Study on the Combination of “Online Open Course” and “Cloud Class” in the Embryology Teaching: a randomized controlled trial

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Abstract

Background The purpose of this study was to illustrate that only by focusing on curriculum design and implementation can we use modern information education tools reasonably and effectively. Thus it could provide an interactive platform to improve the teaching quality and to change the traditional classroom from “passive learning” into “initiative learning”. **Methods** A prospective, randomized controlled study was performed. Students of Clinical Medicine (The First and Second Affiliated Hospital) enrolled in 2017 were taken as the research subjects. 3 classes were chosen in the experimental group using the new blended teaching strategy (combination of “online open courses” and “Cloud Class”), while the other 3 classes were allocated to the control group using the traditional teaching method. A questionnaire about “evaluation of learning environment, self-learning ability and teaching effects” was administered in the experimental group after class. The whole learning process was evaluated to form formative assessment, which worked as the daily grade. All the students took an examination in the final semester. **Results** The rank sum test were used to measure the statistical difference between the two groups. Comparison of academic achievement in the embryology part of final exam between the two groups, statistically significant differences could be identified ($p = 0.005$). The results revealed that the combination teaching strategy could significantly enhance the final score of medical students compared with the control. The questionnaire showed that most students thought the new teaching method bringing a good experience of online learning. And application of smartphones not only stimulated their interests in learning, but also made perfect use of fragmented time. Reviewing videos after the class might prove more effective. Most students from the experimental group were satisfied with the new teaching strategy, and more than 90% students accepted this online and offline combination teaching module. **Conclusion** The combination of “online open courses” and “Cloud Class” provides a platform for improving students’ learning ability and learning effects. These results demonstrate that the new approach appears to be a successful learning method among the fresh students.

Background

1.1 MOOCs

With the emergence of high-quality courses such as MOOC (Massive Open Online Course) at universities, the traditional education model has been subverted. Although the lecture remains the most practiced means of transmitting knowledge[1], especially in China, the students have been used these resources for their learning and research, and teachers have begun to explore how to combine the online resources with the traditional classroom learning.

A MOOC is an online course for distance education, and was first introduced in 2006 and emerged as popular mode of learning nowadays[2]. Due to the open nature of MOOCs, the absence of a subscription fee and with learners only requiring an internet-enabled electronic device for enrollment courses can attract large numbers of learners and form a heterogeneous population of participants. The characteristics of MOOCs create a learning context that directly challenges the design and

implementation of pedagogical practices that aim to promote social interactions. Millions of social people have regarded the MOOC as an important tool to widen access to higher education. In recent years, the construction of online courses has been highly valued in China. In 2015, the Ministry of Education issued opinions on strengthening the application and management of online courses in higher education institutions. In 2017, 490 courses of “National Boutique Online Open Courses” were identified, which were the representative of MOOCs in our country. 70% of the courses were launched by Peking University, Tsinghua University, WuHan University, Shanghai Jiao Tong University and etc.— the top universities of China. 70% of the courses were led by academicians and famous professors. Nowadays, approximately 5000 open courses have been put online, the number of college students and social learners has exceeded 70 million, and more than 11 million college students have earned credits. Coursera co-founder Anddrew Ng said in a speech at the MOOC Academy's 2014 online education theme forum that one out of every eight new learners is from China. China has become the largest country of MOOCs.

It should be clear that the development of a MOOC can be a complex and time consuming process. It is not necessary to build its own MOOC for every school, and we can use high-quality courses on a high-quality platform. The most important thing is how to use the course.

People's Medical Publishing House is a national-level and professional medical and health publishing house directly under the National Health and Family Planning Commission (NHFPC) of the People's Republic of China. It was established on June 1, 1953. It is a medical publishing institution with large scale, strong strength and many varieties of publications in China. The MOOC of People's Medical Publishing House (PMPHMOOC.COM) includes all the medical national boutique online open courses, and it is free for all the people. The aim of the platform is to promote the sharing of teaching resources nationwide, promote the innovation and reform of medical teaching and personnel training mode, promote the realization of the fairness of medical education, and improve the training effects of medical talents and the level of medical and health services.

