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Initial experience with pediatrics online learning for nonclinical medical students during the COVID-19 pandemic

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Abstract

Background: To minimize the risk of infection during the COVID-19 pandemic, the learning mode of universities in China has been adjusted, and the online learning of clinical medicine is facing great challenges. This study preliminarily discusses the experience of express team-based learning (eTBL) combined with a flipped classroom (FC) and case-based learning (CBL) online for nonclinical medical students and addresses the distribution of online learning resources used in pediatrics. This study helps to document additional experience in online learning during the global trend of digital learning.

Methods: When online learning was fully launched at Sichuan University in the spring of 2020, 236 penultimate-year students of nonclinical medicine majors were selected as the research objects. The penultimate-year students of the same majors in the spring of 2019 were taken as the reference objects. The research objects successively used the methods of eTBL combined with FC and CBL methods to conduct online learning in pediatrics, and students were encouraged to search and share online learning resources. The reference objects used the method of eTBL combined with CBL for offline face-to-face learning, and the test results of the two learning environments were compared. At the end of the pediatrics course in the spring of 2020, the research objects were invited to participate anonymously in an online questionnaire survey involving 12 items on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) to evaluate the participation, satisfaction, and distribution of online learning resources used in pediatrics.

Results: 1. Student participation and test scores: i. A total of 75.8% (179/236) of the respondents completed the questionnaire effectively, and 7 items on the Likert scale indicated that online

learning with eTBL + FC had higher student participation than eTBL + CBL (4.64 vs 4.27, $P < 0.001$). ii. In the spring of 2019 and 2020, the average scores of the last four subjects were higher than those of the first four subjects ($P < 0.001$). The average scores of online learning courses in the spring of 2020 were higher than those of offline learning in the spring of 2019 ($P < 0.001$). 2. Online learning resources: i. The main motivations for students to use online learning resources were pre-class preparation (4.83), class discussion (4.28) and pre-class testing (3.79). ii. A total of 72.9% (129/179) of the students “most or all of the time” searched online learning resources in the pre-class preparation stage. iii. Students' online learning resources mainly included Chinese academic databases, search engines, teaching platforms and foreign databases. iv. The information retrieval ability of students was improved after the above online learning methods (after versus before, Mdn 5 VS 4, $U = 591.0$, $P = 0.007$). 3. More students thought that the online learning method of eTBL + CBL was more beneficial for understanding than that of eTBL + FC ($P = 0.044$), while the online learning method of eTBL + FC was more conducive for online learning resource retrieval than that of eTBL + CBL ($P = 0.034$), and the workload was greater ($P = 0.001$). Both of the online learning methods were conducive to online learning resource sharing ($P = 0.298$). 4. The results of five items on the Likert scale in the questionnaire showed that students' satisfaction with the online learning mode was high (4.16).

Conclusion: i. During the COVID-19 pandemic, online eTBL shortened the learning time of typical TBL. After online learning with eTBL, in combination with FC, CBL and the use of online learning resources, students had high rates of participation and satisfaction. ii. Online learning test results were as good as offline test results. iii. The main motivation for students to use online learning resources came from learning tasks. Chinese academic databases and search engines were

the main learning resources for nonclinical medical students. iv. Both online combined learning methods were helpful for students to share online learning resources. eTBL + FC was more helpful in retrieving online learning resources, and the workload was also larger, while eTBL + CBL was more helpful for students to understand course content.

Keywords: COVID-19; Online learning; TBL; FC; CBL; Learning resources

Introduction

Under the current situation of the global COVID-19 outbreak, offline learning was forced to be abruptly interrupted, and China took the lead in “unceasing study” with an online learning strategy. The network platform replaced campus as a new teaching environment, and learning resources were extended to online learning resources, such as literature retrieval, online teaching videos and interactive materials [1]. Different from traditional theoretical learning, clinical medicine pays more attention to the integration of theory and practice, and there is more unpredictability in comprehensive online learning. Its effectiveness may be hindered by factors such as communication network support, social interaction, learners' motivation and preferences [2][3]. The comprehensive online learning of clinical medicine faces great challenges [1][4].

