WeChat as a Platform for Blending Problem/Case-Based Learning and Paper Review Method Among Undergraduate Pediatric Orthopaedics Internship: Feasibility and Effectiveness Study

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Research Article

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Abstract

Background:

Pediatric orthopedics is a significant and difficult discipline that is for undergraduate students to master. During the COVID-19 pandemic, we relied on the WeChat platform and integrated the advantages of PBL, CBL and paper review teaching methods to establish a blended new online teaching model and demonstrate its feasibility and effectiveness.

Objective:

This study aims to explore a new blended pedagogical method merged PBL, CBL and Paper Review, which is relied on the WeChat platform and based on real clinical cases and frontier literatures for undergraduate participated in a internship pediatric orthopaedics and to demonstrate its feasibility and effectiveness.

Methods:

We enrolled 22 students participating in the Department of Pediatric Orthopaedics. They adopted the WeChat blending pedagogy mode. Their scores of departmental rotation examination were compared with 23 intern doctors who adopted the traditional teaching method. Moreover, an anonymous questionnaire was administered to evaluate students’ perceptions and experiences.

Results:

The total average score of students adopted WeChat blending pedagogy mode and traditional teaching methods was 47.27 and 44.52. There was no statistically significant between WeChat blending pedagogy mode and traditional teaching method in the aspect of possessing professional accomplishment, gaining knowledge and promoting interpersonal skills ($P = 0.07$, $P = 0.12$ and $P = 0.65$, respectively). In terms of independent clinical thinking, self-improving capability and improving clinical skills, the score of WeChat blending pedagogy mode was 8.00, 8.00 and 6.00, whereas the traditional teaching methods was 6.70, 6.87 and 7.48.

The response rate to the questionnaire was 100% (22/22). and the overall satisfaction reached 100%. 64%, 86%, 68%, 64% and 59% of students chose very large or large in the aspect of professional accomplishment, knowledge absorption, independent clinical thinking skills, English reading and literature exploring capacity, as well as interpersonal skills. 15 participants considered that WeChat blending pedagogy mode was less helpful to them in promoting the improvement of clinical skills. 9 students thought the WeChat blending pedagogy mode was time-consuming.
Conclusions:

Our study verified the feasibility and effectiveness of WeChat blending pedagogy mode for undergraduate pediatric orthopaedics internship.

Trial registration

Retrospectively registered.

Introduction

In December 2019, a case series of a novel type of pneumonia was reported in Wuhan, China. The causing viral agent was identified as a novel betacoronavirus, named SARS-CoV-2, and the respective infection was named as “Coronavirus Disease 2019 (COVID-19)” [1]. As of June 2022, more than 600 million cases have been diagnosed and more than 6.5 million people have died [2]. The virus puts health care systems to the test and to affect the lives of physicians, residents, and medical students in an unprecedented manner. Because large population gathering can greatly increase the infection rate of COVID-19, academic institutions have been shut down, training, and teaching has been put to a halt in many countries including China [3–5]. Therefore, online teaching has become the main teaching method in China during the COVID-19 epidemic [6].

WeChat, a mobile phone-based social networking service similar to WhatsApp [7], is one of the fastest growing mobile apps and the most popular platform visited daily among university students in China [8]. Because of its powerful functions including releasing messages in various formats (e.g., texts, videos, voices, and images) to an individual or a specific group, check-in, punch-in, examination, assessment and interaction, WeChat has become increasingly popular as an interactive communication tool in helping improve the efficiency of medical education in recent years [9–11]. But traditional teaching model has a deep-rooted influence on a majority of faculty, they still adopt teacher-centered, class-oriented didactic lectures and exam-oriented course teaching, which still make students in a passive state of "acceptance" [12]. So medical undergraduates lack learning initiative and enthusiasm, and the knowledge they have learned cannot be put into practice, which leads to them forgetting more easily.

Pediatric orthopedics is an important branch of pediatric surgery that explores orthopaedic surgical-related diseases of all children from the birth to adulthood, as well as related medical education and basic research. The clinical manifestations of pediatric orthopaedic patients are lack of typicality and intuitiveness because of unclear presentation and poor positioning. And some acute diseases, such as supracondylar fracture of humerus and femoral shaft fracture, will cause lifelong disability or death if not treated correctly in time. Both the diagnosis and treatment of pediatric orthopaedic diseases are complex, which makes it significant and difficult for undergraduate students to master basic knowledge on pediatric orthopaedic diseases.
All of these characteristics make pediatric orthopaedics a difficult subject to learn, and students need to change their role from passive to active. The choice of appropriate teaching methods is crucially important.

