

# Exploration of "Online + Offline" Blended Teaching Mode in Molecular Biology Experiment Under the Background of COVID-19

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## Research Article

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# Abstract

**Backgrounds:** The outbreak of coronavirus has had a serious impact on the economy, life and education of virtually all countries around the world. In China, the pandemic continues to pose a great challenge to the traditional in-person education model of schools. Educators in China are facing the agonizing decision of whether to resume in-person instruction while there's still no effective cure for the new coronavirus. Therefore, in order to ensure the quality of teaching and learning during the period of special time, we explore the "online + offline" blended teaching mode.

**Methods:** Four hundred medical undergraduates from Dalian Medical University in China took part in a simulated teaching model to improve their learning ability of innovation and exploration. Taking molecular biology experiment - cell apoptosis as an example, we experimented with the blending of "online + offline" teaching mode and evaluated the learning outcome under this mode from the perspectives of experiment operation, report writing and group cooperation.

**Results:** Over 95% of them totally agree with this teaching mode and expect to have it applied to other subjects, while less than 10% of the students have the opinion that the traditional teaching mode is better. The result of the innovation project competition also shows that the students trained under this teaching mode perform better than those under the traditional teaching mode in both objective questions and answers and experimental operation.

**Conclusions:** Adoption of this "online + offline" blended teaching mode is effective and provides a new perspective to solve the problems encountered by medical students when they reach a higher level of development. In the process of carrying out this teaching mode, the cultivation of students' independent learning and innovative exploration ability were emphasized. Furthermore, it also helps students to lay a solid foundation for their future study and career development.

## Background

Starting in late 2019, a new coronavirus has swept the globe, with all kinds of negative effects on human life. One of the areas most heavily affected by the virus is education, especially in developing countries. As the largest developing country in the world, the study and life of the vast majority of students in China have been seriously affected as a result of COVID-19. At most universities in China, courses are traditionally lecture-based, incorporating the use of textbooks and conventional microscopy<sup>[1]</sup>. Digital teaching is not fully popularized. These courses have been confronted with resource limitations, including too many students and inadequate space to accommodate the mall, and very few instructors and teaching resources<sup>[1]</sup>. But in American and many European countries, virtual online learning has become a big trend. Some students miss the interaction in a regular classroom, whereas self-directed learners are more successful in online education<sup>[2]</sup>.

With the continuous renewal and development of the Internet in China, electronic education has moved away from the hard medium to an online environment<sup>[3]</sup>. Web-based learning is an important tool especially in medicine because it is continually being developed and updated<sup>[4]</sup>. Chinese medical students need new teaching models that not only have the potential to guarantee the goals of the current education system, but also to foster students' ability to innovate with independence.

In order to ensure the quality of learning and teaching for medical students during the epidemic period, this paper proposes a merger of "online + offline" teaching mode. Conversion to online or virtual learning can replace some in-person instruction during a pandemic<sup>[5-7]</sup>. This model can be applied not only to undergraduate medical education but to also to any environment where the use of evidence-based practice is paramount<sup>[8]</sup>. This paper aims to explore a new "online + offline" blended teaching mode different from the traditional teaching mode, in order to cope with the challenges brought by the epidemic and improve the ability of students' independent learning, cultivate their unique ability of innovation and exploration.

## Methods

### Setting

We explored this teaching model with 400 students from Dalian Medical University as samples. Founded in 1947, Dalian Medical University (DMU) is a pilot university of China's National "Excellent Doctor Education and Training Program" project, aiming to cultivate outstanding medical talents with equal emphasis on both clinical and scientific research. It encompasses 23 teaching and scientific research units, 27 affiliated hospitals, 23 undergraduate programs, 4 post-doctoral research stations, 4 first-level doctoral programs, one professional doctoral program, 11 first-level master's programs and 6 professional master's programs. The university has more than 9,000 faculty and medical personnel, and 13,300 full-time students, including 4,900 postgraduates, 7,500 undergraduates and 900 international students. Dalian Medical University has been a well-known medical college in Northeast of China.