Relevant literature published after the outbreak of the epidemic proposed that comprehensive online learning should consider students' satisfaction, interactivity and applicability [2] [4] [5]. It was necessary to adjust the online learning scheme and verify its practical effect on the basis of existing online and offline learning experiences.

In 2019, based on the systematic evaluation and meta-analysis of the effectiveness of online

learning and offline learning for medical undergraduates, Leisi Pei et al. [6] proposed that online learning was a potential learning method, and interactive online learning could help improve the online learning effect [7]. Team-based learning (TBL) is an interactive learning method with students as the center and teachers as the guides [8]. Online TBL during the epidemic period has helped strengthen students' communication [8] [9]. A meta-analysis on the effectiveness of TBL in medical education in China suggested [10] that compared with traditional lecture-based learning (LBL), TBL could effectively improve academic performance, attitudes and skills in medical theoretical education. Chaya Gopalan et al. [11] proposed that flipped classrooms (FCs) under the premise of TBL combined with literature retrieval learning were the most suitable learning method for teams and were conducive to improving the cultivation of the application ability of theoretical knowledge[11]. Case-based learning (CBL) addresses the integration of medical theory and practice and is one of the deep learning methods in medical education, along with TBL and FC. CBL is a good beginning for students to transition from traditional theoretical knowledge learning to practice and is suitable for nonclinical medical students who graduate in the penultimate year [12].

Taking the clinical pediatrics course of the Pediatric Teaching and Research Office in the West China School of Medicine of Sichuan University as an example, the Pediatric Teaching and Research Office has rich experience in TBL clinical teaching. The teaching method of appointing experienced clinical pediatricians, such as attending physicians and professors, is responsible for teaching that has been favored by most students. To maintain students' enthusiasm for clinical pediatrics, avoid the decrease in students' communication during isolation, and achieve the quality of online learning equivalent to offline learning, the Pediatric Teaching and Research Office

adjusted the online learning mode of the pediatrics course in the spring of 2020 on the basis of the offline Express TBL (eTBL) learning mode in the spring of 2019. This paper aims to explore and evaluate students' participation, satisfaction, test scores and the use of online learning resources under the online learning environment by designing the online learning mode of pediatrics courses and questionnaires.

Research objects and methods

1 Research objects

The objects of this study were penultimate-year undergraduate students of the nonclinical medicine college of Sichuan University who took pediatrics as a selective course in the spring of 2020, involving the School of Public Health, School of Basic Law and School of Pharmacy, with 207 students in grade 2017 from Prevention, Basic Medicine and Forensic Medicine (all four-year students) and 29 students of grade 2016 from Clinical Pharmacy (five-year students). A total of 246 penultimate-year students with the same majors in the spring of 2019 were taken as the reference objects to compare their after-class test scores. Nonclinical medical students who were in other grades or taking pediatrics courses but not participating in eTBL pediatrics were excluded. This study was approved by the Medical Ethics Committee of West China Second University Hospital of Sichuan University.

2. Teaching design

Referring to the offline eTBL learning scheme in the spring of 2019, the online eTBL learning scheme of the same specialty in the spring of 2020 (Fig. 1) was designed. The research objects used a small private online course (SPOC) for theoretical knowledge learning, and on the

basis of eTBL, combined FC and CBL methods successively for integrating theory and practical application. The reference objects adopted offline LBL for theoretical knowledge and the eTBL + CBL method for integrating theory and practical application.

Note: LBL: Lecture-based Learning, eTBL: express Team-based learning, CBL: Case-based learning, SPOC: Small Private Online Course, FC: Flipped Classroom.

Fig. 1 Review of offline learning and design of online learning

The textbooks and contents of pediatrics in the spring of 2019 and 2020 were the same, including *Pediatrics* (2nd edition, edited by Mu Dezhi) published by Higher Education Press and *TBL Course of Pediatrics* (1st edition, edited by Wan Chaomin, Mu Dezhi and Gao Xiaolin) published by Sichuan University Press. The themes of eTBL combined learning were vitamin D deficiency rickets, neonatal jaundice, pediatric pneumonia, congenital heart disease, nephritis and

nephrotic syndrome, childhood anemia, infantile diarrhea, and suppurative encephalitis. The learning time was 2 class hours (90 minutes) each time, and the learning program, objective and schedule of the two years were the same. All pediatric learning was guided by the Pediatric Teaching and Research Office in the West China School of Medicine of Sichuan University and was the responsibility of teachers above the attending pediatrician with rich clinical experience.