1.2 Tendency of blended learning in the internet era

Under the tide of “internet+”, how to make full use of excellent education resources and platforms and develop efficient ways of providing high-quality education have become the most important challenge for all. With the application of the MOOCs in the modern pedagogy, their advantages have become more and more evident. While online learning is increasing popular, the educational circles have reached a consensus that combining the advantages of traditional classroom methods with online digital media can obtain the best learning effect[3,4]. This kind of education program is called “Blended Learning”. Blended instruction is reportedly more effective than exclusively face-to-face or exclusively online classes[5,6]. As for the percentage of time allocated for traditional face-to-face settings and online learning activities is still in debate. Some are 50% instruction online and 50% instruction face to face [7] or somewhere between 30 and 79% online[8]. However, the use of blended learning pedagogy is increasing dramatically on higher education campuses across the globe[9,10,11]. It is well known that

students' attention decreases after only ten minutes and students can only remember approximately 20% of the transmitted content directly following a lecture[12]. And Some reasons for inadequate acquisition of knowledge online may be lack of time, lack of motivation, or highly complex content. So this incorporation can play the teacher's leading role to guide, illuminate students and monitor the whole teaching process. Moreover, it is a major contributor to student satisfaction and to improve students' attitudes towards learning. Students can work on their own with new concepts which frees teachers up to circulate and support individual students who may need individualized attention[13,14].

1.3 Cloud Class

"Cloud Class" is a mobile teaching assistant APP launched by Beijing Mosoink Information Technology Co., Ltd. It is a cloud service platform dedicated to teaching, which can realize interactions of teachers and students in and out of classroom. Based on the class space created by teachers in the cloud, the APP can provide students with course subscriptions, message pushes, assignments, teaching courseware, videos and materials on mobile devices. It mainly consists of five modules. The first is the details of the class, such as the class invitation code, study requirements, study progress, exam schedules, etc.; the second is the member information of the class, in this module teachers can achieve class check-in, and understand the learning progress and experience values of the class individuals; the third is the resources of the class, including various learning materials uploaded to the class, such as lesson plans, courseware, videos, etc.; the fourth is class activities, including testing, Q&A/discussion, brainstorming, and voting/Questionnaire, etc.; the fifth is the notification module, in which the teachers can publish course information in time. The application of this APP transforms the smartphone from an entertainment tool to a useful learning tool. At present, in China many high schools are using this APP to assist class teaching[15,16].

1.4 Current situation of embryology learning in medical curriculum

Embryology is the science dealing with the formation, development, structure, and functional activities of embryos. Embryonic development is characterized by a dynamic nature that occurs simultaneously on a macro- and microscopic scale, making it a difficult subject to learn and teach[17]. More than most other morphological medical science disciplines, embryology has had trouble finding a comfortable niche in the busy modern medical school curriculum and can be easily overlooked. However, knowledge of embryology is important for understanding normal and abnormal human development, as well as the clinical and surgical treatment of malformations. Hamilton J and Carachi R[18] have arrived at a conclusion that embryology should be taught at the right level, depth and through various methods. We have been through many attempts in embryology teaching over the years. Nevertheless nowadays the main teaching method is still the traditional face-to-face teaching including wax models of staged human embryos, embryo and fetus dissection, studies of clinical cases of malformations, images, films and computer-assisted learning. And the students should follow the teacher's rhythm to learn and comprehend.

1.6 Smartphones support for teaching and learning in higher education

Smartphone has become an indispensable tool of our lives. Its ownership is 100% in universities. The popularization of smartphones has brought a new round of opportunities for changing pedagogic techniques. Almost all of the college students can use their own mobile terminal devices to achieve “4A” learning—anytime, anywhere, anyone and anyway. Therefore, mobile-based autonomous learning has become a new trend. The teacher released the course announcement through the “Cloud Class”, as well as videos and discussion questions before class. Students learn independently through smartphones, complete assignments and participate in discussion on the “Cloud Class”. In the terms of Bloom’s revised taxonomy [19], this means that students accomplish lower-order cognitive processes (acquisition of knowledge and comprehension) independently prior to classroom instruction in order to subsequently execute higher cognitive learning process (use of knowledge, analysis, synthesis and evaluation) in the classroom phase, during which they can be directly supported by students and teachers.

Although the medical education literature is well populated with computer-based learning approaches[20], the potential role of new teaching module about embryology could improve knowledge or confidence or satisfaction among medical students more than working through the traditional learning module at their own pace? Against this background, we conducted a randomized controlled trial to investigate the education effectiveness and their satisfaction with the course through a feedback questionnaire of the new teaching module compared with theoretical face-to-face education.