Problem-based learning (PBL) is a student-centered pedagogy in which students learn through solving listed questions. It guides students to find and solve clinical problems with preset questions and gradually given diagnosis conditions [13]. Case-based learning (CBL) is defined as a case-based education method that is grounded in the analysis of medical records with the aim of restoring the real clinical scene and prompting students to identify and develop new areas of learning [14]. PBL and CBL approach have been introduced into medical education with great success, by which medical students obtained significantly higher knowledge and skill scores, excellent academic performance and higher success rates in examinations [13–16]. However, taken alone, neither PBL nor CBL is without limitations [17]. The problems in PBL teaching sometimes deviate from the clinical practice. Students cannot apply the knowledge into clinical cases [18]. And there is a predominating uncertainty about the breadth and depth of learning without a syllabus in PBL teaching [19], which are not beneficial to maintaining students’ interest in learning. And CBL demands teachers create a set of questions for students to discuss, leading to a tendency for students to lack proactive involvement in and general enthusiasm for the learning experience [17]. In addition, no matter PBL or CBL requires participants to spend a lot of time preparing materials before class, which is extremely difficult for medical undergraduates. Because their literature retrieval ability is weak, and their means of acquiring knowledge basically comes from textbook knowledge. As a result, the discussion in PBL or CBL teaching process cannot fully mobilize students’ subjective initiative.

Paper review teaching mode refers to guiding students to read the specified foreign relevant literature in the teaching process, which can improve students’ ability to read, summarize and refine information, emphasize the summary and expansion of knowledge, and finally return to solving clinical practical problems [20]. It is a kind of collective reading method with clear purpose and strong sense of design, which can greatly make up for the shortcomings of students’ weak literature retrieval ability.

Therefore, we hypothesize that a new pedagogical mode that bases on the WeChat platform and combines the virtues of PBL, CBL and paper review can better achieve the goal of promoting effective, high-quality undergraduate pediatric orthopaedics internship learning, and aim to demonstrate its feasibility and effectiveness.

Materials And Methods

Participants

The study was performed with 22 fourth-year students majoring in clinical medicine at the Qilu Medical College of Shandong University and participating in a 2-week internship in the Department of Pediatric Orthopaedics at the Qilu Hospital of Shandong University from November to December 2020. There were
4 groups totally and each group comprised 5 or 6 students. 2 clinical doctors with over 3 years of experience teaching the pediatric surgery content and over 1 years experience teaching online and 1 standardized patient were enrolled in this study. The integration of standardized patients is proven to be a feasible learning strategy [21]. All participants adopted the new Wechat blending pedagogy mode. Informed consent was provided to the participants and signed prior to beginning the study. The study was approved by the Medical Council of Qilu hospital, Shandong University.

**Wechat Blending Pedagogy Mode**

The new blending pedagogy mode was constructed on the basis of the WeChat app. WeChat is a popular app that is available on Android, iPhone, and Windows, and is supported by Wi-Fi, 4G, and 5G data networks. Using WeChat, students can communicate with each other anywhere and at any time [22]. All participants had their own mobile phones and were required to install WeChat. All were familiar with the practical aspects of WeChat.

We chose supracondylar fractures of humerus, developmental dysplasia of the hip, polydactyly, acute osteomyelitis and bone cysts as the topic for applying the WeChat blending pedagogy mode in this study. Because these five diseases are common and frequently occurring in pediatric orthopedics and the diagnosis and treatment of these diseases is the key courses that students must master in the Department of Pediatric Orthopedics.

During the 2-week internship in pediatric surgery, students need to learn about the five diseases above. Each course lasts for 2 days. In the morning of the first day, students follow the teacher's mobile phone video for online daily ward rounds, and in the afternoon of the first day and the second day, they use Wechat platform for online teaching.

