Pathophysiology teaching reform during the COVID-19 pandemic

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Abstract

The Coronavirus Disease 2019 (COVID-19) pandemic has drastically changed the lives and teaching of students. At the beginning of the 2020 spring semester, the Chinese Ministry of Education adopted online education to reduce the spread of the virus and possible health risks to students. China was the first country to choose large-scale online education nationwide (1). However, as there was no reference on which to base these changes, it was not known whether moving all classes online would affect curriculum studies or how these changes would impact student life. Two issues needed to be considered before classrooms could go online, i.e., which platform could be used for online teaching and whether Internet speed could ensure normal course progress. For the first question, Tongji University purchased the enterprise version of Zoom, with platform stability guaranteed to a certain extent. Regarding the second question, the Shanghai Municipal Government increased home Internet speed for teachers, especially upload speed. However, as our students were distributed all over the country, Internet speed could not necessarily be guaranteed.

Different universities and courses implemented diverse and flexible online teaching methods (2, 3). Various universities adopted recording and broadcasting, whereby instructors video- or audio-recorded relevant lectures, which were then sent to their students. Although this approach allows flexible download, it has relatively high instructor requirements, such as mastering recording techniques. Other schools adopted live broadcasting, similar to traditional classroom teaching. However, this approach faces potential issues regarding slow Internet speed as well as unavoidable background noise and disturbance depending on the home lives of the participating students.

In addition, online education resources can also be used as a reference for student curriculum studies. For example, online course platforms such as Coursera, edX, Udemy, and FutureLearn provide diverse and popular courses (4, 5). In China, more and more online courses are becoming available for higher education (6, 7). Many universities record videos for certain subjects on related platforms, most of which are free for students and instructors. The current mainstream platforms for Chinese university courses include iCourse (http://www.icourses.cn/home/), Xuetangx (https://www.xuetangx.com/), Treenity (https://www.zhihuishu.com/), and Top Chinese University Massive Open Online Courses (MOOCs) Alliance (https://www.cnmooc.org/home/index.mooc) (8). These platforms contain many medical courses, including those related to pathophysiology. This wealth of online resources can be used as an important supplement for course study during the pandemic.

Before the start of the 2020 spring semester, the pathophysiology teaching team of Tongji University School of Medicine actively discussed the specific teaching methods of the course, hoping to find a way to minimize the impact of the pandemic on curriculum studies. In this report, we detail the teaching methods adopted during the pandemic,
which included online education resources, live discussion courses, and after-class WeChat study groups. We also explored the impact of these changes from the perspective of our students and evaluated the effects of the combined teaching approaches compared with traditional teaching.

**METHODS**

**Self-Compiled Questionnaire**

To understand the impact of the pandemic on students’ psychology and academic performance, we designed a questionnaire with 15 questions. The questionnaire was sent to students via their WeChat study groups, but answers to the questionnaire were anonymous. A total of 145 questionnaires were collected, with the information automatically generated into an Excel form.

**Students**

In China, most medical school students study the pathophysiology course in their second year. The students who participated in this study were clinical students of Tongji University School of Medicine. The 147 students from the 2018 class were divided into two teaching groups for the pathophysiology course and completed their final exams in the spring semester of 2020. Among the students, 29.7% were from rural areas, 39.3% were from cities, and 31.0% were from small towns (Supplemental Fig. S1; see https://doi.org/10.6084/m9.fgshare.15168276.v1).

**Teaching Plan**

Because of the COVID-19 pandemic, most universities in China introduced online teaching in the spring semester of 2020 for students to study at home. The specific teaching methods of each course across China could differ because of course characteristics and instructor arrangements. Given that some students may have a slow Internet speed, especially students from rural areas (29.7%), we redesigned the curriculum teaching plan to adapt to the new learning environment for most students. Therefore, we used a combination of online educational resources (https://www.icourse163.org/course/HUST-1002598054) and live video discussions via Zoom. For the online resource section, students could watch and study according to their own schedules, so Internet stability and speed issues could be reduced to a greater extent.