Methods

2.1 Participants

The participants in this study were around 176 first level medical students, Clinical Medicine, Dalian Medical University enrolled in 2017 (students demographics shown in Table 1). The embryology course of our university is small class lecture with integrated theoretical and experimental education. Each class has about 30 students and is taught by one teacher. Each teacher of our research group teaches 2-6 classes. The teaching reform was attempted for the first time. In a bid to avoid the different results in teaching caused by different teachers, only the six classes instructed by the research group leader at the same time were selected to conduct the teaching reform experiment. Class 1 and 3 of the first affiliated hospital and Class 3 of the second affiliated hospital were chosen randomly in the experimental group, while Class 2 and 4 of the first affiliated hospital and Class 6 of the second affiliated hospital were allocated to the control group. They were informed that their participation was voluntary and would not impact their grade in any way. Students who agreed to participate in experimental group signed a consent form.

The students were registered in “MOOCs of People's Medical Publishing House” and “Cloud Class”, which are totally free of charge. And students of every experimental group were organized to divide into 3 teams. The students of control group were advised to register and study the online open courses, but no supervision.

Table 1 Participant demographics

	Experimental group		Control group	
	Count	%	Count	%
n	89		87	
Age	19-26 yrs.		19-22 yrs.	
mean	20.5		20.2	
Sex				
Female	50	56.2	49	56.3
Male	39	43.8	38	43.7
Smartphone ownership	89	100	81	100

2.2 Curriculum arrangement

2.2.1 Experimental group

Before class: In a week before class, the teacher released the course announcement through the “Cloud Class”, as well as videos. Students learned independently through mobile terminals, and made a mind mapping (shown in Fig.1) which was published in the cloud class. During self-learning students could raise questions they did not understand, and team leaders would organize team members to discuss and summarize.

During class: At first, team leaders informed the questions raised by team members; According to the themes of students' questions, teachers arranged them into different threads, which assisted students tracing these more easily. Teachers would give lectures aiming at solving questions and focus on key and difficult points. After the lecture contents, teachers issued CBL (Case-Based Learning) cases in the “brainstorming” module of Cloud Class (shown in Fig.2), arranged students to discuss, thereby testing the students' basic knowledge understanding and clinical application. Before the end of class, teachers issued lecture related A2 (Best Choice Question for Summary of Medical Case) exercises and common choice questions in the “testing” module (shown in Fig.3), and the students were requested to answer questions immediately. At last, teachers would explain in detail about the questions with high error rate.

After class: Students reviewed the teaching contents through “MOOCs” and “Cloud Class” platform. Questions could be resolved in the “Q&A/discussion” module. The course arrangement could be adjusted in time according to the instruction feedback and suggestions collected from the “voting/Questionnaire” module.

At the end of general embryology, PBL (Problem-Based Learning) class is performed to improve the students' ability of analyze and comprehensive application in specific clinical cases.

2.2.2 Control group

The traditional face-to-face teaching method was adopted.

Before class: Same as the experimental group, the teacher released the course announcement and courseware, and students learned independently through mobile terminals.

During class: Teachers gave complete and systematic explanation of the lecture, which was the teacher led teaching mode in the traditional classroom. But the depth of the key points and difficulties is completely consistent with the experimental group.

After class: There was no interaction between teachers and students.

At the end of general embryology, PBL (Problem-Based Learning) class was performed to improve the students' ability of analyze for specific clinical cases both in experimental and control groups.

2.3 Lectures evaluation

At the end of the course, the students took part in the final examination, and the results were compared between the two groups of students and statistically analyzed.

Through the "MOOCs" and "Cloud Class" platform, the information about students of experimental group watching videos, participating in discussion and the quality of assignments could be attained. Formative assessment (FA) was evaluated depending on the whole learning process.

The students of experimental group were invited to submit an online survey questionnaire (Table 3), which was on a 5-point Likert scales (1 = strongly disagree; 5 = strongly agree). The questionnaire consisted of 26 choice questions asking the students about his opinion in comparing virtual classroom learning with face-to-face learning. In addition, there was an open-answer question and students were required to give suggestions to improve the course and their impression about the experience of the new teaching method. Based on the domestic literatures[21,22] and combined with the characteristics of our teaching module, we developed the options for the questionnaire survey, aiming at understanding the students' recognition and benefits, as well as soliciting opinions and suggestions which can provide good opportunities to reflect our teaching practice.

2.4 Statistical analysis

The final scores were composed of three parts: final exam, lab test and daily grade. The final exam papers of the two groups were identical. The lab test was conducted for the histology part. The teaching reform was carried out in the embryology section, after the completion of histology content. The daily grades of experimental group were from the formative assessment of Cloud Class, whereas the control group were from the performance in class and lab reports. The statistical analyses of the two groups were conducted only focusing on the embryology questions in the final exam, and only comparing the learning effects of embryology knowledge after the embryology teaching reform.