### Participating students

This article is focused on examining the effectiveness of the "online + offline" blended teaching model in the experimental course-apoptosis series of teaching, which is taken by undergraduates in their second year in DMU. In this experimental classroom, a total of 400 students participated in this experimental study. They came from clinical medicine, preventive medicine, nursing and other related medical specialties. Prior to this innovative learning, they had neither laboratory operation experience nor any exposure to relevant professional training.

In this study, the topic area contains key biochemistry and molecular techniques that are widely used in biological and clinical laboratory contexts<sup>[9]</sup> such as apoptosis sections, including Immunocytochemistry (ICC) Assay, q-PCR analysis and western Blot techniques. Besides, the statistical analysis is also a key

point for undergraduate students to master<sup>[10]</sup>. These selected experimental components help students understand and verify the technical theories they need to learn, through which they are provided with opportunities for scientific and laboratory practice.

### **The Virtual Simulation Teaching Experiment Center in DMU**

The Ministry of Education of China established the "Virtual Simulation Teaching Experiment Center" in 2013, which vigorously promoted the development of practical teaching. In case of the impact of corona virus, DMU proposed an open virtual simulation experiment teaching management platform in 2019. This platform is supported by Beijing Rainier Network Technology Co. Ltd, which is a professional provider of virtual simulation experimental teaching solutions with the leading technology in China. It is one of the first companies in China to provide an interactive learning environment of "Internet + virtual reality + education". It also provides development services for more than 700 universities all over the country, rendering essential technical support for the reform and innovation of experimental teaching in Chinese higher education. When using the platform, students can easily connect to the open learning resources (<http://icim.dmu.rofall.net/virexp/ffzy>) with their student's ID, regardless of time and location<sup>[11]</sup>. The learning resources for each topic area contain a teaching video resource as well as several related interactive practical exercises, with which students may have easy access to the websites. Within the teaching area of Innovative Experimental Course-Apoptosis, there are currently several practical training sessions. Also, the use of virtual slides is found to be a useful way for interpreting findings in textbooks<sup>[12-14]</sup>.

### **Teaching Strategies in Apoptosis sections**

In order to demonstrate the advantages of this teaching mode, we chose the most representative cell apoptosis experiment as the main teaching content. Apoptosis is the most common process of programmed cell death that can be triggered by multiple chemical and biological factors. This concept is of great importance to a wide of range of disciplines including biology, physiology, toxicology and medicine<sup>[15]</sup>. The experimental session of this curriculum has the overall aim of training students to handle the principles of apoptosis as well as the operating processes of a series of techniques, which include Immunocytochemistry (ICC) Assay, q-PCR analysis and western blot<sup>[16]</sup>. We will evaluate students' mastery of the experimental content and ability of operation under this teaching mode through various evaluation indicators. It is significant to note that before this laboratory experimental class, the students neither received laboratory-based training nor operational experiences. They are not as a result familiar with basic experimental instruments, and the majority of them are unfamiliar as a result with the use of a pipette, centrifuge machine, spectrophotometer, and electrophoresis apparatus. In order to achieve the learning outcomes in this area, a series of teaching methods were employed online, such as literature reading, experimental demonstrations, small group teaching, and discussion sessions, in all of which the students are free to ask questions. The detailed process of this mode is shown as follows in Fig.1.

## Online Preview learning

The first part is completely online based on the website, mainly including the following three steps: self-learning (video course), online simulation experiment and summaries of difficult problems. During the process, students are provided with the learning resources that include the principal and practical protocols, as well as the instructional videos on the platform. In addition, they can download them and print out and repeatedly read them. After previewing and understanding the relevant content by themselves, the students can frequently conduct model experiments on the platform, find the possible problems in the experiment, record and upload them on the platform. Then they may try to solve those problem in the subsequent study.

They are also required to complete such pre-class activities as searching several set questions based on the experimental laboratory activities and the theoretical principles, as well as other related learning goals for the upcoming class. It is regarded as an important activity, as the pre-class assignments not only deliver teaching material to students but also enable students to focus their attention on areas that could be potentially difficult for them. This had the net effects of producing richer in-class discussions, with the online system providing the major means of content delivery.