In recent years, online courses in Chinese universities have increased substantially. Before the course started, our instructors browsed all online pathophysiology courses and selected good-quality courses as learning materials for the students. We also surveyed our students’ experiences of online course study. We found that only 5.5% of students take online courses often, 56.6% of students take online courses occasionally, and 37.9% of students have never taken an online course (Supplemental Fig. S2; see https://doi.org/10.6084/m9.fgshare.15168291.v1). Our survey showed that most current college students still mainly study via face-to-face lectures.

In terms of curriculum design, our regular teaching plan includes face-to-face lectures (2 teaching groups) and problem-based learning (PBL) discussion classes (multiple groups, ~10 students in each group). The pathophysiology course contents include conspectus of disease, water and electrolyte balance and imbalance, acid-base balance and imbalance, hypoxia, fever, stress, ischemia-reperfusion injury, shock, and hemostasis disturbance (9). Each lecture consists of two teaching hours (45 min for each teaching hour). For PBL, we include two discussion classes and a summary class, for a total of six teaching hours. In this part of study, we cultivate the ability of students to analyze clinical cases and recognize basic pathological processes in specific cases for a more comprehensive understanding. Course assessments include 1) midsemester in-class quiz (25%), with students informed several weeks in advance; 2) formative assessment (20%), with instructors scoring student performance in the PBL class; 3) final exam (50%); and 4) attendance (5%) (Fig. 1A).

During the pandemic, the teaching plan was changed and included the following:

1. In preclass self-study, students were required to watch online videos, read relevant chapters in the textbook and PowerPoint (PPT) presentation prepared by course instructors, and sign into WeChat before the discussion course to avoid potential network congestion and to promote self-study.

2. In the discussion course, the original two teaching hour lectures were reduced to one teaching hour to avoid potential network congestion. At the beginning of the online discussion class, the teaching assistant contacted any students who had not yet entered the Zoom discussion (e.g., power outage, illness, disconnection) to ensure that as many students as possible participated in the class. The discussion course focused on combining knowledge with clinical case analysis. Approximately 20% of students were randomly invited to answer questions in a Zoom discussion. On the basis of the students’ ability to answer the questions, the instructor would explain concepts in depth. Our discussion class was videotaped throughout. The web address of the video was sent to the WeChat group for students who could not participate in the discussion for whatever reason. After discussion of each chapter from the course textbook, a 5- or 10-min in-class quiz (open book) of 5 or 10 multiple-choice questions was immediately given to the students. The multiple-choice questions were uploaded to https://courses.tongji.edu.cn/, and the order of the questions was random.

3. PBL was also carried out by Zoom to revise what had been learned in depth and to prompt self-teaching of what had not been studied.

4. For the WeChat study group, instructors posted course learning materials and requirements through WeChat, which is the most popular online communication app in China. Any problems encountered by students in the learning process could be asked at any time through the WeChat group, and questions with lower accuracy as well as their answer points were also posted as feedback of students’ study after each quiz. Instructors and students could discuss any problem in the WeChat group, not only to strengthen the mentor-student relationship but also to identify and resolve any physical or mental health issues faced by the students during the pandemic.
In the assessment part of the course, we split one-time in-class quizzes into multiple short quizzes upon completion of the discussion course of each chapter and then calculated a total in-class quiz score (25%). All other evaluations remained unchanged, except that the final test was conducted online (Fig. 1B). The final test was closed book, and the whole process was video recorded. According to the requirements of the Tongji University Undergraduate School for examinations, students logged into Zoom through both mobile phone and computer and turned on the cameras. Cameras were requested to face each student at different angles during the final test.

Statistics

Data are presented as means ± standard deviation (SD). Data were analyzed with t tests, and a P value of <0.05 was considered statistically significant.

RESULTS

Follow-up of Students’ Course Study

The reformed teaching plan required students to complete three preclass learning activities, including watching online video courses and reading the textbook and course PPT presentation provided by the course instructors. These preclass learning processes were to provide a preliminary understanding of the contents that needed to be learned, thus making discussion classes easier and helping students understand the related pathological processes. After completing the above three requirements, students were asked to check in and report on the accomplishment of the preclass learning in the WeChat study group. We surveyed the completion of the preclass study. In terms of time, 44.8% of students spent ~60 min completing the preclass activities, but the average time spent was ~80 min (Fig. 2A). This was longer than the one teaching hour that was set aside for them. Regarding the completion of the learning materials, 69.7% of students fully completed the above requirements (Fig. 2B).