The statistical analyses of the exam results and survey responses were conducted using SPSS statistical program version 17. The mean values and standard deviations were calculated and rank sum test were used to measure the statistical difference between the two groups. With regard to probability, a *P* value less than 0.05 was considered significant.

The whole study design shown in Figure 4.

Results

3.1 Results of final exam

Comparison of academic achievement in final exam between the two groups of students, statistically significant differences could be identified ($P < 0.05$). The comparison of two groups were shown in Table 2.

All students of experimental group completed the questionnaire of survey. 83 students answered the choice questions; 73 students gave personal opinions about this new strategy of learning.

Description of the survey data is shown in Table 3, Figure 5 and 6.

Table 2 rank sum test

Runk sum test				
group categories		N	rank mean	rank sum
scores	Experimental group	86	97.62	8395.50
	Control group	87	76.50	6655.50
	sum	173		

test statistic ^a		Result/score
Mann-Whitney U		2827.500
Wilcoxon W		6655.500
Z		-2.783
progressive significance(two sided)		.005

a. grouping variable: group categories

From the above table, it is found that the significance is 0.005 that is $p=0.005<0.05$, so the difference of two groups has statistical significance.

3.2 Results of questionnaire

Table 3

Survey instrument.

Questions with options	Mean
Choice questions:	
1) Are the course resources rich, including videos, pictures and expansion references provided by the teacher (copied from the teacher directly or from the campus network platform)?	4.55
2) Are you satisfied with using the fixed or mobile terminals to find relevant learning materials online at any time through the campus network?	3.86
3) Can you use the WeChat group to communicate with others smoothly?	4.53
4) Are the problems you encountered during your studies the same as those encountered by your study team?	2.36
5) Can your get help from your study team wherever you encounter problems in your studies?	3.29
6)Is there any question that can not be solved even after studied with your study team?	2.41
7) Do you have a strong desire to continue your inquiry about the problems that can't be solved by your study team?	2.9
8) Do you have a desire to solve your problems in the class?	4.45
9) The biggest feature of this course is that the problems are raised by yourself and the solutions are sought by yourself.	4.55
10) Teachers' explanations are helpful for you to solve problems.	4.43
11) You want the teacher to set the questions.	2.81
12) In the process of solving problems raised by yourself, you have practiced your analytical and problem solving skills.	4.4
13) The implementation capacity of solving problems enhanced.	4.08
14) There are more ways to solve problems.	3.8
15) The communication and collaboration capacity with your classmates improved.	3.98
16) The teaching module is different from the traditional teaching method.	4.35

17) The teacher plays the different role from the traditional teaching method.	4.21
18) It is greater about the teacher's potential support and help.	4.52
19) It is better and more detailed about the teacher's teaching design and arrangement.	4.36
20) It is more convenient to get help from the teacher in class and out class.	4.47
21) About this course, the knowledge modules and key points designed by the teacher can guide you to study better.	4.49
22) Do you think the efficiency of this course is high?	4.29
23) Do you think it costs you more time after class?	2.96
24) Do you like this teaching method?	4.12
25) Do you prefer the traditional teaching method?	2.45

26) The most achievement about this course is (multiple choices): 1:Ability to solve unexpected problems has been improved, 2:Communication skills have been improved, 3:Collaboration skills have been improved, 4:There are more ways to solve problems.

27) Open-answer question:

In order to improve your overall quality and ability, and be in line with the future work, what are your suggestions about teaching and learning approaches?

73 students provided their own comments to the open-answer question. All comments demonstrated that the new teaching method was excellent and beneficial. It provided very useful tools for learning with almost the same advantages of traditional learning including student's engagement and interaction.

Experimental teaching methods were sufficient to understand realize the sequence of events in Embryology.

Discussion

4.1 Final exam grade difference

The aim of this study was to evaluate the efficacy of online courses combined with classroom teaching. Numerous studies have been documented with comparable outcomes from online learning and traditional classroom instruction[23,24]. However, the present study is considered to be the first trial of conducting an online based course—"MOOCs" and "Cloud Class" combined with the face-to-face teaching in embryology subject with a survey evaluating obtained from the participants' comments, which is based on their performance in the official final exam. Motivation to complete online learning and pay more attention on the face-to-face learning was largely driven by preparation for examinations. So the final exam will be a great method to test the student's learning situation.

