Exploration and Evaluation of the Long-term Effects of Diverse Online Teaching Methods of Basic Clinical Courses in Clinical Medicine During the COVID-19 Pandemic

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Abstract

To explore and evaluate the long-term effects of diverse online teaching methods to minimize the negative influences of online teaching of basic courses in clinical medicine during the COVID-19 pandemic. Forty-nine students in grade 2017 majoring in clinical medicine (five-year program) were enrolled in this study (study group). They received online teaching of six basic clinical courses, including diagnostics, basic clinical skills, general surgery, medical imaging, and doctor–patient communication, from March to July 2020. The study first introduced the process of online teaching, especially basic clinical skills such as history taking, physical examination, internal punctures, electrocardiography and so on. Then, they reviewed the schedules to reinforce these skills when the students returned to school. The final exam scores of four clinical courses, including internal medicine, surgery, obstetrics and gynaecology, and paediatrics, and the scores of graduation examinations were used to evaluate the long-term effects of online teaching. These scores were compared with students in grade 2014 who learned through offline teaching (control group). After graduation examinations, questionnaires were distributed to understand the influence of online teaching on learning clinical courses, internships and postgraduate entrance examinations. The results showed that the scores of internal medicine part I and surgery part II in the study group were higher than those in the control group, and the differences were statistically significant ($P < 0.05$). Differences were not statistically significant in scores of internal medicine part II, surgery part I, obstetrics and gynaecology, and paediatrics between the two groups ($P > 0.05$). Two students postponed graduation in grade 2017, so 47 students took part in the graduation examination. The scores for knotting, dressing change, and cardiopulmonary resuscitation in the study group were significantly lower than those in the control group ($P < 0.05$). For the three items internal punctures, four-step palpation in obstetrics, and assessment of children's growth and development, the scores in the study group were higher than those in the control group, and the differences were statistically significant ($P < 0.05$). There were no statistically significant differences between these two groups in the three items of history taking, physical examination and disinfection ($P > 0.05$). All 47 participants in the study group completed the questionnaire survey, with a response rate of 100%. Twenty students thought that the online learning experience had a great influence on learning clinical courses such as internal medicine, surgery, obstetrics and gynaecology and paediatrics, whereas 27 students thought it had a slight influence. There were 23 students who thought online learning had a great influence and 24 students who thought it had a slight influence when attending the internship qualification examination. Thirteen students thought that the influence on the internship was great, 30 students thought it was slight, and 4 thought that online learning had no influence. Regarding which course had the most influence on the internship, 36 students thought it was diagnostics, 7 students thought it was general surgery, and 3 students thought it was other courses. Among the 40 students who participated in the entrance examination for a master's degree, 2 thought the online learning experience had a great influence, 19 thought it had a slight influence, and

11 students thought it had no influence. Among the six courses that influenced the re-examination for postgraduate students, 16 students thought the most influential course was diagnostics, 5 students chose general surgery, and 1 student thought it was another course. Exploration of diverse online teaching methods is helpful and successful for mastering clinical knowledge. However, online teaching had a great influence on some basic clinical skills that require more practice. The strategy used to reinforce these skills after returning to school makes up for the shortage of these practical skills in online courses to a certain extent.

Keywords: COVID-19, online teaching, teaching effectiveness, clinical medicine

1. Introduction

At the beginning of 2020, with the spread of COVID-19 around the world, many offline activities were forced to be suspended, including school teaching at all levels. As of March 13, 2020, 61 countries, including China, announced the closure of schools (UNESCO 2020). To avoid affecting teaching progress, various countries and areas have adopted online teaching to complete teaching tasks.

The teaching mode changed suddenly from traditional offline to online, posing a large challenge for universities, teachers and students. Additionally, online teaching requires advanced designs of teaching strategies and arrangements, combined with students' self-learning and self-motivation to fulfil all teaching tasks. Integrating teaching resources with higher quality and efficiency, improving student attendance, and ensuring teaching effectiveness have become core issues in online teaching. Various colleges and universities have conducted many explorations and practices in terms of management (Tong, et al., 2022), technology and equipment (Fang, et al., 2020) and teachers (Zhu 2022; Cui, et al., 2022; Li, et al., 2022; Singh & Arya 2020). For example, the interaction between teaching and learning should be increased, a preclass–in class–after class teaching plan should be developed, and family–school contact should be strengthened (Zhu 2022). A variety of online teaching platforms are used to construct teaching resources, and virtual simulation platforms are used for experimental teaching. At the same time, assessment indices for online courses are established to strengthen formative evaluation (Cui, et al., 2022). The teaching plan is carefully designed based on MOOC (Li, et al., 2022). A hybrid flipped classroom was introduced to online teaching (Singh & Arya 2020). Some scholars believe that most teachers lack experience with online teaching, so teaching programs should be designed carefully. Teachers should make full use of resources such as video and audio (Bao 2020). Therefore, in their online teaching practice, the procedures and quality of online teaching can be ensured through six aspects, including the development of online teaching plans; decomposition of teaching content into small modules; use of "voices" in the teaching process; setting of teaching assistants; supervision of students' extracurricular learning by assigning homework; and online learning and offline self-learning (Bao 2020).

Online teaching in medicine is perhaps the most remarkable subject among all disciplines due to its professional and practical features. In addition to the theoretical component, the medical curriculum often includes practical skills and communication with real patients in the hospital. The practical component is a necessary process for training a qualified doctor. During the COVID-19 period, many medical schools implemented many methods to complete online teaching according to the characteristics of the curriculum and school conditions. Jonuscheit et al. (2021) introduced online optometry teaching in six universities in five countries in the Asia–Pacific region. The theoretical part was completed online, and the practical part, including in the laboratory and in the hospital, was completed by using videos, group discussions, case-based learning or learning after returning to school (Jonuscheit et al. 2021). Problem-based learning combined with a multidisciplinary team and mind mapping are also used during online teaching (Pan et al. 2021; Xiao et al., 2021). Some teachers try to simulate and recreate clinical scenes to strengthen students' clinical skills and thinking by recording videos of teaching rounds, skills demonstrations and explanations, case discussion and other teaching methods (Lin, Zhou & Zhang 2021).

In China, the Ministry of Education issued a notice on online teaching in colleges and universities nationwide at the end of January 2020 (Jin et al., 2021). With the support of internet technology, colleges and universities used various online teaching platforms, such as Superstar Learning Link, Rain Classroom, Tencent Conference, Tencent Classroom, MOOC, DingTalk, and Zoom, to complete the teaching process. At the same time, they cooperated with chat software such as WeChat and QQ to communicate with students in real time and complete teaching processes, such as lectures, homework, and examinations.