The learning themes and after-class test of pediatrics in spring 2019 and 2020 were the same (after-class test of pediatrics using the web course center of Sichuan University). In the spring of 2020, the Pediatric Teaching and Research Office carried out an after-class test after combined eTBL learning of each theme (8 themes, 5 multiple-choice questions each time). The after-class test (once every 4 themes, 2 times in total, 20 multiple-choice questions each time) was conducted after reviewing the offline LBL combined with eTBL and CBL in the spring of 2019.

3 Implementation method of online learning (Table 1 for each stage)

Online learning grouping: All students were divided into 24 groups according to the order of the name list, with a fixed number of 9-10 students in each group. We adopted the principle of voluntary basis for the students, designated the teacher and set a leader in each group. According to the learning schedule and grouping order, the 24 groups were divided into 4 online modified TBL pediatrics classes, each consisting of 6 groups of students.

Table 1 Three stages of online eTBL combined learning

Phase 1	Phase 2	Phase 3
Before live online class		Live online class

Pre-class preparation	Pre-class test (15-45 min)	Course application (90 min)

3.1 Stage of pre-class preparation:

Internet and software service support: Staff of the Office of Academic Affairs and the Information Construction and Management Office assisted teachers in the whole process of selecting online resources and interactive management software for online classes, setting up groups through Tencent QQ to cooperate with online teaching, discussion, counseling, Q&A and other teaching activities.

Teaching task allocation: Before the online learning started, the teacher established an online learning group and uploaded the syllabus and learning schedule. Teachers would release learning objectives and tasks one week in advance, and students would work in groups to study and discuss task plans before class.

Learning resource support: In addition to the designated electronic version of pediatric textbooks and SPOC video learning, students could independently choose to learn shared pediatric resources of national quality courses and the website of the Curriculum Center of Sichuan University. Meanwhile, eTBL combined FC learning was guided by the task of students preparing speech notes, while eTBL combined with CBL learning was guided by the goal of a

student-oriented case study, urging students to expand their knowledge through online learning resources based on the team.

3.2 Online test

To save time and allocate more time to the online live class, the preview test was changed to the pre-class and after-class test. The SPOC platform was used for pre-class test, and the test content was related to each theme. The system would randomly choose 15 questions from 30 questions on each theme for that test. Each theme would be tested 3 times, not exceeding 15 minutes each time, which would be completed before the class began. The highest score of the 3 tests would be the student's personal test result. The after-class test was conducted on an on-campus online platform. See the above teaching design for details.

3.3 Course application

For the purpose of reducing the number of students' learning tasks, the order and method of 4 "S" principles were adjusted (see Table 2). Each group previewed the relevant questions/tasks of each theme in advance, integrated the preview materials, and unified the lecture notes/answers. To urge the students to master the key points of each theme comprehensively, the students were randomly selected to explain the basis of the answers or comment and discuss with each other to promote the students' healthy competition in learning.

Table 2. Team completion methods for online 4 "S" principles		
4 “S”	Completion methods	
	eTBL +FC	eTBL+ CBL

Significant problem	Flipped classroom	Case study
Same problem	Searching online learning resources and in-group discussions	
Specific choice	Unifying answers; preparing specific answer notes	Unifying answers
Simultaneous report	Giving answer options in oral and text form, simultaneously (QQ group online class)	
	Each group giving a lecture on the assigned problem within the allocated time	Randomly selecting students to explain the basis of the answer
	When there was doubt, the group discussed with each other to get a consistent answer. If the answer was inconsistent within the allocated time, the teacher would summarize	