The final exam result of our study demonstrated that a statistically positive significant difference was detected between the experimental and control groups and reflected the success of the experiment in the opinion of the participants. This is in agreement with many studies which were done in the fields of web-based learning[25,26,27]. Gallagher et al.[25] examined the effectiveness of alternative methods of course delivery by comparing student profiles and instructional outcomes from a dental hygiene gerontology course offered both on the Web and in a traditional classroom setting. They concluded that students selecting an online open course format demonstrated greater motivation and learning success based on final course grades, completion of assignments, and knowledge retention over time. Some research also thought that new teaching method may approach to enhance student satisfaction, learner engagement, and learning outcomes [28]. However, this outcome maybe affected by many factors such as interactivity, online discussion, practice exercises or repetition of material, just as David A Cook.[29] explored. Of course, the good results of experimental group maybe also correlated with the student's increased workload[30,31,32]. Students of experimental group have the normal time of class same as the students of control group, after they finished the online courses. And for the control group, students did not raise questions and present mind mappings before class, so it was not possible for us to determine if they have learned the online open courses and the extent and time they spent for. During class, no CBL cases and testing part. After class, no interactions occurred between teachers and students. While for experimental group, because of the cloud class platform, students could continue receiving the course announcements, such as the progress of online courses, supervising of self-learning before class, reminding to complete homework after class. All of above maybe affected the final results. But if the preparation before the class, the cases and questions during the class and the post-reading after the class can increased student responsibility for learning, why not try?

4.2 Individual opinions about new teaching method

73 students gave personal opinions about this new strategy of learning. One student said “I love this course, combined with network, making full use of network technology and network resources to bring students a good experience of online learning. After all, in this era of big data, “the mobile phone is pervasive and ubiquitous”, it is really a good way to use the mobile phone for learning. On one hand, it interests us, on the other hand, it has utilized the fragmentation time efficiently. In addition, it provides a better platform for reviewing. You can review the video at any time after class. Compared with the traditional learning, the video is more impressive. There is no exaggeration that this would be the most efficient way to review the video lesion while eating a meal. In the classroom, I think the teacher gave a great lecture. She created an open and respectful environment, combining interest and textbook, which completely broaden our horizons and enrich our minds.”

Another student said “I like this method. First, many offline extracurricular time has not been used very well. This model can supervise us to make the best use of time, less of the drama, wandering the TikTok (the Chinese short-form video app), and playing games online but more learning. And watching MOOC lectures won't take too much time. Second, I like CBL cases. When we study with the cases, we will think automatically and independently. No matter we look for answers from textbooks, literatures or BIDU (search engine of China), all of these procedures enhance our knowledge and engagement for better performance in our practical life. Finally, when the teacher summarized these cases, I always could find something I have never thought before.”

4.3 Limitations

This kind of application of cloud class with online open course is more suitable for small class teaching. It's better to answer students' questions and participate in discussion. However, for large class teaching, it is difficult for teachers to take care of all students, and students may not be able to keep up with the pace of class. Moreover, some students are used to the traditional teaching method and accept knowledge passively. Such students have no problem for short-term learning and taking exams, but they are not conducive to learn and think actively. For such students, it is necessary to guide them self-learning. Effective life-long learning is facilitated by active learning, teaching for understanding[33]. Indeed, studies have shown that medical students perceive their self-directed lifelong learning skills are enhanced by the online courses[34]. This was a small study based on a single teaching session. The principal researcher's position as an insider- researcher and teacher-as-researcher should be considered when interpreting the results. This increases the subjective dimensions of how data is collected and analyzed but allows for a better understanding of the educational context by the researcher and rapport with participants[35].

4.4 Importance of instructional design

David A Cook.[29] addressed the importance of instructional design in his article. Our study design includes four stages. For the first stage, we improve the preparation of PBL and CBL cases, ameliorate the database construction of A2 and discussion questions, and complete teacher's training. For the second stage, the online teaching module is carried out in embryology class of research group membranes. For the third stage, we should carefully review our experience, amend and improve our project design, clinical

cases, discussion and test questions, which is called the closed loop test. For the fourth stage, this project will be expanded throughout the whole university.