To date, there have been many studies about teaching modes or blended offline and online teaching modes during the COVID-19 pandemic (Arenas 2021; Wang & Xu 2020). Some of them have evaluated teaching effects, but there is very little research on the long-term effects of online teaching. To address this shortcoming, this paper first reviewed the process of online teaching in grade 2017 students majoring in clinical medicine who finished six basic clinical courses, including diagnostics, diagnostic experiments, basic clinical skills, general surgery, medical imaging and

doctor–patient communication, from March to July 2020 in our school, with a particular focus on basic clinical skills, such as history taking, physical examination, internal punctures, electrocardiography and so on. Then, schedules to reinforce these skills were introduced when students returned to school. The final exam scores of four clinical courses, including internal medicine, surgery, obstetrics and gynaecology, and paediatrics, and the scores of graduation examinations were used to evaluate the long-term effects of online teaching. These scores were compared with students in grade 2014 who adopted offline teaching. After graduation examinations, questionnaires were distributed to understand the influence of online teaching on learning clinical courses, internships and postgraduate entrance examinations.

2. Methods

2.1 Participants

The control group included students majoring in clinical medicine in grade 2014 (five-year program) at Jinan University. All courses were completed offline.

The study group included students majoring in clinical medicine in grade 2017 (five-year program). For one semester, all courses were taught online.

Students in both groups come from different provinces in mainland China. The training program, curriculum, course hours and credits of the two groups were consistent.

Exclusion criteria: students who transferred to majors, were suspended or retook courses were excluded.

2.2 Course Arrangement

2.2.1 Five-Year Teaching Arrangement for Students in Grade 2017 (Study Group)

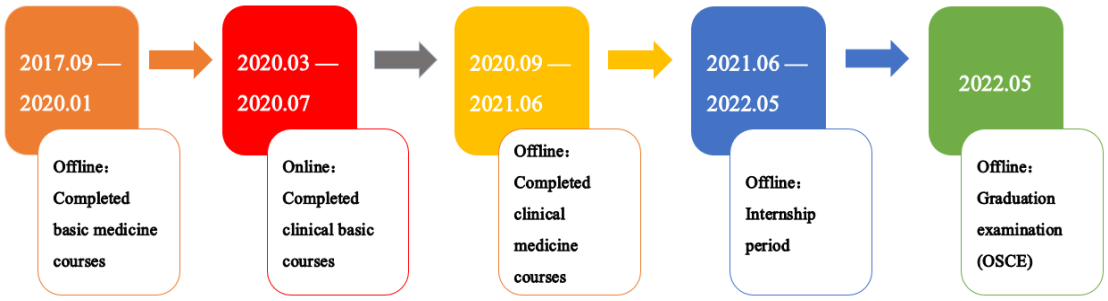

Figure 1. Five-year teaching arrangement for students in grade 2017

Online teaching period and courses: From March to July 2020, students completed the following six courses: diagnostics, diagnostic experiments, basic clinical skills, general surgery, medical imaging, and doctor–patient communication.

Offline teaching time and courses: As shown in Figure 1, students completed basic medicine courses before the epidemic and clinical courses such as internal medicine, surgery, obstetrics and gynaecology and paediatrics from September 2020 to June 2021. The internship phase was from June 2021 to May 2022. Students attended graduation examinations in May 2022.

Online teaching arrangement

Four courses, including diagnostics, diagnostic experiments, basic clinical skills, and doctor–patient communication, were arranged by the department of internal medicine; general surgery was arranged by the department of surgery; and the course of medical imaging was arranged by the department of imaging. The online teaching arrangements for these six basic clinical courses are as follows:

(1) The lists of students who selected these courses were imported into the e-learning platform Rain Classroom by the Office of Academic Affairs.

(2) A WeChat group was established for each course. Students, teachers and administrators were invited into the group to communicate at any time.

(3) Arrangement of the theoretical part.

Teachers prepared contents according to the syllabus. The following platforms could be chosen to complete the course: Rain Classroom, Tencent Classroom and Tencent Conference. The platforms had voice live broadcast, video live broadcast, and playback functions, which can be selected by teachers. In the process of teaching, the functions of random roll call, bullet screen, and distribution exercises to students could be used to increase interactions between students and teachers. At the end of the class, the data of the class could be analysed to adjust teaching management and strategies (Figure 2).

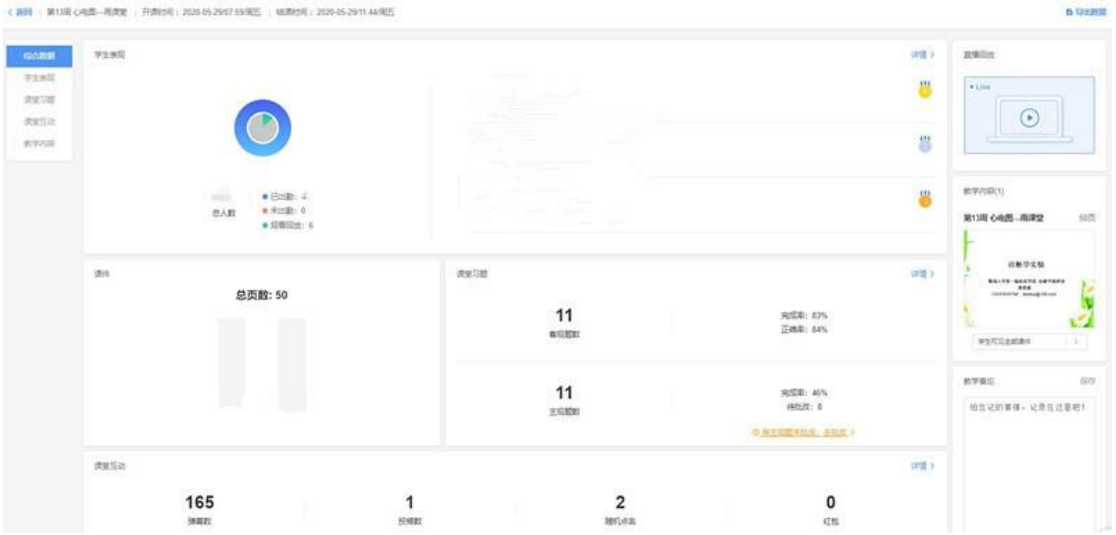

Figure 2. Comprehensive classroom data of the Rain Classroom platform (showing data such as students' performance, exercises, teacher–student interactions, teaching contents, playback, etc.)

(4) Practical part

Combined with learning resources such as video and audio, the process of the practical part was focused on the procedures and methods of each clinical skill. Teaching methods of basic clinical skills, such as history taking, physical examination, electrocardiogram (ECG), medical record writing, and clinical thinking, were described in detail. The above contents included three courses: diagnostics, diagnostic experiments and basic clinical skills. These contents were taught by using the live broadcast of Rain Classroom, and a three-segment teaching mode was introduced. The mode was based on the previous literature published by our team (Huang et al. 2020). Skills included in general surgery were mentioned briefly.