## Offline learning

After performing the above operations, teachers will guide students to complete the experiment operation and answer the relevant questions in person. Students conduct the experiment in groups with the help of teachers. After the experiment, according to the relevant content of the group discussion, the experimental operation report is written and uploaded on the virtual platform.

## Online Review learning

The last part of the content is also completed online, including group report, mutual evaluation of experimental report and summary. We will organize each group to make a PowerPoint presentation based on their own experimental results. Each experimental group can ask and answer questions individually. Finally, the teacher will make a summary according to the experimental operation performance and evaluate the quality of the experimental report.

## Results

Different methods and designs have been applied to evaluate web-based learning<sup>[11]</sup>. On completion of all of the practical sessions, the lecturers found that the outcome of learning was fully attained. In addition, the students' motivation for learning had been enhanced by using the simulation systems. The online work data show that 98.9% of the students work online for more than 2 hours, and only the students in Class H study for less than 2 hours. Besides, a total of 90.56% students spent more than 5 hours on online learning. The overall data of each class are as follows: A (90.3%), B (91.7%), C (87.5%), D (94.5%), E (93.7%), F (89.8%), G (90.3%), H (83.9%), I (91.8%), J (92.1%).

According to the score data of the final experiment operation, all the students in each class achieved excellent results. The average scores for ICC staining and lab reports were even as high as 98, with Class C's ICC staining results and Class A's lab reports scoring 100. The average scores of q-PCR and western blot were 94.93 and 97.87, respectively in Tab. 1.

The results of the data collected are very exciting. The table shows that the students are quite interested in this mixed teaching mode, and they have achieved excellent results in these experiments. Combined with the average score obtained from the above learning methods, Western blot was the most difficult one with the lowest score that the students got compared with the other experiments. In addition, students from Classes C, E, F, H also spend more time online comparing with the average level of time spent online. The online practical data showed that participants all have passed the online exercises, which indicated that they had significantly improved their procedural knowledge, motivational levels, as well as their interest in the topic.

We also prepared a questionnaire to get students' feedback on the hybrid model (Excerpt from Fig.2). Interestingly, all the students attended in group discussion enthusiastically and thought that using the online platform had a great effect on their learning. Compared with traditional teaching mode, more than 98% students prefer to this teaching mode and highly approve of online teaching platform. They found the platform easy to understand and helpful for learning. They even have the opinion that the model can be applied not only to experiments, but also to other disciplines.

From the views of both teachers and students, this blended teaching model has clearly been widely accepted. Of course, in addition to the advantages, they also offer some suggestions. For example, more and better educational resources are expected to be introduced, so that students can understand comprehensive knowledge, pay attention to practical methods closely related to the theoretical concepts in the textbooks, and improve students' learning efficiency.

### **Long-Term Learning Effect Evaluation**

Knowledge testing alone does not equate with the ability in real clinical scenarios, medical educators should also assess the application of skills in simulated clinical scenarios in addition to assessing knowledge in written tests<sup>[7]</sup>. Dalian Medical University holds an experimental innovation project competition each year (Excerpt from Fig.3), including theory examination and operation technology. A total of 40 students participated in this competition, 20 of whom participated in this training. The other 20 students came from the Department of Public Health, Nursing Department, Management Department and other related specialties, although they also participated in related experimental classes, it was merely a traditional practice method.

In this competition, when the scores for both objective and subjective items were carefully observed, the students trained with hybrid techniques performed better than those who had just been trained with traditional practical methods, suggesting that the interactive method helped them acquire knowledge more intensively.

