and guided them. Students learned on their own. During the self-study process, students used human anatomy web-based learning system to learn. The system was divided into 4 modules: course introduction, specimen learning, self-test, and examination. The learning system was distributed according to the 9 major systems of the human body. For specimen learning, there were specimen descriptions and basic concepts, and most specimens also had structure descriptions, knowledge extension, and other items. For example, in the lower limb thigh muscle of the locomotor system, students could observe the structures of the satorius, quadriceps femoris, vastus medialis, rectus femoris, vastus lateralis, and gluteus maxiums from both the front and back views. The locations and functions as well as the corresponding English names of these muscles were also displayed. For knowledge extension, the innervation of the muscles was introduced. Students can test their mastery of anatomy through the self-test and examination modules after self-study. In addition, group study and discussion were also encouraged. Meanwhile, teachers provided help to the students' self-study.
2) During the class, students summarized the content and materials they learned, made PPTs (Power Points), and discussed them with classmates and teachers. The teachers explained the learning points and guided the students to discuss the relevant contents. For example, the teacher pointed out the safe area for injections in the deltoid muscle and gluteus maximus and explained them in details. Additionally, the teachers participated in the student discussions. The teachers should timely evaluate and guide the student discussion as well as correct the errors during student discussions. Through the steps above, the teaching process of flipped classroom and web-based learning system was completed.

2.4. Efficacy evaluation

Human anatomy specific exams were conducted before and after anatomy course education, respectively. A standardized test was designed based on the standardized test of the licensed physician qualification examination. The exam scores before and after anatomy course were respectively recorded as pre-quiz scores (at the beginning of the semester) and post-quiz scores. The post-quiz scores included school work cores (accounted for 10%), examination scores of anatomical specimens (accounted for 40%), and the final exam scores (accounted for 50%). The test scores of examinations of anatomical specimens were subdivided into those of the locomotor system, alimentary system, respiratory system, nervous system, urinary system, etc. The difference in terms of exam scores between groups was considered as the primary indicator of efficacy. Furthermore, a 5-point Likert scale questionnaire was filled by each student in experimental group at the end of the semester, with results expressing as mean rating for each item, severing as secondary indicator for efficacy. The scoring criteria in the questionnaire included: 5 points, strong agreement; 4 points, agreement; 3 points, general agreement; 2 points, disagreement; and 1 point, strong disagreement.

2.5. Statistical analysis

The statistical analysis was carried out with the Statistical Package for the Social Sciences (SPSS) version 19.0 (IBM Corp., Armonk, NY). A two-sided $P < .05$ was considered statistically significant. Normal distribution and homogeneity of variance of the data were evaluated. Data were expressed as mean ± SD. The mean scores of pre-quiz and post-quiz for each session were compared and analyzed using paired *t* test. The scores of 5-point Likert scale were calculated and expressed as percentages to indicate agreement or disagreement of students with regard to the statements in the questionnaire.

3. Results

3.1. Baseline characteristic

A total of 89 students were enrolled in the study, including 45 students assigned to the experimental group and 44 students assigned to the control group. There was no significant different in terms of sex ratio, ages, and mean pre-quiz score for the 2 groups (all $P > .05$, Table 1).

3.2. Improvement on student performance

There were no significant differences in mean pre-quiz score between the 2 groups (33.87 ± 3.81 vs 35.70 ± 6.42, $P > .05$). After anatomy course education, the mean exam scores (post-quiz score) of experimental and control group were 91.44 ± 6.25 and 86.13 ± 11.67, respectively, with a statistically significant difference ($P < .05$, Table 2). Furthermore, significant differences in terms of components of human anatomy specific exams were also observed between groups, including scores of school work cores, examination scores of anatomical specimens, and the final exam scores (all $P < .001$, Table 2).

3.3. Subjective assessment

Students who participated in the teaching activity responded to the questionnaire regarding their perception toward this teaching method. The rating of each item in questionnaire was summarized in Table 3. Among 45 students in experimental group, 44

Table 1

Demographic information of participants.