3.4 Summary by the teacher

After learning each theme, the teacher would make a brief summary. To encourage discussion among students, the number of effective discussions between groups (the content was not completely repeated each time) was regarded as the evaluation standard of reward, which was included in the class performance score together with attendance. At the same time, to avoid the subjective bias caused by the mutual evaluation between teachers and students, the subjective scoring of teachers and students was canceled, and after-class test questions were used as one of

the evaluation contents of students' learning effect. The after-class test questions were from the pediatric question bank on the website of the Sichuan University Course Center. Five single-choice questions were the key and difficult points were discussed among students in the course application stage. Bonus points would be awarded according to the number of effective discussions in class, and all of the students in a group would get the same points. Personal tests (including before and after class) and class performance scores were included in the usual score, accounting for 36% of the final score (personal test 24%+ class performance 12%).

4. Teaching effect evaluation

Students' learning attitude and application and acquisition of learned knowledge were the main standards for measuring the teaching effect by the Pediatric Teaching and Research Office. Online medical education emphasized participation, satisfaction and applicability [2][4][5]. The online tests were a small number of open-book, non-multiple choice questions of moderate difficulty, and the number of pre-class tests for each theme could be up to 3. The online test results could not be used as the only standard of teaching effect. Students searched online learning resources to solve the problem/task of each theme, which covered the entire online pediatrics course. The Pediatric Teaching and Research Office took the lead in preparing an anonymous questionnaire for the students who participated in the eTBL combined learning of online pediatrics in the spring of 2020 to evaluate the students' participation, satisfaction and online learning resource distribution.⁵

Statistical analysis

SPSS22 was used to analyze the data. The data collection database (Jinshuju) automatically generated the proportion of students in the questionnaire. The chi-square test was used for

qualitative count data, and Fisher's exact test was used for data of less than 5 in the table. The overall fractional normal distribution was assessed using the skewness and kurtosis Mann-Whitney tests. The self-rating scores of online information retrieval application ability and the average scores of each theme were compared by a two-tailed paired t-test. $P < 0.05$ indicated that the difference was statistically significant. A bar chart was created to show the distribution of students' participation, understanding and application, and medical information retrieval.

Results

1 General information

The completion of the questionnaire: Based on the principle of anonymity and voluntariness, 180 complete questionnaires were collected, 1 of which was excluded as the student was in grade 2018, and 179 were included in the questionnaire analysis. The effective recovery rate of the questionnaire was 75.8% (179/236). Age: (21.0 ± 0.8) years old. Male ($n = 56$, 31.3%): female ($n = 123$, 68.7%) $\approx 1:2.2$, and most of them were female. There was no significant difference in gender distribution between the research subjects and those who effectively participated in the questionnaire survey (male: female = 79:157 $\approx 1:2.0$) ($\chi^2 = 0.169$, $P = 0.637$).

2 Students' participation in online improved eTBL combined with the learning process of pediatrics in the spring of 2020

Students' participation was assessed by 7 items (Fig. 2) on a Likert scale. Item scores: 1 =strongly disagree, 2 =disagree, 3 = neutral, 4 = agree, 5 = strongly agree. The total score of 7 items indicated that eTBL combined with FC online learning had a higher participation rate of

students than did eTBL combined with CBL online learning (the average score of all items was 4.64 (0.66) vs 4.27 (1.21, $t = 9.587$, $P < 0.001$)).

1=Full pre-class preparation, 2 = complete the pre-class test, 3 = great team contribution, 4 = concentration, 5 = active participation in class discussion, 6 = completion of after class test, 7 = active learning

Fig. 2 Score distribution of two online eTBLs combined with learning

2.1 Information retrieval

The questionnaire asked about the learning environment: “Comparing the online environment with the offline environment, which environment can retrieve more online learning resources?” More than half of the students (63.7%, $n = 114$) chose an online learning environment, less than 5% (4.5%, $n = 8$) chose an offline learning environment, and nearly 1/3 students chose "the same".