Every course is introduced by a real clinical case. Clinical cases are presented to students in three parts. The first part includes medical history and simple medical history. Students need to ask questions to standardized patients according to their own diagnosis and treatment ideas, and improve the case information. The second part includes the results of the physical examination, laboratory examination and imaging examination. The third part is the operation picture or video. Each section is followed by 2–3 questions for discussion.

The two days of each course are arranged as follows (Fig. 1). In the afternoon of the first day, students mainly learn the book knowledge independently, read 2–3 specified foreign relevant literature reviews given by the teacher, and summarize the knowledge according to the questions prepared in advance. In the morning of the next day, followed the first part of clinical cases provided by the teacher, students began to discuss and study in groups, and gradually promoted the case content presentation along with the discussion process, so as to complete the final teaching. And by the afternoon, the teacher gave extended lectures according to the differential diagnosis of diseases. On the last day of the internship, students completed the departmental rotation examination and subjective anonymous questionnaire.
Evaluating Wechat Blending Pedagogy Mode

The key to evaluating the WeChat blending pedagogy mode was to infer whether its teaching effect can be comparable to or exceed the offline teaching method. The evaluations included two sections: (1) the departmental rotation examination, which is an objective and comprehensive evaluation given by the teacher based on student’s performance, and (2) the subjective evaluation of the whole WeChat blending pedagogy mode experience after the 2-week internship.

At the time of the departmental rotation examination, all students were assessed with the same questions. A 2-year-old boy had swelling, pain, and limited mobility after elbow trauma. Through this chief complaint, the students began to ask questions to the standardized patients. According to the answers of the standardized patients, the students made their own diagnosis and treatment procedures and briefly described the operation process. The teacher evaluates the students from possessing professional accomplishment, gaining knowledge, improving clinical skills, developing independent clinical thinking, as well as promoting interpersonal skills and self-improving capability six aspects according to their performance (detailed grading rules shown in Supplemental Information Table 1). 5 grades were set for each aspect: excellent, good, medium, poor and extremely poor, and the difference of score between each grade was 2 points. A maximum score of 10 points for each item on a 60 point scale. All the evaluation indicators were based on Bloom’s Taxonomy [23], which categorizes cognitive activities into six hierarchical levels, namely, memory, understanding, application, analytical skills, assessment, and creativity. In November and December 2018, the same questions were also applied to trainee doctors’ admission tests, which were taken offline because there was no pandemic at that time. They used traditional teaching method, in which the teacher taught knowledge in the classroom, carried on ward rounds at the bedside, and students developed knowledge on their own after the internship.

Then students were required to complete the same anonymous subjective questionnaire (shown in Supplemental Information Table 2) to evaluate their feedback and perceptions regarding usage and qualitative utility of WeChat blending pedagogy mode. The questionnaire consisted of 10 questions, including questions about general impression, doctors’ professional quality, knowledge absorption, improving clinical skills, clinical thinking skills, English reading and literature exploring capacity, interpersonal skills, student-teacher interaction and platform utilization conveniency, as well as how much free time the course consumed. The questions were discussed by the 2 clinical doctors who participated in this research to ensure its quality. Students were asked to estimate the degree of influence for them of each item on a 5-point Likert ranging scale from 1 “strongly dis-influenced” to 5 “strongly influenced”. Compared with other scoring areas, for time consumption, grade 1 to 5 respectively represented the time consumption from much to little. Furthermore, in WeChat blending pedagogy mode, students’ preparation time was recorded as having been spent previewing the textbook and reading foreign relevant literature reviews given by the teacher as well as searching for supplemental materials on the Internet. The reliability of the questionnaire was evaluated. The Cronbach’s alpha coefficient was 0.836.
Data analysis

The total scores of the departmental rotation examination were compiled, and the scores of the trainee doctors who adopted the WeChat blending pedagogy mode were compared with those 4 groups, totally 23 trainee doctors who studied in the department of pediatric orthopedics in the same period in 2018, which used the traditional teaching method, so as to evaluate the teaching quality of online and offline teaching. The average score for each aspects of the rotation examination was calculated by adding up all the subitem scores and divided by the total number of participants involved. Then compared the results generated by each of the two groups using an independent sample T-test. Measurement data were expressed as mean +/- standard deviation.

Percentages were used to describe the overall anonymous subjective questionnaire results and was calculated by the number of participants who agreed with each item divided by the total number of participants (N = 22).