	Control group (n = 44)	Experimental group (n = 45)	*P*
Age, yr	19.74 ± 0.74	19.71 ± 0.75	.70
Gender			.97
Male	5 (11.4%)	5 (11.1%)	
Female	39 (88.6%)	40 (88.9%)	
Pre-quiz score	35.70 ± 6.42	33.87 ± 3.81	.10

Table 2

Scores of experimental group and control group (mean ± SD).

	Control group (n = 44)	Experimental group (n = 45)	*P*
Total post-quiz scores	86.13 ± 11.67	91.44 ± 6.25	.01
School work scores (accounted for 10%)	8.12 ± 0.86	8.88 ± 0.74	<.01
Examination scores of anatomical specimens (accounted for 40%)	29.16 ± 7.33	32.13 ± 5.11	<.01
The final exam score (accounted for 50%)	43.20 ± 6.15	46.29 ± 4.95	.01

(97.8%) students agreed with flipped classroom combined with human anatomy web-based learning system; 43 (95.6%) students obtained improved study interest in anatomy learning; and 42 (93.3%) students felt that the interactive, applied in-class activities during the class greatly enhanced their learning. The mean ratings for each category ranged between 4.16 and 4.87, indicating that the students appreciated the flipped classroom combined with human anatomy web-based learning system.

4. Discussion

Anatomy is a compulsory subject for medical students. Anatomic training is necessary for understanding the three-dimensional body, development of touch mediated perception, appreciating the importance of the patient, learning the basic language of medicine, diagnostic imaging, and medical specialties. Traditional anatomy education techniques including lectures and anatomical dissection have recently encountered significant challenges and criticism. In the mode of flipped classroom, the students are exposed to the information outside of the classroom before in-class time. Then, during in-class time, the students apply the knowledge under the instruction of the educator in a stimulation or problem-based learning activity. In this study, we found that the flipped classroom combined with human anatomy web-based learning system showed promising effects in anatomy education and performance in exams by improving students' autonomous learning ability.

4.1. The teaching method of flipped classroom combined with human anatomy web-based learning system can improve students' autonomous learning ability

In the mode of flipped classroom, the role and status of the student is greatly changed, and the student becomes the subject of learning. Self-study before class requires students to study independently, which improves the students' autonomous learning ability to a certain extent and mobilizes the enthusiasm and initiative of students. Flipped classes enable instructors to engage the participants, help the stakeholders toward self-directed learning, and facilitate them toward critical thinking, which will result in better understanding of the subject.[16,17]

Whether there is a place for digital anatomy teaching and whether it can effectively replace the traditional teaching methods has attracted much attention.[6] The human anatomy web-based learning system enables students to view specimens without time restrictions. This learning method overcomes the limitations of the traditional learning methods. As long as the students have time and access to a computer, they can enter the system to learn at any time.[18] For students who are absent due to illness and other reasons, they can learn via watching videos, PPTs and other learning materials repeatedly. The enthusiasm and initiative of students are fully stimulated in the learning process. Through our questionnaire, we found that the students were satisfied with our teaching methods. Totally, 43 (95.6%) students obtained improved study interest in anatomy learning. They thought this method was more engaging and interesting in comparison to traditional class. Additionally, 42 (93.3%) students felt that the interactive, applied in-class activities during the class greatly enhanced their learning.

4.2. The teaching method of flipped classroom combined with human anatomy efficiency in learning

How to stimulate the learning interest of college students currently remains a challenge for college teachers. The teaching method of flipped classroom allows students to think by themselves and find out the answer through groping. Through this process, students' learning interest is stimulated. Meanwhile,

Table 3

Perceptions of the students to the teaching-learning activity/%.