Our results indicated that although the pandemic affected regular study patterns and approaches, it did not affect student motivation or attitude toward course study, and most students arranged their course study well in the home environment.

We also investigated the difficulties encountered by students throughout the pathophysiology course during the pandemic. In total, 42.8% of students believed that the main obstacle to study was poor network stability at home (Fig. 3A). Almost all schools in China used online teaching in the 2020 spring semester, and therefore Internet use was very high. During the discussion course, some instructors and students would be forced to temporarily withdraw from the meeting room because of Internet problems. This was an important reason why we adopted a teaching method combining online education resources and live discussion courses.

Impact of the Pandemic on Student Psychology and Curriculum Learning

The pandemic has affected all aspects of students’ study and life. Thus, we investigated the greatest concerns of students during the pandemic. Survey results showed that 65.5% of students were “afraid of delay in learning,” 63.5% of students “did not know how to arrange time,” and 48.3% of students were “afraid of a lack of freedom in life” (Fig. 3A). Other worries included “fear of infection,” “spiritual emptiness,” “low learning efficiency at home,” and “noise in the neighborhood.” In regard to the extent of the impact of the pandemic on study, 80.7% of students believed that the pandemic would have a moderate impact on their course study, whereas only 5.5% of students thought it would have a serious impact (Fig. 3B). Although these were the subjective feelings of students, our results indicate that the epidemic has affected all aspects of student life and study to varying degrees.

Comparison of Student Performance Under Different Teaching Methods

The 2016 and 2017 classes were taught via traditional teaching methods, whereas the 2018 class was taught via a...
combination of online education resources and live discussion courses on Zoom. In the final exam for the 2017 class, we introduced a multiple-choice exam with multiple answers, which differed from that used for the 2018 class. Thus, we only compared student performance of the 2016 and 2018 classes under the two different teaching methods. Assessment of student performance included in-class quizzes (25%), formative assessment (PBL, 20%), attendance (5%), and final exam (50%). Since the learning process of PBL did not change, except that it was held online, and student attendance remained the same, we did not include these scores in our analysis. Table 1 summarizes the assessments of the two classes (2016 and 2018). Results showed that the in-class quizzes and overall performance of the 2018 class were statistically higher than that of the 2016 class, whereas the final exam scores were comparable between the two classes. We also looked at the distribution of the final exam scores (total score is 100 points). The proportion of students with a final score of <60 points did not differ significantly between the two classes (2018, 8.2%; 2016, 11.2%); however, the proportion of students with a final score ≥ 90 points was much higher in the 2018 class (21.1%) than in the 2016 class (10.4%) (Fig. 4). Furthermore, analysis showed that the final exam score distribution was flatter in the 2018 class than in the 2016 class.

Evaluation and Suggestions for Online Courses from Student Perspectives

Finally, we surveyed the students regarding their subjective evaluation of the online courses. In total, 43.5% of students rated the online courses as good and 47.6% of students rated the online courses as fair, with only 4.8% and 4.1% of students rating the courses as very good and bad, respectively. When asked “What kind of course format do you think is worth promoting in future course study?”, 40.7% of students hoped to adopt off-line face-to-face lectures as the

Figure 2. The status of students completing the pathophysiology course and their main difficulties during the pandemic. A: time spent by students in pre-discussion course study. B: the percentage of students who completed the prelearning, including watching online video courses, browsing the course PowerPoint (PPT) presentation, and reading the textbook. C: the main difficulties encountered by students in completing the pathophysiology course.

Figure 3. Impact of the pandemic on student psychology and curriculum learning. A: the various effects of the pandemic on students’ psychology. B: from students’ perspective, the overall impact of the pandemic on their curriculum learning.
main teaching method and online courses as a supplementary teaching method. In addition, 35.2% of students believed that online study before the main theory course could help them in mastering course content (Fig. 5). These opinions will be considered in future teaching arrangements to help students better understand course content.