## Discussion

In this paper, the teaching model innovation course was divided into three parts. The first part was to evaluate the changes how the students chose to act and solve. When students met with difficulties during the experiment, what were their attitudes? They decided to give up immediately or they chose to analyze the reasons, then solved the problems positively. Secondly, the students focused on changing or improving the tasks they perform. After a discussion, they designed the schedules and performed the experiment following the procedures. Besides, they made a record of the data and selected an appropriate statistical analysis to gain the results. Although not all the groups obtained the high-quality outcomes from the experiment, they enjoyed the process of participating in designing the outline, conducting the experiment, presenting the conclusion, and solving the problems. After this integrated scientific experimental course, the students upgraded what they had learned. They fully understood the definition of apoptosis and the different concepts between apoptosis and necrosis specifically. This integrative experiment course provided students an opportunity to discover science by themselves and benefited them in studying a complicated underlying concept through experimental practice.

This teaching mode not only arouse the students' interest in learning, but also gives them a deeper understanding of the complex principles. Teachers also reported that students not only had a stronger grasp of the material, but also improved their hands-on skills. As for teachers, their teaching skills and experimental design as well as their understanding of students' learning have also improved. This course innovatively used the combination of traditional teaching and network virtual platform for the first time, providing students with more facilities to master experimental operation techniques, cultivating interest in molecular biochemistry technology, and improving students' subjective initiative in learning. To sum up, adopting this teaching mode is very effective in cultivating the ability of unity, cooperation and independent thinking of higher education graduates.

According to the practice of this teaching mode, we also found some deficiencies that in need of future improvement. For example, we should pay more attention to the opinions of students themselves, set up more innovative courses and introduce more educational and teaching resources from the perspective of students. Furthermore, we need to carry out innovative reforms by combining traditional teaching models with modern science and technology and promote the development of higher education with students as our core.

## Conclusions

"Online + offline" blended teaching mode is very effective in that it provides us with a new perspective to observe the drawbacks of the traditional teaching model and provides us with a new opportunity to develop students' independent learning ability during the epidemic. We investigated the learning outcomes of 400 undergraduates in Dalian Medical University who were taught under this teaching mode. Our results show that students' mastery of the content and, more importantly, their hands-on skills

are improved under this model, which better supports their challenging transition from medical students to junior doctors and beyond<sup>[17]</sup>.

## Abbreviations

ICC: immunocytochemistry; q-PCR: quantitative real time polymerase chain reaction.

## Declarations

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### Authors' contributions

ZH Xu, Y Yu, SL Xia, B.T, TJ Man and B Zhou contributed to the conception and design of the systematic review. YH Qin and Z Sun conducted the systematic review. All authors were involved in drafting and revising the manuscript. All authors read and approved the final manuscript.

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### Availability of data and materials

Data sharing is not applicable to this article as no datasets were generated or analyzed during this qualitative review.

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

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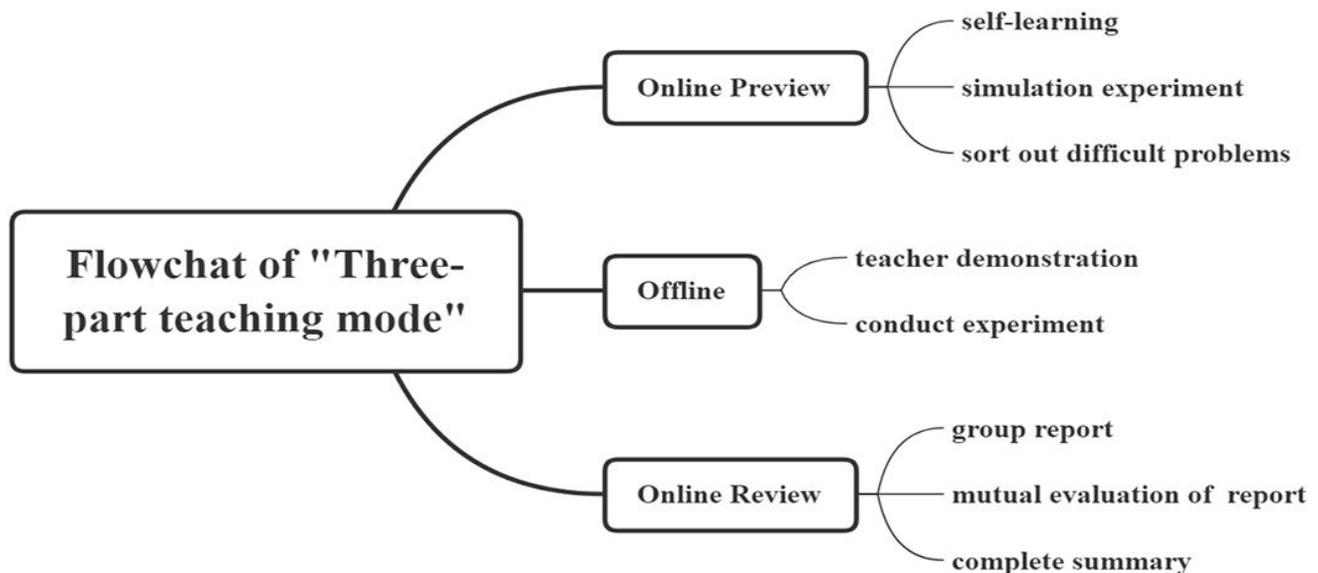
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## Tables