MOOC and Cloud Class are excellent education resources, but how to make full use of those modern resources and platforms in education is indeed a problem deserved to delve deeper. The aim of our study is to explore the application of MOOC into the high-quality education. We have attempted to just announce the online open courses at the MOOC platform (like the control group), but due to no supervision, the efforts yielded almost no fruits. Owing to the application of “Cloud Class”, the effects of experimental group were remarkable. Some reports [36,37,38] believe that the first group of students is characterized by their low level of engagement with the learning system, and exhibit low effort and cognitive engagement in the course, performance goal orientation, surface approach to learning, and poor regulation of their tool use. By contrast, the second group is characterized by a high level of student engagement and active participation in the course. The students are primarily driven by a mastery approach goal orientation, demonstrate high cognitive engagement, a deep approach to learning and, not surprisingly, achieve a solid course performance. Meanwhile, it needed time and energy to design the contents of cloud class to get efficient results. In our study, problem based learning was performed, students raised questions before class, and teachers gave lectures to solve problems during class; CBL cases provided students opportunities to brainstorm and negotiate ideas and teachers modeled how to use theories to solve practical problems. Moreover, the interaction between teachers and students more convenient because of “Cloud Class”, which could give the experience values automatically depending on student engagement, thus achieving formative evaluation. Therefore, we believe that a good instructional design can really achieve remarkable efforts in teaching.

Conclusions

The online open course provides a very good platform for self-learning, and the cloud class offers a useful channel to interact between teachers and students in and out of classroom. The combination of online open course and cloud class can improve the students' interests in learning, promote abilities to study and solve problems independently, as well as cultivate spirit of group communication and cooperation. The boring basic knowledges combined with clinical cases greatly motivates students' enthusiasm and initiative, make them feel learn to have to use. And according to our study, the final exam scores showed the significant difference between two groups. The experimental group students got higher scores.

In addition, the teachers felt that the students of the experimental group had higher enthusiasm and more interest. Thanks to the lectures with the questions, the more interaction happened between teachers and students in and out of classroom. The classroom atmosphere was very active. Through the training of CBL, PBL and brainstorming, the initiative and ability of students to solve problems has been significantly improved. Many students said that they hope to add more cases in teaching and hope to get in touch with the clinic earlier.

All these results demonstrated that online embryology teaching based on “online open courses” and “Cloud Class” appears to be a successful teaching method among the undergraduate students. And online learning will be an essential part of medical education, and we should go on seeking ‘when’ to use online learning and ‘how’ to use it effectively when we do.

Abbreviations

MOOC	Massive open online course
NHFPC	National Health and Family Planning Commission
CBL	Case-Based Learning
A2 exercises	Best Choice Question for Summary of Medical Case exercises
PBL	Problem-Based Learning
FA	Formative assessment
TikTok	the Chinese short-form video app

Declarations

CONSORT guidelines

My study adheres to CONSORT guidelines.

Ethics approval and consent to participate

The formal ethics approval was got from ethics committee of Dalian Medical University. Students who agreed to participate in experimental group signed a consent form.

Consent to publish

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

GLL prepared the A2 questions and was a major contributor in writing the manuscript. SY and ZX prepared the CBL cases. HJ prepared question exercises. LJ collected the final paper information. CXM was responsible for the Cloud Class platform. ZLY analyzed the data. CWJ designed the project and questionnaire. HLH is responsible for all the project, taught students of experimental and controlled classes and performed the final embryology exam. All authors read and approved the final manuscript.

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Authors' information

The corresponding author Hao Lihong has long been engaged in the histology and embryology teaching for decades of years and an expert in China. She has a strong interest in technology-enhanced learning, and have published several literatures in approving teaching methods. In Dalian Medical University, because of her excellent teaching, she has got lots of honors, such as the “Teaching celebrities in Liaoning Province”, “most popular teachers for students”, “teaching masters award”.

References

- [1] Van der Vleuten CP, Driessen EW. What would happen to education if we take education evidence seriously? *Perspect Med Educ*. 2014; 3 (3):222–232. <http://dx.doi.org/10.1007/s40037-014-0129-9>.
- [2] Kaplan AM, Haenlein M. Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster. *Business Horizons*. 2016;59: 441–450. <http://dx.doi.org/10.1016/j.bushor.2016.03.008>
- [3] Bell F. Connectivism: Its place in theory-informed research and innovation in technology-enabled learning. *International Review of Research in Open and Distance Learning*. 2011;12(3): 98–118. DOI: 10.19173/irrodl.v12i3.902
- [4] Kop WS, Hill BC. Connectivism: Learning theory of the future or vestige of the past? *International Review of Research in Open and Distance Learning*. 2008;9 (3) :1-13.
- [5] Garrison DR, Kanuka H. Blended learning: Uncovering its transformative potential in higher education. *Internet and Higher Education*. 2004;7(2): 95–105. <http://dx.doi.org/10.1016/j.iheduc.2004.02.001>.
- [6] Means B, Toyama Y, Murphy R, Bakia M, Jones K. Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies. *US Department of Education*. 2009;115(3): 93. <http://apo.org.au/node/18720>