1) History taking

The teaching model was teacher-standardized patients, in which the teacher served as a standardized patient to help students to complete history-taking process. Here, the teacher had two identities: one as a teacher and the other as a patient. The most important objective in this part was to cultivate basic skills of doctor–patient communication and humane care and master the skills of history taking, especially the contents of a patient's present history. All cases used for teaching were from real patients in the clinic. A total of 5 classes were arranged, including cardiovascular, respiratory, gastroenterology, rheumatism, and a review class, with 4 hours per class. At the beginning of the lessons, students reviewed the contents of history taking and skills of doctor–patient communication, and then they completed history taking based on the information given by the teacher.

For example, a patient came to the hospital complaining of abdominal pain, which is a common symptom of the digestive system. The scene setting was in the gastroenterology unit, and the patient was recently admitted to the hospital. First, students were required to conduct history taking. They communicated with teacher-standardized patients and recorded the data. Then, the students summarized and reported chief complaints, present history and other medical history when they finished the procedures. Feedback was given by the teacher. Generally, some information would be omitted, and this omitted information would be supplemented under the guidance of the teacher. Finally, the teacher summarized the aetiology of abdominal pain and the main points of history taking and skills of doctor–patient

communication. After class, students were required to complete the medical records and handed them in. The teacher corrected the materials and provided feedback. The history-taking procedures are shown in Figure 3.

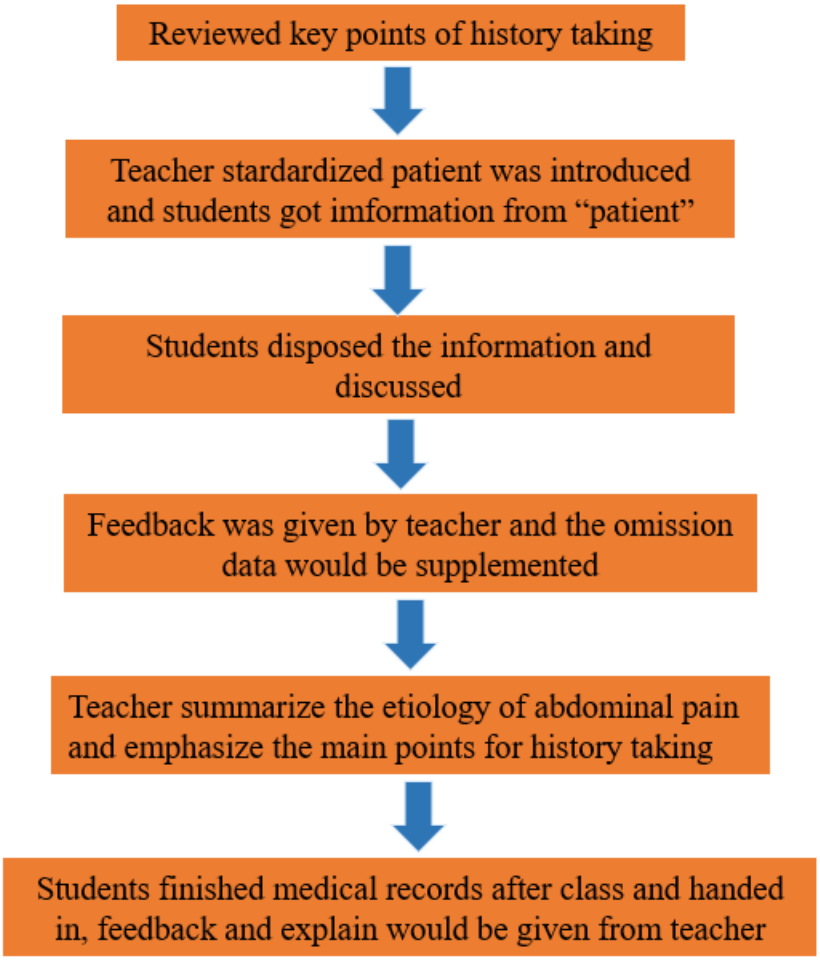

Figure 3. Online teaching procedures for history taking

2) Physical examination

At the beginning of the lesson, the clinical relevance of symptoms and abnormal signs were reviewed through cases. Then, the procedures, methods and key points of the items were explained. Many teaching resources were applied, such as videos, audio and images, during the process to arouse students' interest and motivation during the process. Exercises were inserted randomly and were to be completed within a limited time. When time was up, the teacher checked the results for completion and accuracy, which provided a very important index for teachers to adjust their teaching strategies. For example, in studying abdominal examination, the case of decompensated liver cirrhosis was shown first. Key points of taking a history with patients complaining of jaundice were reviewed, abnormal signs such as facial features, yellow-stained skin and eyes, spider angioma and liver palms could be found in this case, and their clinical relevance was analysed. Physical abdominal examination procedures were explained after the student finished reviewing the case. Table 1 and Figures 4-8 show the mode of abdominal practical teaching.

Table 1. Online teaching procedures for liver palpation

Preparation	**Prepare examination tools and sanitize your hands. Pull the curtain, stand at the right side of the patient.**
Communication & Humanistic Care	"Mr./Ms.**, I am Dr. XX from XX department. We are going to perform a liver examination, please go to the washroom before we start". When the patient comes back, "Please lie down and relax". "If you feel any discomfort during the process, please tell me".
Position	Instruct the patient to take a supine position and bend his or her legs and breathe with abdominal breathing. Expose the abdomen fully.
Method of Palpation	Unimanual Palpation: The fingers of the right hand should remain stretched and stay together. Place the hand roughly parallel to the costal edge and palpate from the right side of the umbilicus. Instruct the patient to exhale and inhale. When the patient exhales, slightly press the fingers down, and lift up the fingers while the patient inhales (Here, a question is asked to students: **Why?**); gradually move the fingers towards the costal edge, until touching the liver edge or the costal edge.  Figure 4. One-hand palpation (Wan X.H. et al. 2020) Bimanual Palpation: The right hand proceeds the same as in the unimanual palpation. The left hand touches the back of the right lumbar and part of the ribs, lift up the body during the process.

Figure 5. Two-hand palpation (Wan X.H. et al. 2020)

Comments	The liver cannot be palpated. If palpated, describe the size, texture, edge and surface condition, and tenderness carefully.
Attentions	The examination should be performed with the patient's breathing, so instruct the patient to take deep breaths during palpation. Examine on the midclavicular line and anterior midline.
Termination	Thank the patient for his or her cooperation. Sanitize your hands again.