In the questionnaire, questions were asked about the online learning resources between the

online and offline learning environments (Fig. 3), “For comparison of eTBL + FC and eTBL + CBL learning methods (the first vs. the second), ① Which learning method has more workload? ② Which learning method shares more online learning resources? ③ Which learning method searches more online learning resources? ④ Which learning method is more helpful to the understanding of pediatrics?” Answer options: "the first is obviously more, the first is more; the two are the same; the second is more, and the second is obviously more." The chi-square test (Fisher's exact test) of the remaining four options (excluding the option “the two are the same”) showed that more students believed that the online learning method of eTBL+ CBL was more beneficial to their understanding than eTBL+ FC (52.5% VS 15.1%, $\chi^2=4.071$, $P=0.044$), eTBL+ FC was more conducive to online learning resource retrieval than eTBL+ CBL (41.9% VS 19.0%, $\chi^2=4.473$, $P=0.034$), and the workload was also larger (72.0% VS 3.9%, $\chi^2=11.921$, $P=0.001$). Both online combined learning methods were conducive to online learning resource sharing (68.7% VS 5.1%, $\chi^2=1.886$, $P=0.298$).

Fig 3: The population distribution of workload, information (resource) sharing/retrieval and practice application of the two online combined methods

2.2 A list was sorted according to the motivation of searching online learning resources: the

students answering the questionnaire gave a ranking of pre-class preparation, pre-class test, course application, after-class test, foundation for future work and interest according to their motivation.

The top three were: pre-class preparation (4.83), class discussion (4.28) and preparation of personal confirmation test (3.79) (see Table 3).

2.3 Time distribution of medical information retrieval by students.

Table 3 Motivation ranking of medical information retrieval in online eTBL learning								
Assignment: first choice =6, second choice =5, third choice =4, fourth choice =3, fifth choice =2, sixth choice =1, no choice =0)								
choice	first choice	second choice	third choice	fourth choice	fifth choice	sixth choice	synthesis score	ranking
Pre-class preparation	84	38	23	21	3	9	4.83	1
Course application	45	54	27	29	8	15	4.28	2
Pre-class test	23	41	48	31	19	13	3.79	3
After-class test	16	33	53	46	13	16	3.65	4
Foundation for future	3	9	16	31	80	34	2.31	5

work								
Interest	8	4	11	17	49	85	1.93	6

In the questionnaire, the options of time period were divided into four levels ("most or all of the time", "often", "occasionally", "rarely or never"). If any expected frequency was greater than 5, the chi-square test was used, $\chi^2 = 341.183$, $P < 0.001$, suggesting that the number of students choosing different time periods was different. A total of 72.9% ($n = 129$) of the students "most or all of the time" retrieved information in the pre-class preparation stage; 35-40% of the students "often" retrieved information in the pre-class test stage (37.7%, $n = 66$) and the course application stage (35.6%, $n = 63$). Approximately 40% of the students "occasionally" and "rarely or never" retrieved information, and the time period was mainly in the after-class test stage (39.2%, $n = 69$, 41.5%, $n = 73$) (Fig. 4).

Fig 4: Time distribution of medical information retrieval in online eTBL combined learning on pediatrics

2.4 Distribution of online learning resources

Students answering the questionnaire gave indefinite choices about online learning resources.

Table 4 shows that the goodness-of-fit test suggested a significant difference ($\chi^2=137.592$, $P \leq 0.001$), indicating that there was a significant difference in the proportion of choices. The difference could be compared by response rate or popularity rate. Students' online learning resources were mainly Chinese academic databases, search engines, teaching platforms and foreign databases (response rates were 25.3%, 18.9%, 15.8%, 14.1%, and popularity rates were 95.0%, 83.2%, 52.0% and 46.4%, respectively). The top three Chinese academic databases were Chinese National Knowledge Infrastructure (CNKI) (97.6%, $n = 166$), Wanfang (75.3%, $n = 128$) and VIP (65.3%, $n = 111$). Baidu (93.3%, $n = 139$) was the main search engine. SPOC (96.8%, $n = 90$) was the main teaching platform, and PubMed (84.4%, $n = 70$) was the main foreign database.