- [7] Bernard RM, Abrami PC, Borokhovski E, Wade CA, Tamim RM, Surkes MA, & Bethel EC. A meta-analysis of three types of interaction treatments in distance education. *Review of Educational Research*. 2009;79(3), 1243–1289. <http://dx.doi.org/10.3102/0034654309333844>.
- [8] Allen IE, Seaman J, Garrett R. Blending in: The extent and promise of blended education in the United States. *What is Blended Learning?* Newburyport, MA: Sloan Consortium. 2007. p. 5-7.
- [9] Bernard RM, Borokhovski E, Schmid RF, Tamim RM, Abrami PC. A meta-analysis of blended learning and technology use in higher education: From the general to the applied. *Journal of Computing in Higher Education*. 2014;26(1), 87–122. <http://dx.doi.org/10.1007/s12528-013-9077-3>.
- [10] Lim CP, Wang LB. (Eds.) Blended learning for quality higher education: Selected case studies on implementation from Asia-Pacific. Bangkok: UNESCO. 2016. p.39–65.
- [11] Norberg A, Dziuban CD, Moskal PD. A time-based blended learning model. *On the Horizon*. 2011;19(3), 207–216. <http://dx.doi.org/10.1108/10748121111163913>.
- [12] Hartley J, Cameron A. Some Observations on the Efficiency of Lecturing. *Educ Rev*. 1967;20(1):30–37. DOI:10.1080/0013191670200103
- [13] Bransford JD, Brown AL, Cocking RR. How people learn: Brain, mind, experience, and school. Washington, DC, US: National Academy Press. 2000. doi:<http://dx.doi.org/>
- [14] O'Dowd DK, Aguilarroca N. Garage demos: using physical models to illustrate dynamic aspects of microscopic biological processes. *CBE Life Sci Educ*. 2009;8(2):118–122. DOI: 10.1187/cbe.09-01-0001
- [15] Xu XY, Huang T, Huang G, Chen XL, Jiang H, Zhang J, Ma BC. Application of MOSO teaching in histology and embryology class for nursing undergraduates. *Chin J Anat*. 2018; 41(02):106-107. Chinese. DOI: CNKI:SUN:JPXZ.0.2018-02-029
- [16] Tan CL. Education reform practice of flipped classroom based on Moso Teach. *Logistics Engineering and Management*. 2016;38(6):219-220. Chinese. DOI: 10.3969/j.issn.1674-4993.2016.06.083
- [17] Yamada S, Uwabe C, Nakatsu-Komatsu T, Minekura Y, Iwakura M. Graphic and movie illustrations of human prenatal development and their application to embryological education based on the human embryo specimens in the Kyoto collection. *Dev.Dyn*. 2006;235(2): 468–477. DOI: 10.1002/dvdy.20647
- [18] Hamilton J, Carachi R. Clinical embryology: is there still a place in medical schools today? *Scott Med J*. 2014;59(4):188-192. DOI: 10.1177/0036933014550953
- [19] Anderson LW. Taxonomy for learning, teaching, and assessing. *European Legacy*. 2001;114(458): 1013-1014. DOI: 10.1093/ehr/114.458.1013