Data were analyzed using the statistical package for the social sciences version 23 (SPSS Inc., Chicago, IL) statistical software. P-values of less than 0.05 were considered significant.

Results

Basic characteristics and information

A total of 22 fourth-year students participated in a internship in the Department of Pediatric Orthopaedics at the Qilu Hospital of Shandong University from November to December 2020, they adapted the WeChat Blending Pedagogy Mode. Their mean age was 20.91 ± 0.133. Among them, the ratio of male to female was 1:1, accounting for 50% each. We collected the rotation examination results of pediatric orthopedic interns in the same period in 2018, a total of 4 groups, 23 people. They used the traditional bedside apprenticeship and face-to-face teaching methods. The mean age of the students was 20.82 ± 0.156. Among them, there were 8 female students, accounting for 34.8%. Table 1 compares the basic student characteristics who adapted the WeChat blending pedagogy mode and traditional teaching method. There were no significant differences between the two groups in terms of gender and age (P = 0.46, P = 0.66, respectively).
Table 1
The basic characteristics of all the participants

<table>
<thead>
<tr>
<th>Item</th>
<th>WeChat Blending Pedagogy Mode (N = 22)</th>
<th>traditional teaching method (N = 23)</th>
<th>Statistics</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>( \chi^2 = 0.534 )</td>
<td>0.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>11 (50%)</td>
<td>15 (65.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>11 (50%)</td>
<td>8 (34.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>20.91 ± 0.133</td>
<td>20.82 ± 0.156</td>
<td>( T = 0.850 )</td>
<td>0.66</td>
</tr>
</tbody>
</table>

The comparison of the departmental rotation examination scores between the WeChat blending pedagogy mode and traditional teaching method

We systematically evaluated the teaching quality of the two models from possessing professional accomplishment, gaining knowledge, improving clinical skills, developing independent clinical thinking, as well as promoting interpersonal skills and self-improving capability six different aspects through the same departmental rotation examination. As illustrated in Table 2, the total average score of students adapted WeChat blending pedagogy mode and traditional teaching method was 47.27 and 44.52, respectively, which was not statistically significant (\( P = 0.08 \)). This showed that the quality of clinical internship teaching using the WeChat as a platform for blending problem/case-based learning and paper review methods can be comparable to, or even exceed, the offline teaching (total scores 47.27 > 44.52). There was no statistically significant between WeChat blending pedagogy mode and traditional teaching method in the aspect of possessing professional accomplishment, gaining knowledge and promoting interpersonal skills (\( P = 0.07 \), \( P = 0.12 \) and \( P = 0.65 \), respectively) (shown in Table 2). Among them, the training of interpersonal skills benefited from the application of standardized patients in online teaching, which greatly imitated the process of face-to-face consultation with patients in clinical practice, so that the score of WeChat blending pedagogy mode in interpersonal skills was no less than that of traditional teaching method. However, in developing independent clinical thinking aspect, WeChat blending pedagogy mode was obviously superior to traditional teaching method (average score 8.00 > 6.70, \( P = 0.001 \)), which may benefit from the application of problem/case-based learning in the blended teaching method. In addition, in the aspect of self-improving capability, the score of WeChat blending pedagogy mode and traditional teaching method (total scores 8.00 and 6.87, respectively) showed that WeChat blending pedagogy mode had a clear advantage (\( P = 0.01 \)) (shown in Table 2), which was closely related to the application of paper review teaching mode.

It is worth noting that in terms of improving clinical skills, the performance of WeChat blending pedagogy mode was not satisfactory (average score 6.00 < 7.48, \( P = 0.002 \)) (shown in Table 2). This is the only side
that WeChat blending pedagogy mode scores worse than traditional teaching method, which is related to the lack of actual hands-on operations in online teaching (Fig. 2).