Table 4 Summary of response rate and popularity rate of different online learning resources in online eTBL combined teaching and the frequency distribution of specific online learning resources

Tools	Specific tools	n	Response		popularity rate (n=179)
			N	response rate	
Chinese academic databases	CNKI	166	170	28.9%	95.0%
	Wanfang	128		-	-
	VIP	111		-	-
	CBM	107		-	-
	CMCI	28		-	-
Foreign databases	PubMed	70	83	14.1%	46.4%
	Medline	40			
	Uptodate	16	-	-	-
Teaching platform	SPOC	90	93	15.8%	52.0%
	Course center	57	-	-	-
Search engines	Baidu	139	149	25.3%	83.2%
	Google	44	-	-	-

	360	31	-	-	-
Mutual assistance	-	-	38	6.5%	21.2%
Communications	-	-	55	9.4%	30.7%
Summary	-	-	588	100%	328.5%
$\chi^2=137.592, P=<0.001$					
CNKI: Chinese National Knowledge Infrastructure, VIP: China Science and Technology Journal Database, CBM: China Biology Medicine disc, CMCI: Chinese Medical citation Index, SPOC: Small Private Online Course					

3 Student evaluation

3.1 Evaluation of retrieval ability of online learning resources

Students were encouraged to search online learning resources through the objectives of the case study/flipped classroom lecture task in online eTBL combined learning. Students' information retrieval ability was self-rated (1 = very low, 5 = very high). The Wilcoxon signed-rank test showed that students' information retrieval ability after the modified TBL combined teaching method was improved compared with beforehand (median 5 vs 4, $U = 591.0, P = 0.007$) (Fig. 5).

Fig 5: Comparison of the median score of medical information retrieval ability between before and after online learning

3.2 Students' satisfaction survey

The 5 items of the Likert scale (Table 5) showed that students' satisfaction was high, with an average score of 4.16 (0.55).

Table 5 Students' satisfaction survey (Assignment: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)	
Items	Mean Scores (SD)
1. I'm satisfied with the online eTBL combined learning method for pediatrics this semester.	4.22 (0.71)
2. I'm satisfied with the retrieval of online learning resources encouraged in the online eTBL combined learning method.	3.85 (0.74)

3. I will recommend my classmate use the method of searching online learning resources to expand the application of theoretical knowledge	4.22 (0.66)
4. I think the online retrieval of online learning resources is helpful to improve the effectiveness of eTBL combined learning.	4.30 (0.69)
5. I think the online eTBL combined learning method is helpful to improve the learning effectiveness of pediatrics	4.18 (0.73)
Average	4.16 (0.55)

Table 6. Comparison of total average scores between different online learning methods and different learning environment.

Themes	Online learning in the spring of 2020		Offline learning in the spring of 2019	<i>T value</i>	<i>P value</i>
	Total average score of pre-class test	Total average score of after-class test	Total average score of after-class test		
The first 4	95.4 (8.3)	90.4 (8.1) [△]	83.9 (7.3) [△]	9.187 [△]	<

themes					0.001
The last 4 themes	96.9 (9.4)	93.2 (10.8) ∇	87.1 (10.3) ∇	6.278 ∇	< 0.001
<i>T value</i>	4.866	3.630	4.883		
<i>P value</i>	<0.001	<0.001	<0.001		
In the online learning of 2020, the learning method of "the first four themes" was eTBL + FC combined, while the learning method of the "last four themes" was eTBL + CBL combined. Δ, comparison of the after-class test results of the first four themes in 2019 and 2020, ∇, comparison of the after-class test results of the last four themes in 2019 and 2020.					

3.3 Test results

The results of the paired T-test showed that (Table 6) the total average scores of the last four themes were higher than those of the first four themes. The total average score of eTBL combined with CBL was higher than that of eTBL combined with FC in the spring of 2020, which was consistent with the difference in the same themes before and after the offline learning method in the spring of 2019, but the same offline learning method was used for all themes in the spring of 2019. Therefore, the comparison of the total average scores of the different themes could not be used as a basis for the difference in scores caused by different online learning methods. Whether this was due to the difficulty of the course content or students' gradual adaptation to pediatric learning deserves further study.