- [20] Cook DA, Levinson AJ, Garside S, Dupras DM, Erwin PJ, Montori VM. *Internet-based learning in the health professions: a meta-analysis*. Centre for Reviews and Dissemination (UK), 2008;300:1181–1196. DOI: 10.1001/jama.300.10.1181
- [21] Zhang XT, Zhou JS, Li YJ, Wu XL, Lu M, Tian H, Wang LR, LYU HX, Qi YL, Zhong NT, Cui ZG. Construction and application of evaluation system of histology and embryology based on the formation evaluation methods. *Medical education research and practice*. 2017;25 (4): 582-585. Chinese. DOI: 10.13555/j.cnki.c.m.e.2017.04.027
- [22] Zeng R, Yue RZ, Qiu HY, Zeng J, Wan XH, Zuo C. Preliminary investigation into application of problem-based learning in the practical teaching of diagnostics. *Advances in Medical Education and Practice*. 2015;6: 223-229. DOI: 10.2147/AMEPS78893
- [23] Moraes SG, Pereira LAV. A multimedia approach for teaching human embryology: Development and evaluation of a methodology. *Annals of Anatomy*. 2010;192(6): 388-395. DOI: 10.1016/j.aanat.2010.05.005
- [24] Liu Q, Peng W, Zhang F, Hu R, Li, Yan YX, Wei R. The effectiveness of blended learning in health professions: systematic review and meta-analysis. *J. Med. Internet Res*. 2016;18 (1): e2. DOI: 10.2196/jmir.4807
- [25] Gallagher JE, Dobrosielskivergona KA, Wingard RG, Williams TM. Web based vs. traditional classroom instruction in gerontology: a pilot study. *J. Dent. Hyg*. 2005;79 (3):7.
- [26] Al-Neklawy, Farid A. Online Embryology teaching using learning management systems appears to be a successful additional learning tool among Egyptian medical students. *Annals of Anatomy*. 2017;214: 9–14. DOI: 10.1016/j.aanat.2017.07.001
- [27] Ng EMW. Integrating self-regulation principles with flipped classroom pedagogy for first year university students. *Computers & Education*. 2018. S0360131518301775-. DOI: 10.1016/j.compedu.2018.07.002
- [28] Jones-Bonofiglio KD, Willett T, Ng S. An evaluation of flipped e-learning experiences. *Med Teach*. 2017: 1-9. DOI: 10.1080/0142159X.2017.1417577.
- [29] David A. Cook. The failure of e-learning research to inform educational practice, and what we can do about it, *Medical Teacher*. 2009;31(2): 158-162, DOI: 10.1080/01421590802691393.
- [30] Galway LP, Corbett KK, Takaro TK, Tairyan K, Frank E. A novel integration of online and flipped classroom instructional models in public health higher education. *BMC Med Educ*. 2014;14(1):181. DOI: 10.1186/1472-6920-14-181
- [31] Sharma N, Lau CS, Doherty I, Harbutt D. How we flipped the medical classroom. *Med Teach*. 2015; 37(4):327–330. DOI: 10.3109/0142159x.2014.923821

- [32] Rotellar C, Cain J. Research, perspectives, and recommendations on implementing the flipped classroom. *Am J Pharm Educ*. 2016;80(2): 34. DOI: 10.5688/ajpe80234
- [33] Murdoch-Eaton D, Whittle S. Generic skills in medical education: developing the tools for successful lifelong learning. *Med Educ*. 2012;46(1):120–128. DOI: 10.1111/j.1365-2923.2011.04065.x
- [34] Christopher R, Lynley P. Advances in medical education and practice: student perceptions of the flipped classroom. *Adv Med Educ Pract*. 2017;8:63–73. DOI: 10.2147/AMEP.S109037
- [35] Mercer J. The challenges of insider research in educational institutions: wielding a doubled-edged sword and resolving delicate dilemmas. *Oxf Rev Educ*. 2007;33(1):1–17. DOI: 10.1080/03054980601094651
- [36] Wise AF, Speer J, Marbouti F, Hsiao YT. Broadening the notion of participation in online discussions: examining patterns in learners' online listening behaviors. *Instructional Science*. 2013; 41(2): 323–343. <https://dx.doi.org/10.1007/s11251-012-9230-9>.
- [37] Kovanović V, Gašević D, Joksimović S, Hatala M, Adesope O. Analytics of communities of inquiry: Effects of learning technology use on cognitive presence in asynchronous online discussions. *The Internet and Higher Education*. 2015;27, 74–89. <https://doi.org/10.1016/j.iheduc.2015.06.002>.
- [38] Lust G, Vandewaetere M, Ceulemans E, Elen J, Clarebout G. Tool-use in a blended undergraduate course: In Search of user profiles. *Computers & Education*. 2011;57:2135–2144. <https://doi.org/10.1016/j.compedu.2011.05.010>.

Figures

Figure 1

The examples of mind mappings prepared by the experimental group students.

Figure 2

CBL cases were shown in the “brainstorming” module of Cloud Class.

(a)

(b)

Figure 3

The common choice questions (a) and the students' accuracy (b) were shown in the "testing" module.

Figure 4

The sketch of study design about experimental group and control group.

Figure 5

The survey results of 25 questions.

The most achievement about this course is

- **A:Ability to solve unexpected problems has been improved**
- **B:Communication skills have been improved**
- **C:Collaboration skills have been improved**
- **D:There are more ways to solve problems**

Figure 6

Percentages of multiple choice question (No.26) response.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [CONSORTchecklist.pdf](#)