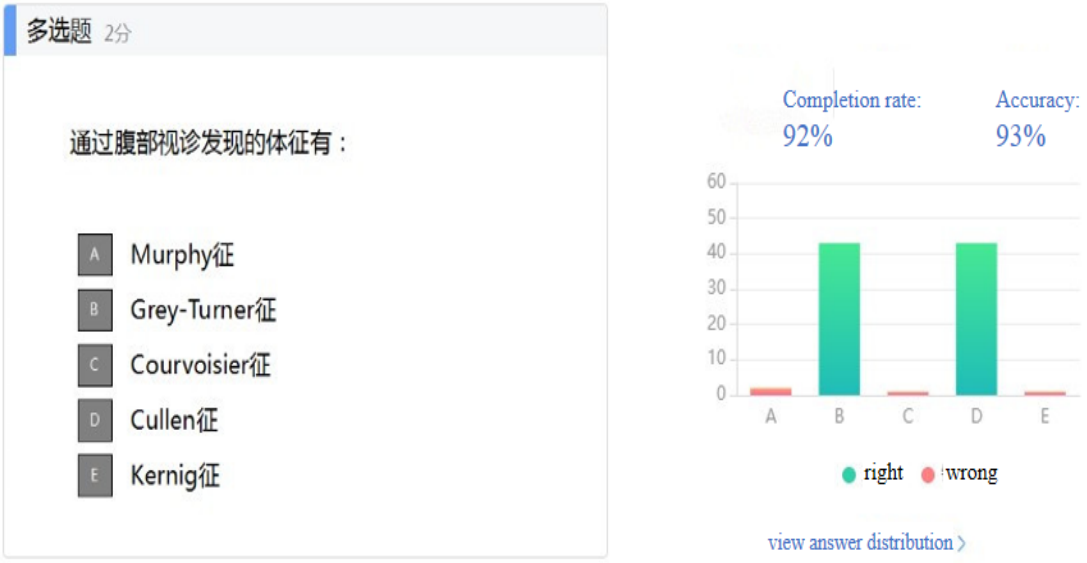

Figure 6. Exercises for abdominal examination (inspection, multiple choice)

Figure 7. Exercises for abdominal examination (auscultation, single-choice question)

Figure 8. Exercises for abdominal examination (fill in the blanks)

3) Internal punctures

The four commonly used internal punctures in the clinic are thoracentesis, abdominocentesis, bone marrow aspiration and lumbar puncture. Similar to the teaching method of physical examination, these contents were taught through cases, pictures, videos with exercises and questions inserted.

4) Laboratory and auxiliary examination

In this part, cases including history, physical examination and lab index were introduced. The teaching objective was to focus on guiding students to master the principles of selecting laboratory indices, normal values of these indices and the clinical relevance of abnormalities. A teaching chapter about routine blood tests is given in Table 2.

Table 2. Online teaching procedures for routine blood tests

Case for routine blood test	
Medical history	A 23-year-old woman presents to the clinic complaining of dizziness and fatigue for the past 1 year. In addition, this discomfort has been aggravated for the past 2 months. She also feels palpitation and loss of appetite. She denies bowel changes, melena, or haematochezia, but she reports an irregular menstrual cycle with an interval of 20-28 days, a menstrual period of 7 days and large menstrual volume. She was healthy in the past and had no blood diseases.
Physical examination	T 36.2 ℃, R 20/min, P 96/min, BP 110/70 mmHg. The general condition is normal. There is slight pallor of conjunctiva, skin and palms. Superficial lymph nodes are not palpated, and no tenderness of the sternum is reported. Chest is clear to auscultation bilaterally. Examination of the cardiovascular system reveals a regular rhythm; heart rate is 96 bpm/min with no rub or gallop and no murmur. Abdomen is soft, no tenderness. Without hepatosplenomegaly. Bowel sounds are present.
Laboratory examination	Results of blood routine test: RBC 3.3×10^{12}/L, Hb 75 g/L, HCT 0.25; MCV 75 fl, MCH 23 pg, MCHC 300 g/L, RDW 16.5%, WBC 4.5×10^{9}/L, PLT 120×10^{9}/L.
Questions requiring answered in class	1. What are the main symptoms of the patient? 2. What are the main signs of the patient? 3. How should the results of the routing blood test be analysed? 4. What are the possible aetiologies for this case?
Homework	1. What is the most likely diagnosis of this case? What is the diagnostic evidence? 2. To further confirm the diagnosis, what other laboratory tests should be done? 3. Please analyse the possible causes of the case. 4. What diseases should this case be differentiated from?

Abbreviations: Red blood cell (RBC), Haemoglobin (Hb), Haematocrit (HCT), Mean corpuscular volume (MCV), Mean corpuscular haemoglobin (MCH), Mean corpuscular haemoglobin concentration (MCHC), Red blood cell volume distribution width (RDW), White blood cell (WBC), Platelet (PLT).

5) ECG

In the practical part, the contents of the ECG lead connection and methods and steps of ECG analysis were first introduced. The former was completed by using videos, and the latter was taught by combining with pictures. The analysis process was divided into 15 questions to guide students to be familiar with ECG analysis steps and master the characteristics of abnormal ECG (Table 3).

Table 3. Process for analysing ECG

Number	Questions	Knowledge point
1	**Analyse rhythm**	(1) Definition of sinus rhythm. (2) ECG characteristics of sinus rhythm. (3) Abnormalities: abnormal ECG features related to sinus P wave; ectopic P wave; absence of P wave.
2	**Measuring heart rate**	Calculation method for regularity and irregularity condition.
3	**Analyse P wave**	(1) Mechanism of P wave. (2) Sequence and its causes for atrial depolarization.

		(3) Duration and amplitude of normal P wave.
4	**Measuring PR interval**	(1) Significance of PR interval. (2) Duration of PR interval. (3) Abnormal conditions: prolonged; shortened; irregular.
5	**Name QRS complex**	(1) Mechanism of QRS complexes. (2) Naming principle.
6	**Analyse duration of QRS complexes**	(1) Normal range. (2) Abnormalities: widening of QRS complexes; no QRS complexes.
7	**Analyse morphology and amplitude of QRS complexes**	Morphology and amplitude; pathological Q wave and R wave abnormal morphology.
8	**Analyse the relationship between P waves and QRS complexes**	(1) Normal situation: before each QRS complex, there is a related P wave, and the frequency relationship between them is 1:1. (2) Analyse: positional and frequency between them.
9	**Analyse electrical axis**	(1) Methods for axis analysis. (2) Normal conditions. (3) Abnormal situations: analyse method and clinical relevance.
10	**Analyse clockwise rotation**	(1) The regular change for QRS complex in the precordial leads. (2) Normal conditions. (3) Abnormal situations: analyse method and clinical relevance.
11	**Analyse ST segment**	(1) Mechanism of ST segment. (2) Normal conditions. (3) Abnormalities: the criteria, morphology, and clinical significances of ST-segment elevation and depression.
12	**Analyse T wave**	(1) Relevance of T wave. (2) Morphology and amplitude of normal T waves. (3) Common morphological changes and relevance of T waves.
13	**Measuring QT interval**	(1) Relevance of QT interval. (2) Normal range. (3) Abnormalities: prolonged and shortened.
14	**Analyse u waves**	(1) Mechanism for u wave. (2) Normal conditions. (3) Abnormalities: increase in u wave.
15	**Write down the characteristics and ECG conclusions for this picture**	The format for conclusions.