Table 6. Comparison of total average scores between different online learning methods and different

learning environment.					
Themes	Online learning in the spring of 2020		Offline learning in the spring of 2019	<i>T value</i>	<i>P value</i>
	Total average score of pre-class test	Total average score of after-class test	Total average score of after-class test		
The first 4 themes	95.4 (8.3)	90.4 (8.1) Δ	83.9 (7.3) Δ	9.187 Δ	< 0.001
The last 4 themes	96.9 (9.4)	93.2 (10.8) ∇	87.1 (10.3) ∇	6.278 ∇	< 0.001
<i>T value</i>	4.866	3.630	4.883		
<i>P value</i>	<0.001	<0.001	<0.001		
In the online learning of 2020, the learning method of "the first four themes" was eTBL + FC combined, while the learning method of the "last four themes" was eTBL + CBL combined. Δ, comparison of the after-class test results of the first four themes in 2019 and 2020, ∇, comparison of the after-class test results of the last four themes in 2019 and 2020.					

The results of the independent t-test (Table 6) showed that the average score of online learning in the spring of 2020 was higher than that of offline learning in the spring of 2019 (the first four themes: online vs offline, 90.4 vs 83.9, $t = 9.187$, $P < 0.001$; the last four themes: online vs offline,

93.2 vs 87.1, $t = 6.278$, $P < 0.001$). In summary, the test result of online learning was not worse than that of offline learning.

Discussion

Online education prevails during the epidemic of COVID-19, requiring internet infrastructure support. Jessica C et al. [2] pointed out that during the epidemic period, some students' participation was interrupted due to poor Internet connections and poor broadband in some areas. The students of pediatrics in the West China School of Medicine of Sichuan University are spread all over different provinces, cities and rural areas in China. The Pediatrics Teaching and Research Office has conducted classes according to the planned curriculum schedule, and there has not been any online learning delay caused by network interruption. The reasons are as follows: (1) The basic network facilities in China are good. For wireless networks, 4G networks are already commonplace. The coverage of most major cities by the 5G network, together with unlimited data plans put forward by mobile network operators, brings about good Internet conditions, which means that occasional network delays or short-term interruptions can be quickly restored. (2) The online classroom of eTBL combined learning is based on the team. When the students who speak on behalf of the team occasionally have a network delay or short-term interruption, other members of the team can relay information quickly without affecting the expression of the team's opinions. (3) The content of opinion expression is conveyed not only in the form of simultaneous voice but also in the form of multiple versions of words. It not only ensures that each teacher and student can follow the teaching/learning schedule in time but also facilitates the students' independent review after class.

Comprehensive online learning needs not only network support but also appropriate learning methods to guide student learning. FC on the basis of TBL combined with literature retrieval is the most suitable teaching method for the team [11]. FC advocates student responsibility and emphasizes students' pre-class preparation. The questionnaire in this paper shows that online eTBL+ FC has a larger workload than the eTBL+ CBL online learning method, which is more beneficial to online learning resource retrieval. The main reason is that FC requires more time and energy from the students [13] and encourages students to use online learning resources [13][14]. Online learning has the advantages of time flexibility, acquiring learning resources on demand and strengthening the cultivation of autonomous learning ability [15], which is consistent with the advantages of typical FC. It can effectively improve students' learning enthusiasm, experience and academic performance [13][14], which is helpful for medical students to strengthen the cultivation of self-directed learning skills and benefit them for life [16].

In medical education, exposure to clinical cases is the best deep-learning method [17]. Undergraduate students in the penultimate year are in the stage of transition from theoretical knowledge to practical application, and CBL is a good choice for students in this stage [12]. Dylan Thibaut et al. [18] suggested that students use the CBL method within a team during the epidemic period in 2020, which would be helpful for students to exchange and share information. More students in our questionnaire thought that online eTBL + CBL was more conducive to students' understanding of pediatrics, and the workload was smaller, which was consistent with the advantages of the typical CBL method with a small workload [17] and flexibility in case selection [17]. It was helpful for students to understand theoretical knowledge and apply it in practice [17], improving their clinical reasoning ability, critical thinking and problem-solving, and was an

effective strategy for clinical medical students to learn basic course content [19].