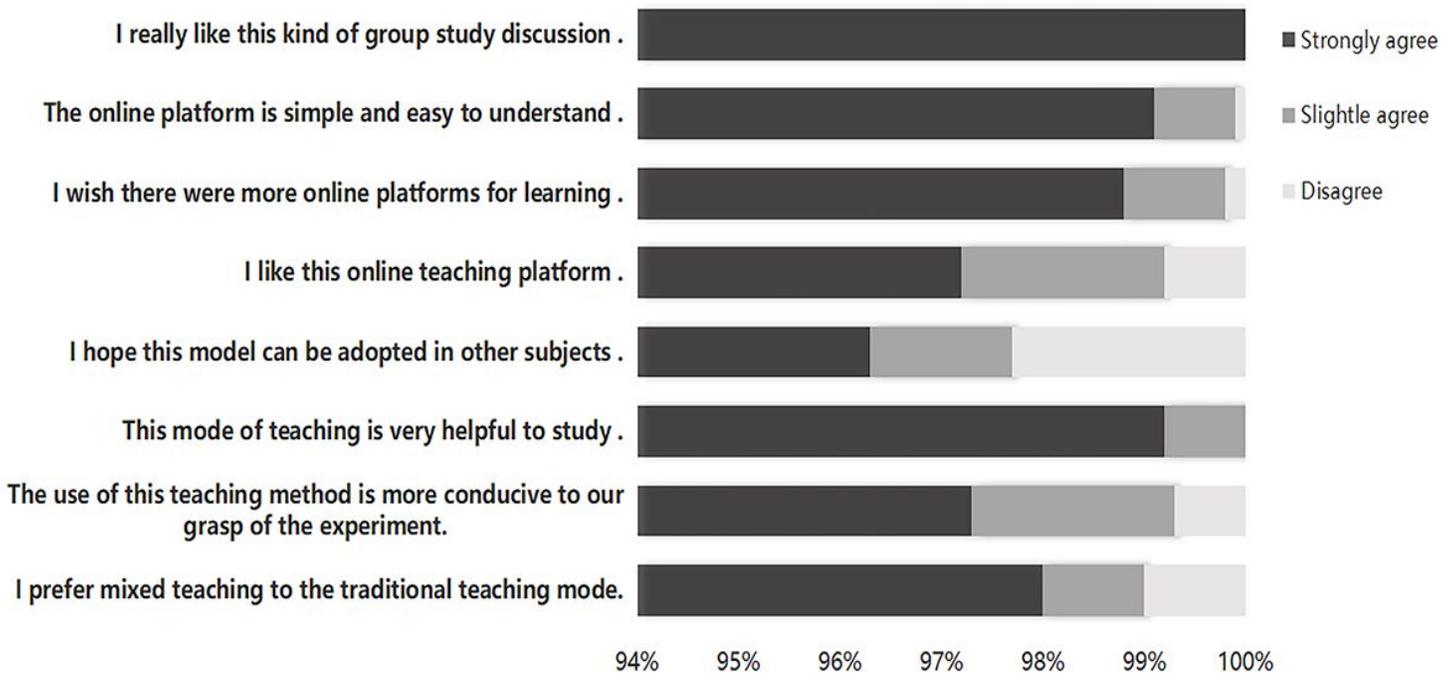
Due to technical limitations, table 1 is only available as a download in the Supplemental Files section.