6) Medical record writing

Students were required to complete medical records during study history taking and physical examination. Key points and attention to medical records were mastered by writing medical records. Problems were summarized, and feedback was given by teachers after corrections.

7) Clinical thinking

Training clinical thinking was one of the core contents in diagnostics. Clinical thinking is a very important ability for students majoring in clinical medicine, and it is mainly cultivated through cases. In the learning process of cases, students were guided to discover, analyse and solve problems.

8) Basic skills included in general surgery

Videos and pictures were to be used in the teaching process. The teacher explained the procedures. According to the course, cardiopulmonary resuscitation (CPR) is a topic of general surgery.

9) Students' opinions of online teaching

In July 2020, after the final examination, a survey was designed by the department of internal medicine to investigate students' opinions of online learning for Items 1-7 listed above. Each question had five choices: strongly agree (5 points), agree (4 points), neutral (3 points), disagree (2 points) and strongly disagree (1 point).

The results showed that teaching strategies and arrangement received higher scores. Interaction between students and teachers was good. The score for "learn voluntarily" was low. In addition, students considered that the effect of online teaching was different from that of offline teaching, and they worried that online learning may influence the study of clinical courses. The questions and results of the survey are shown in Table 4.

Table 4. Survey about students' opinions of online learning (n=49)

Number	Questions	Results (M ±SD)
1	I am satisfied with the strategies and arrangements of online teaching.	4.41 ± 0.54
2	Interaction with teacher during online teaching is good.	4.35 ± 0.66
3	Resources provided during online learning satisfy my needs.	3.94 ± 0.80
4	I can learn voluntarily during online teaching.	3.35 ± 0.88
5	Learning efficacy is not affected by online teaching.	3.31 ± 0.98
6	It is an acceptable and feasible model of online teaching during the COVID-19 pandemic.	4.12 ± 0.83
7	Online teaching achieves the same effect as offline teaching.	3.27 ± 1.11
8	I have not practised these skills offline, especially interviewing real patients; I worry that this will influence my study of clinical courses.	4.22 ± 0.62

Arrangements for reinforcing these skills after students return to school

(1) Clinical basic skills related to diagnostics were reinforced

From 2020 to 2021, these basic skills, such as history taking, physical examination, internal punctures, ECG, medical record writing and clinical thinking, were reinforced in person in internal medicine courses.

In the first semester, which was from September 2020 to January 2021, in practical training in internal medicine part I, students were divided into small groups of 10-13 students and practised these skills. Teachers demonstrated how to take history and how to perform a physical examination. Students reviewed these lessons in the ward and in the clinical skills comprehensive training centre. In the ward, students interviewed real patients to collect medical information. They were required to take a history, complete a physical examination, select lab items based on the patient's condition and interpret lab results, and then analyse the case, including diagnosis, diagnostic evidence, differential diagnoses and treatment plan. Every step mentioned above was performed under the guidance of the teacher. In the clinical skills comprehensive training centre, students practised physical examination and internal punctures with 2-3 students in a

group. The teacher corrected their technique. Examinations, including history taking, physical examination, internal punctures and ECG, were held when students finished practical training.

The second semester was from March 2021 to June 2021, similar to internal medicine part I. These basic skills were also arranged to be reinforced in internal medicine part II.

(2) Basic skills related to general surgery, including washing hands, wearing surgical gowns and wearing gloves, knotting, and suturing, were taught face-to-face in extra time in September 2020. Four lessons were used to teach these skills, and the exam was held the last time.

(3) From April 22 to May 5, 2021, basic clinical skills such as disinfection and draping, dressing change, CPR, and physical examination were strengthened before the internship.

2.2.2 Teaching Arrangement for Grade 2014 (Control Group)

Teaching schedules for basic clinical courses

From March to July 2017, students in grade 2014 studied the above six basic clinical courses. The theoretical part was taught in the classroom, and the practical part was completed in the ward, in the clinical skills comprehensive training centre and in the surgical lab with small groups. The details for teaching methods regarding history taking, physical examination, internal punctures, etc., are described briefly below.

(1) History taking

Students contacted real patients in the hospital and completed history collection.

According to the schedule, they interviewed patients in the following five departments—respiratory, gastroenterology, nephrology, cardiovascular and endocrinology—with one opportunity per department. During the process, the teacher demonstrated the procedures first, and then students were divided into small groups of 3-5 students to complete history taking. After consultation, students wrote medical records and reported them. The teacher analysed and pointed out the mistakes and omissions that could be supplemented by interviewing the patient again. Doctor–patient communication, humane care and clinical thinking were integrated during these procedures.

(2) Physical examination

These skills were trained in a clinical skills comprehensive training centre. The teacher explained the key points, followed by demonstration. Students practised in groups of 2-3 students. Usually, training occurred between students.

(3) Internal punctures

The teaching procedures were similar to those of the physical examination. These parts were trained in models, and sometimes, students had opportunities to observe real patients in the ward.

(4) Laboratory and auxiliary examination

Three lessons were arranged in the lab in this part, covering the common items used in clinics.

For example, routine blood tests, urine tests, and liver and renal function tests were introduced. Students were required to complete the contents with traditional methods. These parameters included red blood cells, white blood cells, platelets, white blood cell classification, and routine urine examination. The students wrote experiment reports after class and submitted these to the instructor for correction. In addition, the teaching contents included visiting the clinical laboratory medicine centre.

(5) ECG

The teacher guided students to complete the connection of ECG leads in the classroom and then explained the steps of ECG analysis through pictures.

(6) Medical record writing

For each interview and physical examination, the corresponding medical records were required to be completed after class. Feedback was given in the next class.

(7) Clinical thinking

Critical thinking was integrated into the contents of history, laboratory and auxiliary examination and medical record writing. Case-based learning was not used in the control group.

(8) Basic skills included in general surgery

Knotting, dressing change, CPR and disinfection were taught face-to-face. The teacher explained and demonstrated the

procedures in class, and students trained with models, pig intestines, pork legs and dogs.

(9) Examining clinical skills

At the end of the semester in July 2017, an exam was held on topics including history taking, physical examination, internal punctures, ECG and surgery skills. The different teaching methods for these basic skills of the two groups are summarized in Table 5.