Table 2

<table>
<thead>
<tr>
<th>Item</th>
<th>WeChat Blending Pedagogy Mode ((N = 22))</th>
<th>Traditional teaching method ((N = 23))</th>
<th>T</th>
<th>(P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possessing Professional Accomplishment</td>
<td>8.64 ± 1.68</td>
<td>7.74 ± 1.51</td>
<td>1.881</td>
<td>0.07</td>
</tr>
<tr>
<td>Gaining Knowledge</td>
<td>8.27 ± 1.55</td>
<td>7.57 ± 1.47</td>
<td>1.570</td>
<td>0.12</td>
</tr>
<tr>
<td>Improving Clinical Skills</td>
<td>6.00 ± 1.38</td>
<td>7.48 ± 1.50</td>
<td>-3.438</td>
<td>0.001</td>
</tr>
<tr>
<td>Developing Independent Clinical Thinking</td>
<td>8.00 ± 1.38</td>
<td>6.70 ± 1.29</td>
<td>3.267</td>
<td>0.002</td>
</tr>
<tr>
<td>Promoting Interpersonal Skills</td>
<td>8.36 ± 1.47</td>
<td>8.17 ± 1.34</td>
<td>0.453</td>
<td>0.65</td>
</tr>
<tr>
<td>Self-improving Capability</td>
<td>8.00 ± 1.23</td>
<td>6.87 ± 1.58</td>
<td>2.686</td>
<td>0.010</td>
</tr>
<tr>
<td>Total average score</td>
<td>47.27 ± 5.91</td>
<td>44.52 ± 4.27</td>
<td>1.784</td>
<td>0.08</td>
</tr>
</tbody>
</table>

The Subjective Evaluation Of The WeChat Blending Pedagogy Mode

To investigate intern doctors’ perceptions of ongoing WeChat blending pedagogy mode, we used a questionnaire that were measured with a 5-point Likert scale. The questionnaire consisted of 10 questions. Question 1 is to investigate students’ overall evaluation of WeChat blending pedagogy mode, while questions 2 to 7 correspond to the six abilities of students in the departmental rotation examination. The departmental rotation examination is the objective evaluation of students by teachers, while the questionnaire is the subjective evaluation of students’ personal performance in WeChat blending pedagogy mode. Question 8 and 9 respectively investigate WeChat as a teaching platform in terms of the convenience and the interaction between the teacher and the students. Question 10 is designed to understand the time spent by students in the preparation of the course in WeChat blending pedagogy mode.

The response rate to the questionnaire was 100% (22/22). The results of the first question indicated that the WeChat blending pedagogy mode achieved positive effects. The overall satisfaction reached 100% (Table 3). As can be seen from the results of Table 3, students were satisfied with what they have achieved through the new mode. The majority of students reported that their professional accomplishment, knowledge absorption, independent clinical thinking skills, English reading and literature exploring capacity, as well as interpersonal skills were improved through the use of WeChat blending pedagogy mode (Question 2–3 and 5–7, 64%, 86%, 68%, 64% and 59% choose “very large” and
others totally choose “large”). Similar to the problems reflected in students’ departmental rotation examination results, more than half of the students’ subjective evaluation considered that WeChat blending pedagogy mode was less helpful to them in promoting the improvement of clinical skills (Question 4, 15/22, 68%). A minority of students (Question 8, 3/22, 14%) considered it was difficult to judge the convenience of WeChat as a teaching platform and poor interaction with teachers reported by (Question 9, 2/22, 9%) of only 2 student. Due to the need to prepare the materials used in problem/case-based learning discussion and read the literature materials issued by the teachers before class, 41% of the students (9/22) thought that the WeChat blending pedagogy mode was time-consuming, 32% of the students (7/22) thought that it was difficult to evaluated the time consumed, and only 6 students (n = 22, 27%) thought that the time consumed was not too much.