Number	Content and structure	Response on Likert scale					Mean rating
		5	4	3	2	1	
1	Learning key foundational content prior to coming to class given by teacher greatly enhanced my learning of course material in class	23 (51.1)	17 (37.8)	3 (6.7)	2 (4.4)	0	4.36
2	I read assigned readings prior to coming to class	24 (53.3)	14 (31.1)	4 (8.9)	3 (6.7)	0	4.38
3	The teaching method greatly enhanced my learning	26 (57.8)	16 (35.7)	2 (4.4)	1 (2.2)	0	4.49
4	I participated and engaged in discussions in class	15 (33.3)	24 (53.3)	4 (8.8)	2 (4.4)	0	4.16
5	Enjoyable way of learning, and full of interest	26 (57.8)	16 (35.6)	3 (6.6)	0	0	4.87
6	This method was more engaging and interesting in comparison to traditional class	34 (75.6)	9 (20.0)	2 (4.4)	0	0	4.71
7	More such modules should be organized in the future	34 (75.6)	11 (24.4)	0	0	0	4.76
8	I agreed with this teaching model	37 (82.2)	7 (15.6)	1 (2.7)	0	0	4.80
9	This teaching method has the advantage in understanding and remembering	30 (66.7)	13 (28.9)	2 (4.4)	0	0	4.62

Values are presented as number of responses to each statement in Response Likert scale (n, %). 5 = strong agreement, 4 = agreement, 3 = general agreement, 2 = disagreement, 1 = strong disagreement.

the learning efficiency has also improved significantly. Because this web-based learning system is assisted by the computer, students can have another way to learn the anatomy course, thus increasing the freshness of the students. This study found that the post-quiz score of the experimental group was significantly higher than that of the control group.

4.3. The human anatomy web-based learning system can overcome the shortcomings of traditional human anatomy experiments, and has the characteristics of intuitiveness

Traditional human anatomy experimental teaching mainly focuses on observing specimens and models, and sometimes there are videos and PPTs.[19] Some of descriptions of the PPTs lack details and include inaccuracies. It is impossible to present anatomy in a three-dimensional way.[20] Human anatomy web-based learning system provides a multiplanar representation of human anatomy. Some human specimens for anatomy teaching are donated free of charge, and some are purchased, but the specimen resources are still lacking, and the specimens are easily damaged, which affects the accurate observation of students.[21] The formalin smell of the specimens also affects the students' learning interest.[22] On the contrary, the anatomical model of the specimen in the human anatomy web-based learning system has no smell, and different tissue structures are marked with different colors. For example, the arteries and veins are marked with red and blue, and the fat is marked with yellow, respectively, which is convenient for students to identify. In addition, the system uses three-dimensional stereo images to show the three-dimensional conformation of human parts or organs. It can be hierarchically sectioned to show the anatomical characteristics of each organ, and a tissue structure can be cut separately to make the structural position adjacent to the surroundings. It is clearly displayed the organ or tissue structures in 3 planes: cross-section plane, sagittal plane, and coronal plane. Students get clearer and more realistic senses. For example, the two-dimensional pictures of the ethmoid bone in the traditional lecture slide are difficult for students to understand and difficult to learn. The human anatomy web-based learning system can display the ethmoid in the skull at rotation angles, thus enabling the observation of the three-dimensional structure and shape of the ethmoid and its relationship with surroundings, such as the frontal, temporal, and occipital bones, and the analysis of the positional relationship of the ethmoid in the skull.[23]

4.4. Limitations

There are certain limitations to this study. First, the sample size was relatively small. Second, the entire course cannot be taught using flipped classroom activity combined with human anatomy web-based learning system. Hence, it is important to plan and consider the adequate length of time to deliver a course using this teaching model. Third, the difference could be the teaching styles. Fourth, the examination scores of anatomical specimens of each human anatomy system were not separately calculated or compared. Further studies with larger sample sizes should be conducted using randomized controlled trials to assess the effectiveness of various learning strategies.

5. Conclusions

In conclusion, our results showed application of flipped classroom combined with human anatomy web-based learning system can improve the student performance by activating learning interest and cultivating their thinking ability. Flipped classroom combined with human anatomy web-based learning system provides a more effective and convenient teaching method for anatomy education.

Author contributions

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Data curation: Hanqi Yang, Yuqin Fan.
Funding acquisition: Yuqin Fan.
Writing – original draft: Chenchen Yang.
Writing – review & editing: Xiaoxian Yang.

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