Table 5. Different teaching methods for basic skills of the two groups

Teaching contents	Study group (n=49)	Control group (n=43)
History taking	Teacher as a standardized patient.	Interviewed real patients in the ward.
Physical examination	Videos, audio, pictures, teacher-explained procedures.	Videos, audio, and pictures; the teacher demonstrated procedures in class, and students trained with each other.
Internal punctures	Same as physical examination.	Videos and pictures; the teacher demonstrated procedures in models, and students practised with small groups.
Laboratory examination	Case-based learning	Completed common items with traditional methods and visited the centre of clinical laboratory medicine.
ECG	Videos; analysis contents were divided into 15 questions for every picture.	Demonstrated the connection of ECG leads with student and analysed pictures.
Medical record writing	The contents and formats were inserted into history taking and physical examination.	It was trained during history taking and physical examinations.
Clinical thinking	Case-based learning.	Integrated into history taking, physical examination and lab items.
Basic skills including in general surgery	Videos, pictures, teacher-explained procedures.	Teacher explained and demonstrated procedures in class, and students trained with models; some skills were practised on animals, such as dogs.

2.3 Assessment Methods

(1) Sores of the final exam of four clinical courses, including internal medicine, surgery, obstetrics and gynaecology, and paediatrics, were used to evaluate the long-term effect between the two groups. The full scores of papers were 100 points, which included multiple choice questions, noun explanation, questions and case analysis.

(2) Graduation scores of objective structured clinical examinations (OSCE)

Every year in May, graduation examinations are held in our university. The examinations adopt OSCE with 16 stations before 2019 and 9 stations from 2020. Therefore, students in the control group finished the exam with 16 stations within half a day, while students in the study group completed the OSCE with 9 stations. In this study, the contents of 9 stations in the study group were used for comparison between these two groups. The evaluation criteria were the same for the same item in the two groups.

(3) Questionnaire survey

Questionnaires were designed and distributed to students in grade 2017 to understand the effect of online teaching,

which included learning experience for clinical courses, internships and postgraduate entrance examinations. The contents of the questionnaire are shown in Table 6.

Table 6. Contents of questionnaire survey

Question	Contents
1	Did the experience of online learning from March to July 2020 affect learning clinical courses such as internal medicine, surgery, obstetrics and gynaecology, paediatrics?
2	Did the experience of online learning from March to July 2020 affect the preinternship qualification test?
3	Did the experience of online learning from March to July 2020 affect the internship?
4	Which online course do you think had the most influence on the internship?
5	Did the experience of online learning from March to July 2020 affect the national master's degree exam?
6	Did the experience of online learning from March to July 2020 affect the re-examination for a master's degree? (Answered by the re-examination students)
7	Which online course do you think had the most influence on the re-examination for a master's degree? (Answered by the re-examination students)

Remarks: There are three answer options for questions 1-3 and 5-6, which are 1) great influence, 2) slight influence, and 3) no influence; there are four options for questions 4 and 7, which are 1) diagnostics, 2) general surgery, 3) other courses, and 4) no effect.

2.4 Statistical Analysis

The data were analysed using SPSS v22.0 and visualized using GraphPad Prism v8.0. Quantitative data are expressed as the mean ± standard deviation (M±SD). The data were analysed by independent sample t tests. Two-tailed p values of <0.05 were considered to be statistically significant.

3. Results

3.1 Basic Information

Study group: A total of 49 students, 28 males and 21 females, in grade 2017 were included.

Control group: There were 43 students in grade 2014, including 15 males and 28 females.

3.2 Comparison of Scores for Clinical Courses

Table 7 and Figure 9 show that the scores of internal medicine part I and surgery part II in the study group were higher than those in the control group, and the difference was statistically significant ($P < 0.05$). The scores of surgery part I, obstetrics and gynaecology, and paediatrics in the study group were slightly higher than those in the control group. The difference was not statistically significant between the two groups ($P > 0.05$). Scores of internal medicine part II in the study group were slightly lower than those in the control group, but the difference was not statistically significant ($P > 0.05$).

Table 7. Comparison of scores for clinical course between the two groups

Courses	Study group (n=49)	Control group (n=43)	*P*
Internal Medicine (part I)	71.82±10.40	63.66±11.92	0.000*
Internal Medicine (part II)	70.92±9.16	71.67±9.79	0.353
Surgery (part I)	77.53±7.68	76.12±9.28	0.214
Surgery (part II)	76.00±8.30	70.63±10.97	0.004*
Obstetrics and Gynaecology	71.97±10.28	71.00±15.70	0.365
Paediatrics	71.98±8.94	68.21±12.94	0.056

*:$P < 0.05$.

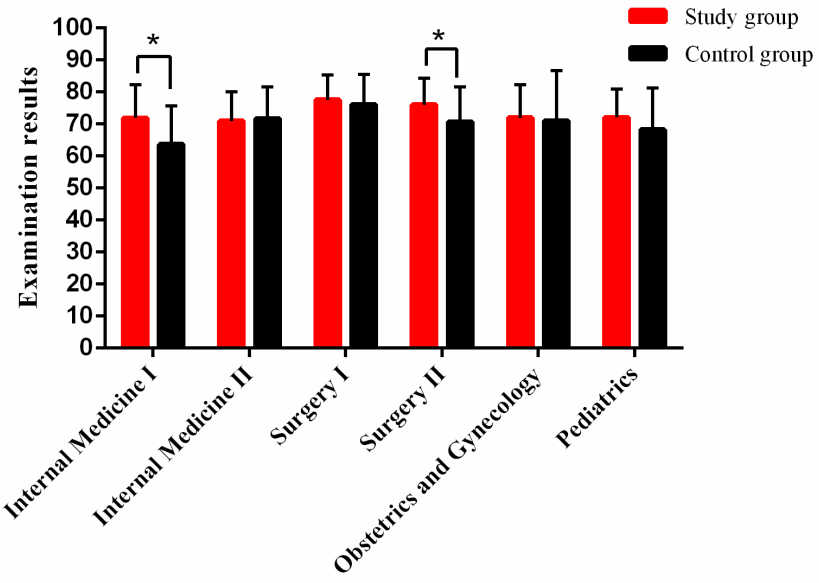

Figure 9. Comparison of scores for clinical courses between the two groups

*: $P < 0.05$.

3.3 Comparison of Results for OSCE

Two students in both groups postponed graduation due to a lack of enough credits, so a total of 47 students and 41 students participated in the OSCE in the study group and in the control group, respectively. Table 8 and Figure 10 describe the comparison results. Among the 9 stations, scores at 2 stations, knotting and dressing change and CPR, were significantly lower in the study group than in the control group, and the differences were statistically significant (all $P < 0.05$). The scores of 3 stations—internal punctures, four-step palpation in obstetrics, and assessment of children's growth and development—were higher in the study group than in the control group, and the difference was statistically significant ($P < 0.05$). The scores of physical examination and disinfection in the study group were slightly lower than those in the control group, and the difference was not statistically significant ($P > 0.05$).