### Table 3
The results of the anonymous subjective questionnaire

<table>
<thead>
<tr>
<th>Question</th>
<th>Likert Ranging Scale (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 (0%) 0 (0%) 0 (0%) 7 (32%) 15 (68%)</td>
</tr>
<tr>
<td>2</td>
<td>0 (0%) 0 (0%) 0 (0%) 8 (36%) 14 (64%)</td>
</tr>
<tr>
<td>3</td>
<td>0 (0%) 0 (0%) 0 (0%) 3 (14%) 19 (86%)</td>
</tr>
<tr>
<td>4</td>
<td>0 (0%) 7 (32%) 8 (36%) 6 (27%) 1 (5%)</td>
</tr>
<tr>
<td>5</td>
<td>0 (0%) 0 (0%) 0 (0%) 7 (32%) 15 (68%)</td>
</tr>
<tr>
<td>6</td>
<td>0 (0%) 0 (0%) 0 (0%) 8 (36%) 14 (64%)</td>
</tr>
<tr>
<td>7</td>
<td>0 (0%) 0 (0%) 0 (0%) 9 (41%) 13 (59%)</td>
</tr>
<tr>
<td>8</td>
<td>0 (0%) 0 (0%) 3 (14%) 8 (36%) 11 (50%)</td>
</tr>
<tr>
<td>9</td>
<td>0 (0%) 0 (0%) 2 (9%) 8 (36%) 12 (55%)</td>
</tr>
<tr>
<td>10</td>
<td>0 (0%) 9 (41%) 7 (32%) 6 (27%) 0 (0%)</td>
</tr>
</tbody>
</table>

### Discussion

The WeChat blending pedagogy mode was based on the WeChat platform and combined the virtues of PBL, CBL and paper review, which was designed to achieve the goal of promoting effective, high-quality undergraduate pediatric orthopaedics internship learning, so as to reach or even exceed the teaching quality of offline teaching. In our study, the total average score of students adapted WeChat blending pedagogy mode higher than those used traditional teaching method. And the majority of students reported that their professional accomplishment, knowledge absorption, independent clinical thinking skills, English reading and literature exploring capacity, as well as interpersonal skills were improved through the WeChat blending pedagogy mode and thought that WeChat was a convenient and effective
platform as a new method of teaching to maintain the continuity of medical education during the COVID-19 pandemic, indicating the acceptance and effectiveness of the WeChat as a platform for blending problem/case-based learning and paper review methods among undergraduate pediatric orthopaedics internship.

Due to the COVID-19 outbreak, online teaching, which is not constrained by physical and temporal limitations, has replaced traditional offline teaching in many countries [24]. The findings of this study illustrate a method through which online blending pedagogy teaching can be facilitated by the use of WeChat. Compared with the use of similar social media platforms such as WhatsApp [25] and Twitter [26], WeChat has some special functions that are particularly well adapted for online education including simple operation, easy obtainment for Chinese students, video conferencing and sharing of documents[19, 22, 27–29]. So it facilitated student-student and student-teacher interactions and communications, participating in group discussions and thus improved the learning efficiency and learning quality.

In contrast to an in-person clinical visit, online education faces particular challenges due to clinical medical education dependence on hands-on training [30]. All trainees had been switched to online mode at the Qilu Hospital of Shandong University in 2020, which greatly reduced the real medical senses and trainee doctors’ take subjective initiative. In order to better simulated the real clinical scenes, we combined PBL and CBL teaching method and standardized patients were invited to join the teaching activities to simulate the patients’ real treatment process in this study. Previous studies have shown that there have been attempts to implement either the PBL or the CBL or standardized patients teaching model in the delivery of various college and university majors. For instance, PBL allows students to learn independent problem-solving, as well as obtain fundamental, and even clinical, knowledge. [17, 31]. And through the preparation of clinical case materials, CBL can stimulate the desire to learn in students and help them develop independent thinking and analysis skills [17, 32]. Meanwhile, standardized patients played a major role in teaching medical students and helping them to acquire clinical experience by interacting with standardized patients, including training trainee doctors’ inquiring skills, improving their ability of collecting medical history, promoting the interpersonal skills and cultivating their sense of mission and responsibility [21, 33–34]. But no have paid attention to combined PBL, CBL and standardized patients teaching in clinical medicine. According to the analysis of students’ scores of the departmental rotation examination and self-perceived competence as measured by the questionnaire in our study, we confirmed that the three could complement and reinforce each other.