**DISCUSSION**

In this study, we report on the changes initiated by the pathophysiology teaching team of Tongji University School of Medicine, i.e., combined online education resources, online discussion courses, and WeChat study groups, for students studying the pathophysiology course during the COVID-19 pandemic. As shown by analysis of student performance and a questionnaire provided to students, our teaching method did not reduce overall student performance during the pandemic but improved the percentage of students with higher scores. The combined teaching methods were also evaluated by the students, who hoped that online education resources could be used as an important supplement for future academic study.

In 2020, during the COVID-19 pandemic, all Chinese students studied at home, while instructors taught remotely. The resulting changes in their external environment, lack of freedom in life, and differences in study affected many aspects of student psychology and behavior, thereby affecting course study (10, 11). In our teaching plan, the following factors were considered: 1) the influence of Internet speed on the smooth progress of online classes; 2) how to overcome the distractions of the home environment and stay motivated; and 3) how to achieve better remote online teaching effects.

Internet speed can greatly affect the smooth progress of online classes. In addition, the latency of the Internet increased during the pandemic because of the increase in online activities (12). If students (or instructors) were forced to disconnect from the Internet during the class or could not connect for extended periods, this would greatly affect course study. Our students came from all over the country, including 29.7% from rural areas and 31.0% from small towns (Supplemental Fig. S1), with Internet issues in relatively underdeveloped areas more problematic. Our survey also showed that 42.8% of students believed that the main obstacle to study was poor network stability at home (Fig. 2C). We considered that if live classes were used for the entire teaching process, students with poorer Internet speed would be greatly affected. In addition, the home environment of students was also likely to differ significantly, e.g., background noise, family disturbance during lockdown. Therefore, we split the traditional two teaching hour lectures into two parts: the online video course and the online discussion course. For the online video course, students could flexibly choose a time when Internet speed was relatively fast, and if disconnected students could continue to study after reconnection with

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**Table 1.** Comparison of academic performance between the regular teaching plan and reformed teaching plan during the pandemic

| Teaing Plan                             | Class  | In-Class Quizzes (25 points) | Final Test (50 points) | Overall Performance (100 points) |
|-----------------------------------------|--------|-----------------------------|------------------------|----------------------------------|
| Regular teaching plan                   | Class 2016 | 20.9 ± 3.1                | 38.4 ± 6.3              | 82.4 ± 9.4                       |
| Teaching plan during the pandemic       | Class 2018 | 22.4 ± 2.9*               | 39.7 ± 6.2              | 86.1 ± 7.7*                      |

Statistical significance: *P < 0.001.

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**Figure 4.** Student scores in the final exam. A: final exam results with a regular teaching plan. B: final exam results with the reformed teaching plan during the pandemic. Red line is the curve fitted by the normal distribution.
Studying from home requires greater self-discipline, which may have little effect on students with high self-motivation but can have an impact on less conscientious students. According to our survey, 65.5% of students worried that the pandemic would delay their studies, and 63.5% of students did not know how to arrange their study time. Our reformed teaching plan considered the impact of these factors on student study. Therefore, we modularized the learning steps. When students completed each requirement, they were requested to check in to the WeChat study group. Our teaching assistant managed these tasks and kept in touch with the students to maintain attendance as much as possible. Although this method increased the external thrust to promote their learning, it also helped students to stay motivated in their home environment. We also added the pathophysiological mechanisms of COVID-19 to different knowledge modules of the course to help students better understand pathophysiology from real life. We believed that this could help them to better understand their responsibilities as medical students, promote their self-discipline, and increase their enthusiasm for active learning.