At the history-taking station, students in the study group finished the exam by lottery, with 15 students taking a history of internal medicine, 24 for surgery, and 8 for paediatrics. Compared with the control group, scores of internal medicine and surgery in the study group were slightly higher, while scores of paediatrics were slightly lower, but the differences were not statistically significant ($P > 0.05$) between the two groups.

Table 8. Comparison of results for OSCE between two groups

Number	Items	Study group (n=47)	Control group (n=41)	*P*
1	History taking			
	Internal Medicine	83.80±8.65	82.66±11.37	0.298
	Surgery	86.33±11.32	84.46±8.74	0.197
	Paediatrics	84.00±6.74	84.56±9.91	0.381
2	Physical examination	82.95±9.79	86.15±10.81	0.074
3	Internal punctures	86.32±9.78	80.05±13.74	0.009*
4	ECG	59.89±25.07	62.70±22.21	0.291
5	Knotting and dressing change	64.96±22.59	84.28±8.48	0.000*
6	Disinfection and draping	85.38±11.78	86.85±8.96	0.064
7	CPR	73.32±12.82	83.20±12.25	0.000*
8	Four-step palpation in obstetrics	80.82±13.50	73.10±14.19	0.005*
9	Assessment of children's growth and development	84.27±9.10	78.80±9.70	0.002*

*: $P < 0.05$.

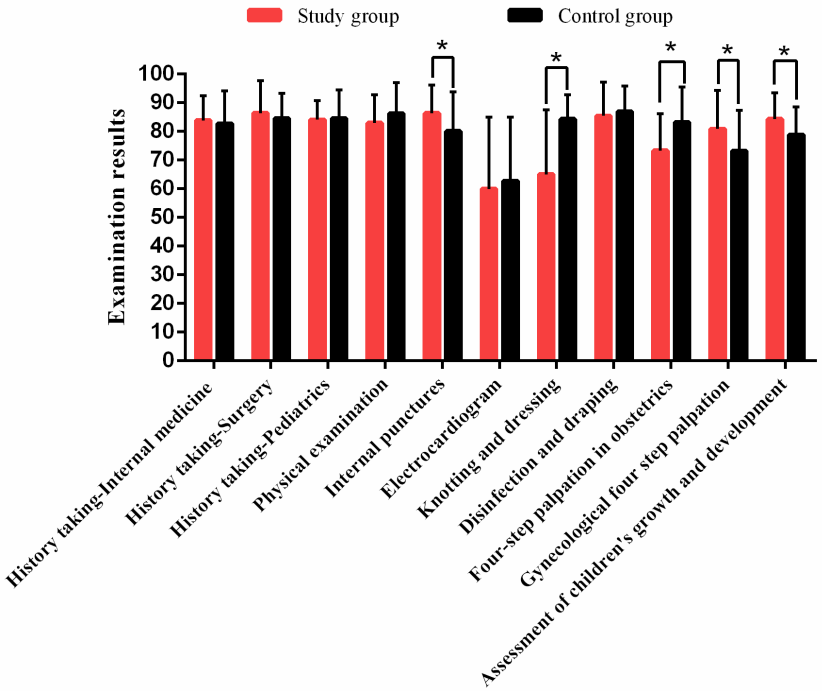

Figure 10. Comparison of results for OSCE between two groups

*: $P < 0.05$.

3.4 Questionnaire Survey

As shown in Figure 11, all 47 participants in the study group completed the questionnaire survey, with a response rate

of 100%. Twenty (42.55%) students believed that online learning of basic clinical courses had a great influence on learning in clinical courses such as internal medicine, surgery, etc., while 27 (57.45%) students thought it had a slight influence. Regarding the impact on the preinternship qualification test, 23 (48.94%) students thought it had a great influence, and 24 (51.06%) considered the influence to be slight.

Thirteen (27.66%) students thought the influence on internship was significant, 30 (63.83%) thought it was slight, and 4 (8.51%) students thought it had no influence. Regarding which course had the most influence, 36 students thought it was diagnostics, and 7 thought it was general surgery.

Among 47 students, 7 were recommended to study for a master's degree without examination. Among the students who participated in the national master's examination, 5 (12.50%) believed that online learning of basic clinical courses had a significant influence on the master's examination. There were 23 (57.50%) and 12 (30%) students who thought it had slight and no influence, respectively.

Of the 40 students, 32 participated in the re-examination of their master's degree. Among them, 2 (6.25%) thought that the online learning experience had a great influence on the re-examination, 19 (59.38%) thought it had a slight influence, and 11 (34.37%) students thought that there was no impact on the re-examination. Sixteen students considered diagnostics to have the most influence, while 5 students considered general surgery to have the most influence.

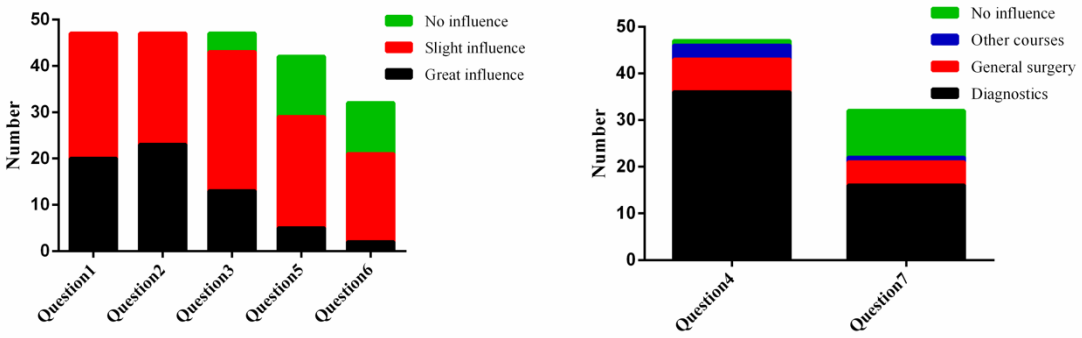

Figure 11. Results of questionnaire survey for online teaching

4. Discussion

During the COVID-19 pandemic, the implementation of online teaching to ensure normal teaching progress and teaching quality is a great challenge for schools, teachers and students (Han et al. 2022). For clinical courses, online teaching faces many difficulties because almost all clinical courses include theoretical and practical parts. The practical part is necessary to consolidate theoretical knowledge, cultivate doctor–patient communication skills and humane care, and strengthen basic clinical skills, such as history taking, physical examination, and interpretation of laboratory examination results, which are also important for cultivating students' clinical thinking.

Although online teaching is not new, the COVID-19 pandemic dramatically increased the scale of this phenomenon, with many more countries and students from primary school to university taking online courses than before the pandemic. Therefore, the process and effect of online teaching are worth studying and exploring, especially since the outbreak of COVID-19. Many areas have adopted online and offline hybrid teaching models in the past two years at a certain period. Our university ahs many foreign students, and many of them have studied online because of COVID-19.