But, for all that, it is worth noting that in terms of improving clinical skills, the performance of WeChat blending pedagogy mode was not satisfactory. For example, when asked to demonstrate external fixation with a plaster bandage on a supracondylar fracture of the humerus during the exam, the performance of many trainee doctors was poor in terms of proficiency, completion time and aesthetics. This was the only side that the online mode worse than traditional teaching method in our study. It may be related to the fact that the online teaching lacks practical hands-on operations. This is consistent with Khalil R et al.’s research [35], they considered that clerking patients cannot be replaced by online learning as “clinical
experience and human interaction are extremely important for the practice of medicine” and online learning cannot completely replace in-person live sessions. A similar situation occurred in online dental teaching practices [36]. Despite this odd, efforts have been made to overcome these disadvantages. Stephan et al. [37] integrated immersive virtual reality for teaching anatomy by reconstructing cerebral anatomy images, which achieved better engagement, more enjoyment, usefulness, and stronger learner motivation. A systematic review and meta-analysis involving 11 studies and 715 participants suggested that basic surgical skills can be taught as effectively through online video-based education as conventional teaching methods [38]. All these attempts are aimed at bringing the online teaching model closer to clinical practice, so that make online teaching effect no less than offline teaching.

What’s more, in order to further promote the literature retrieval ability of intern doctors, expand their understanding of the frontier progress of related diseases, and improve their participation in the discussion in the teaching process of problem/case-based learning, paper review method was added in this study. Although the above purposes were achieved to a certain extent, from the results of intern doctors' questionnaires, it also resulted in the lengthening of students' preparation time before class. As for the time consuming, the reasons may include the following. In the first place both CBL and PBL are reported to cost a heavier workload for students to prepare them, which is time-consuming [10, 39]. Secondly, the English level of intern doctors varies, so part interns may spend too much time reading English literature. paper review method was reported only used to teach master's or doctoral students [20] and It was the first time that been applied in problem/case-based learning teaching of intern doctors. But this attempt was successful, it improved the intern doctors' English literature reading ability and promoted their self-improving capability. Last but not least, without real clerking patients, intern doctors’ understanding of pediatric orthopedic diseases is not in place, which lead to a lot of time to master.

However, several limitations existed in our research. First, our study only analyzed the results from only one clinical department within our institution, these results may have been different beyond our institution. Second, this study lacked feedback concerning long-term online teaching practices. Third, since there was no blind method in our study, some analysis bias is unavoidable. We acknowledge that teachers' assessments of intern doctors may have been influenced by subjective factors, including improved interpersonal bonds that formed over time.

Conclusions

Online teaching is the main teaching method in China during the COVID-19 epidemic, and pediatric orthopedics is a practical discipline that is difficult to master. We integrated PBL, CBL and paper review teaching mode into pediatric orthopedic intern doctors’ teaching based on WeChat platform, built the WeChat blending pedagogy mode and verified its feasibility and effectiveness through teaching practice. In our study, compared with the traditional teaching method, the WeChat blending pedagogy mode can improve intern doctors’ many skills including professional accomplishment, knowledge absorption, independent clinical thinking skills, English reading and literature exploring capacity, as well as interpersonal skills. But further improvement and perfection is needed in the clinical skills. In addition,
some intern doctors’ thought that the WeChat blending pedagogy mode took too much time before class, which may be related to their personal English level, which requires a long-term observation and practice to make the study more robust and produce more grounded assessments.

Abbreviations

COVID-19
Coronavirus Disease 2019
CBL
Case-Based Learning
PBL
Problem-Based Learning

Declarations

Ethics approval and Consent to participate

All methods were performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from all subjects. The study protocol was approved by the ethics committee of the Qilu Hospital, Shandong University. And informed consent was obtained from all subjects.

Consent for publication

Written consent was obtained from the participants.

Availability of data and materials

The original data were deposited into the Mendeley Data, V1(https://data.mendeley.com/datasets) with DOI: 10.17632/6n53cw9ng3.1

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Junfei Chen: Conceptualization; Formal analysis.
Bingjun Gao: Methodology; Project administration.
Kunyao Wang: Writing – original draft.
Yinghan Lei: Investigation.
Shengling Zhang: Data curation.
Shaobin Jin: Writing – review and editing.
Weiwei Yang: Supervision; Writing – review and editing.
Yan Zhuang: Resources.

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References


Figures

![Diagram showing online daily ward rounds, independent study, supracondylar fractures of humerus, polydactyly, bone cysts, rest, online PBL and CBL, extended lectures, developmental dysplasia of the hip, acute osteomyelitis, and departmental rotation examination.]

Figure 1
Basic flowchart of the WeChat blending pedagogy mode

Figure 2

Radar chart of WeChat blending pedagogy mode and traditional teaching method based on six dimensions

Supplementary Files

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- TableS1.docx
- TableS2.docx