Our traditional course learning mainly consists of classroom lectures, with no requirement for preclass study. Some students will preview course content before the lectures, and they tend to perform better in class and have a deeper understanding of course content. In our teaching plan reform, we set aside one teaching hour for students as a preclass study time. The online video courses were selected by the pathophysiology teaching team after careful review of high-quality online pathophysiology courses, which conformed to our course outline and provided in-depth explanations. As there was no interaction between students and video course instructors, online video lessons were shorter than normal classroom lectures and were more suitable for preclass learning. After studying the online courses, students had a general understanding of the main course contents. Our online discussion classes were based on the online video courses. We summarized the main knowledge points and introduced clinical cases to place learning content into specific situations. In the discussion classes, instructors would also randomly ask students questions to gauge their understanding and mastery of class content. Although this may be somewhat stressful for certain students, it also promotes independent learning and provides the opportunity for dynamic thinking. Of note, to reduce potential impact on the more introverted students, answers in class were not counted toward overall performance. After the online discussion classes, we believed that students should have a deep understanding of the course content. In addition, we also established a WeChat study group where students could provide timely feedback to instructors on any problems encountered in their study. Not only could instructors answer questions raised by students, but other students could also actively participate in discussions. The WeChat study group increased the interactions between students and instructors, which was an important supplement to the course plan between the two classes.

Students’ course performance reflected the effects of the teaching reforms. The final exam was closed book, and the whole process was video recorded, with students monitored from two different angles. Thus, the final test score was an accurate reflection of student learning performance. Zhou et al. (13) found no significant differences between traditional teaching and combined Massive Open Online Course (MOOC) microvideo approaches during COVID-19. In our study, the overall performance of the 2018 class was better than that of the 2016 class, which may be due to the higher scores of in-class quizzes. However, there were no significant differences in the average final exam scores between the two years. Importantly, the proportion of students who attained high final exam scores (≥90) in the 2018 class was higher than that in the 2016 class. However, because the proportion of students scoring in the 80s was relatively high (~40%), there were no significant differences in the final exam between the two classes.

On the basis of the above analyses and results, we believe that the reformed teaching approach promotes the learning of some students externally or internally and enhances their enthusiasm for medical study, thereby improving their academic performance. Overall, we believe that the modular teaching methods increased the external motivation of students to learn. The online video and discussion courses deepened the students’ understanding of the course content, and the WeChat discussions were helpful at identifying and resolving gaps in their study. These teaching and learning practices helped students achieve better academic performance.

After the pandemic has passed, students will return to normal classroom learning. However, we believe that the curriculum reform during the pandemic will provide positive reference for future curriculum design. Our survey
found that 40.7% of students also hope that online video courses will be used as supplementary materials for future course learning. In future course plans, we will adopt a mixed online and off-line teaching approach. Specifically, in addition to face-to-face lectures, we will 1) provide excellent online video course information for students, although it will not be mandatory; 2) add in-class quizzes after each chapter to promote learning during the semester; 3) include clinical cases in the curriculum, especially current health incidents, to deepen understanding of pathophysiology and the responsibilities of medical students; and 4) retain WeChat study groups as an important platform for course learning exchange.

**Limitations**

In this report, we discuss our reformed pathophysiology course plan, which was initiated in response to the COVID-19 pandemic. The final examination paper was not originally designed for this teaching reform report, so it was not designed strictly by the requirements of scientific papers, but the overall difficulty of the examination paper was comparable to that of the 2016 class. Our examination paper was designed following the regulations of the Undergraduate Academic Affairs Office of Tongji University, i.e., repetition rate of questions in the examination paper <30% from previous years.

**SUPPLEMENTAL DATA**

Supplemental Fig. S1: https://doi.org/10.6084/m9.figshare.15168276.v1.
Supplemental Fig. S2: https://doi.org/10.6084/m9.figshare.15168291.v1.

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**DISCLOSURES**

No conflicts of interest, financial or otherwise, are declared by the authors.

**AUTHOR CONTRIBUTIONS**

L.Y. and L.L. conceived and designed research; L.Y., K.L., J.H., and L.L. performed experiments; L.Y. and L.L. analyzed data; L.Y. and L.L. interpreted results of experiments; L.Y. and L.L. prepared figures; L.Y. drafted manuscript; L.Y., K.L., J.H., and L.L. edited and revised manuscript; L.Y. and L.L. approved final version of manuscript.

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