Improving students' enthusiasm and evaluating learning outcomes during online teaching are key issues that need to be considered. Different from face-to-face teaching, teachers cannot observe students' conditions during online teaching. Some scholars believe that the learning effect of online teaching is more dependent on students' enthusiasm and their ability for self-study, and tracking and monitoring the learning process is an important method to ensure the effectiveness of teaching (Zhang et al. 2020). Therefore, ensuring online teaching quality is consistent with that of the classroom and is an important task that must be addressed by online teaching. Regardless of which platform is chosen for online teaching, teaching effectiveness and quality are the core and key outcomes.

In this study, we first reviewed the schedule of six basic clinical courses for online teaching during the COVID-19 outbreak in grade 2017. The schedule focused on the practical process of basic skills required for disease diagnosis. Although this was the first time we taught these courses online, all contents were prepared carefully. In a survey conducted by the department of internal medicine, contents about "satisfaction with online teaching arrangements" and "interaction with teacher" received high scores, which indicated that the strategies and arrangement of online teaching had been accepted by students. In some scholars' opinions, teacher–student interaction and learning content are the most important predictors used to evaluate online teaching, and student satisfaction ultimately depends on teacher–student interaction and teaching decision-making (Kuo et al. 2013; Kuo et al. 2014; Kuo & Belland 2016; Kangas 2017). According to these opinions, our plans for online teaching were successful.

It is interesting that the number of students who study voluntarily is not as large as we think. Another study was also conducted by our team about online teaching among clinical medicine (6-year program) students who studied internal medicine. Among 47 students, only 28 (59.6%) expressed that they could learn voluntarily (Huang et al. 2021). Students from grade 2017 also thought online learning would affect learning clinical courses in the future. Students in a previous study had the same feeling (Huang et al. 2021), and 41 students (87.2%) worried that lack of contact with real patients in the learning process would affect the practical process in the future. In fact, interviewing real patients cannot be duplicated and substituted, and online teaching has limitations and shortcomings in developing skills and confidence in communicating with patients (Olivia 2020). In Yang's opinion (2022), the main problems of online teaching include the following aspects: management, technology, teachers' and students' lack of concentration, lack of teacher–student interactions, lack of resources, and decreased classroom participation. Moreover, some students thought online learning could not achieve the same effect as face-to-face teaching. In a survey examining students' attitudes towards online education in Turkey, 72% (725/1007) of students believed that online teaching could not replace face-to-face classes (Ekmel & Hakkı 2021). In a report from China, the authors surveyed students' evaluations of online teaching. Seventy-nine students took part in this survey, and 53.2% of students thought offline teaching could achieve better results. A total of 74.7% of students considered the main factors affecting online learning to be a lack of learning motivation and self-direction (Huang, Xu & Wang 2022).

Online teaching brings different challenges to different disciplines. Some disciplines involve not only theoretical teaching but also involve many hands-on practical skills. Clinical medicine is such a discipline. For basic clinical courses and clinical courses in clinical medicine, practice is one of the important components of the curriculum. It is very difficult for online teaching to restore the offline teaching mode. In our practice, although teachers strive to use resources such as videos, audio and pictures and explain procedures step by step, it is still impossible for online curricula to be completely consistent with offline teaching. Especially in the teaching content of some basic skills, such as physical examination, CPR, internal punctures, etc., there is no model and no instrument on which to practice. Taking into account these shortcomings, we arranged a series of basic clinical skills training and intensive exercises after students returned to school, especially the two most basic clinical skills of history taking and physical examination. From the scores of the final exam for four clinical courses, the theoretical parts were not affected by online teaching, and some online students achieved even higher scores than those in the control group.

Some scholars believe that under epidemic situations, monitoring students and tracking and evaluation learning processes should be strengthened to ensure the effectiveness of the teaching of internal medicine (Rodriguesa et al. 2022). According to the results of the OSCE, at 9 stations, the scores of 2 stations in the study group, one for knotting and dressing change and the other for CPR, were significantly lower in the study group. The reason for these results should be that students did not practice these skills sufficiently because of online teaching, while students received sufficient time to practice in the control group. These skills are not practised enough after returning to school and internships. The results also suggest that online teaching has difficulty obtaining the same effects as offline teaching because these clinical skills require more practice at the beginning of learning. Wang et al. found that for students who learned an orthopaedic curriculum online, their proficiency was significantly lower than that of previous students due to a lack of practical clinical teaching [15]. The performance in the study group at 3 stations, including internal punctures, four-step palpation in obstetrics and assessment of children's growth and development, was better than that in the control group. The differences were statistically significant. Other contents in the two groups were not statistically significant. This proves that intensive training after returning to school is effective and can make up for the shortcoming of learning clinical skills online. It also proves that basic skills for obstetrics and gynaecology and paediatrics were not affected by online teaching. The results of the OSCE provide a reference and experience for online teaching regarding how to manage practical projects.

The third evaluation index for the long-term effect of online teaching is students' perceptions. Although scores on the final exams in four clinical courses in the study group were not affected by online experience, scores in internal

medicine (part I) and surgery (part II) in the study group were even higher than those in the control group. However, all students agreed that the online learning experience affected learning clinical courses to different degrees. In regard to internships, a few students (4/47) thought that the online learning experience did not affect internships. The possible reason is that with the study of clinical courses, especially offline practice, students can become gradually proficient in most clinical skills. Then, the number of students who thought that learning online had no influence increased, indicating that the influence of the online learning experience was further reduced. Regarding the course with the greatest influence, most students chose diagnostics. This finding is likely related to the fact that diagnostics include many basic clinical skills, such as history taking and physical examination, which are the basis of practical components for all clinical courses.

5. Conclusion

The exploration of diverse online teaching methods is helpful for mastering clinical knowledge. However, online teaching had a great influence on some basic clinical skills that require more practice. Providing opportunities to reinforce these skills after returning to school makes up for the shortage of online teaching of basic clinical skills to a certain extent.

6. Limitations and Future Directions

There are some limitations in this study. First, the grade points of the first and second academic years of the two groups were not analysed, which may have made this study more rigorous. The second limitation concerns the assessment contents of history taking in the OSCE. Students in the study group completed this station, taking one of the four courses in internal medicine, surgery, obstetrics and gynaecology, and paediatrics by lottery; as a result, there were only eight students in the history-taking and paediatrics courses. The sample size is small, which may affect the conclusion. The third limitation concerns the questionnaire; there are no quantitative indicators in the options, so we cannot know the exact degree of the effects of online teaching. In general, in the past two years, there have been many improvements in online teaching in our practice; for example, standardized patients have been introduced into training history taking, and live broadcasts are used to demonstrate physical examinations. All these new measures have increased students' enthusiasm. We believe these changes will improve teaching quality.

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Declaration of Interest

The authors have no conflicts of interest to report.

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