## Figures



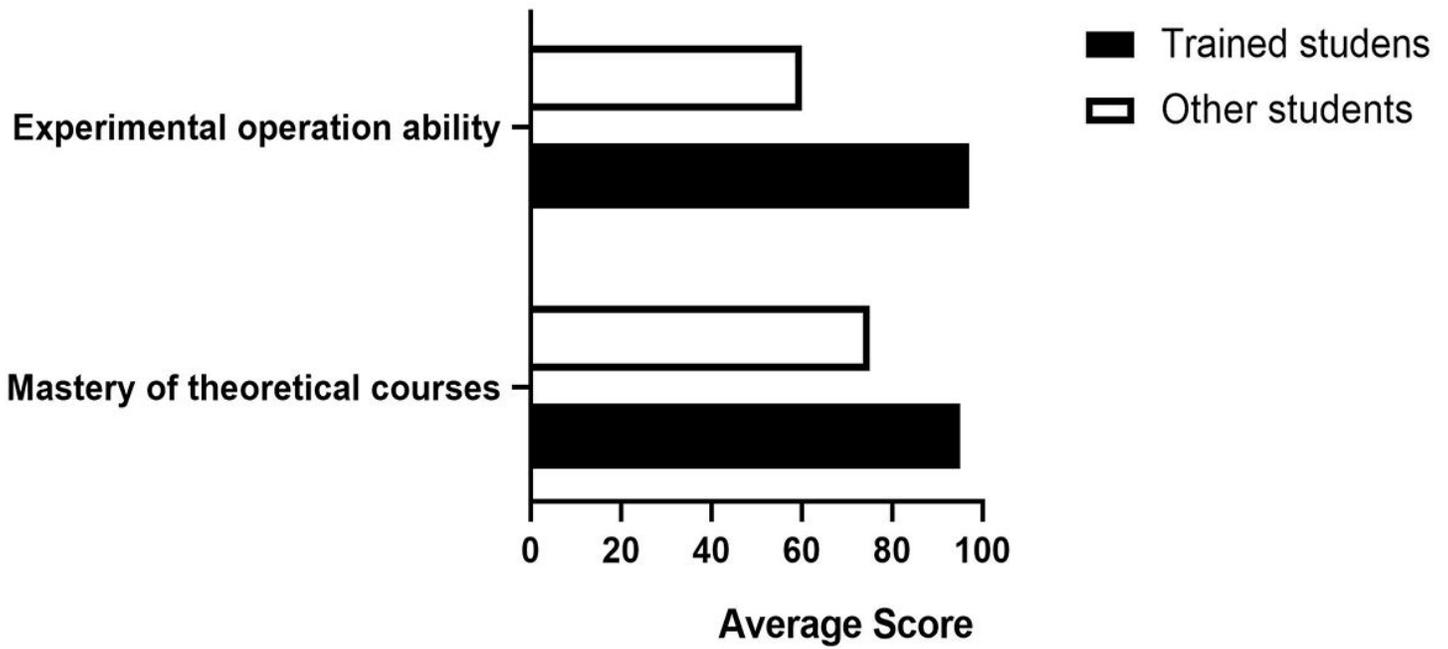
## Figure 1

In order to achieve the learning outcomes in this area, a series of teaching methods were employed online, such as literature reading, experimental demonstrations, small group teaching, and discussion sessions, in all of which the students are free to ask questions. The detailed process of this mode is shown as follows in Fig.1.



## Figure 2

We also prepared a questionnaire to get students' feedback on the hybrid model (Excerpt from Fig.2).



**Figure 3**

Dalian Medical University holds an experimental innovation project competition each year (Excerpt from Fig.3),

## Supplementary Files

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- [Tab.1.jpg](#)