Both online learning methods are carried out in teams to help students share online learning resources, and their test scores are as good as those for offline tests. The questionnaire showed that students had high participation and satisfaction in both online combined learning methods of pediatrics, and the online learning environment encouraged students to retrieve online learning resources. The main motivation for students to retrieve online learning resources was pre-class preparation, class discussion and pre-class testing, which was in accord with the retrieval time distribution of the students. It might be related to learning tasks or objectives that need further study.

A study conducted by Judd T et al. [20] on the selection and use of online resources for first-year medical students under the traditional teaching mode (the effective recovery rate of the questionnaire was 36.2%, 118/326) and the survey results of Lucinda Wynter [1] on the use of learning resources by undergraduate medical students in the last year and the penultimate year (effective recovery rate of questionnaire, 32.3%, 350/1083) showed that medical students' learning resources tended to be nonacademic websites, while websites of academic information were less used. The main reason was that medical students could easily access a variety of high-quality learning resources through teachers' lecture notes or peer recommendations, leading to ignorance of online journals or textbooks by many students. However, online resource retrieval or sharing is not evidence-based and lacks peer review. To a certain degree, our questionnaire indicates the students' choice of online learning resources in a comprehensive online learning environment during the epidemic. The teaching and learning platform ranks second, which may be related to the fact that SPOC (n=90) is the teaching and learning platform we recommend for watching

educational videos. Apart from teaching and learning platforms, online learning resources are more inclined to be from academic information websites. CNKI ranks first in China's academic databases, Baidu is the main search engine, and nonacademic information websites are second only to academic information websites, which may be related to the learning environment of Chinese undergraduate students and their usage habits of search engines. Foreign academic databases, mainly PubMed, rank fourth, which is the best tool for clinicians or researchers [21][22]. Combined with the Medline search interface, it helps balance accuracy and sensitivity [23]. In the questionnaire, undergraduates as beginners can correctly choose global medical literature information retrieval tools.

Online medical literature information retrieval skills provide information resources for medical students to understand and master new medical knowledge and theories. Online learning resources are easy to access, and flexible on-demand learning can be used as a learning aid. In the long run, effective use of online learning resources supports lifelong learning and provides potential tools for clinical practice or medical employment.

In this paper, the research objects' cognition of the offline learning environment originates from their learning in other courses. The same group and the same theme cannot use both online combined learning methods simultaneously. The evaluation of students' ability to identify online resources originates from the students themselves, which lacks authoritative evaluation and cannot accurately describe students' actual ability. There are tests before and after online live class. The reference subjects only have two tests on the same themes. The comparison results of average test scores can only be used as a reference.

Our article did not further analyze a small number of students who may not like team learning but prefer to complete cases/tasks online by themselves [24]. There may be conflicts between limited attention and intensive online learning tasks in students' online learning of multiple courses, which have higher demands on students' time and energy [15]. Whether there is mutual influence within these multiple online learning courses remains to be further explored. When the epidemic situation in some countries or regions improves, medical education will gradually transition to synchronized online and offline learning or even resume the traditional offline teaching mode. The changing epidemic situation and different learning equipment and software in different regions still require the individualized design of teaching modes.

Conclusion

During the COVID-19 epidemic, online eTBL shortens the learning time of typical TBL. eTBL combined with FC or CBL online, in combination with online learning resource retrieval, receives the majority of students' satisfaction, helps students communicate, promotes the cultivation of the application ability of theoretical knowledge, and test results are as good as in the offline environment learning. Students can correctly choose the retrieval tools of online learning resources, and the motivation mainly comes from the requirements of learning tasks. Team-based FC and CBL learning methods emphasize student responsibility, which is conducive to students' sharing of online learning resources. Online eTBL+ FC is more beneficial for retrieving online learning resources, but it also requires more time and energy. Online eTBL+ CBL is more conducive to students' understanding and application and is more suitable for the transition stage between theory and practice. In the long run, choosing an appropriate teaching mode is beneficial to students' study on campus, clinical practice and clinical work.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Author contribution

YM carried out the research of design , sources, insight ,analysis and interpretation of data. LJR, LWR and GXL contributed to the design and sources of this study. QLN contributed to the design of this study, the examination of results, and final permission. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no competing interests.

Ethics declarations

Ethics approval and consent to participate

The research protocol was approved by the Medical Ethics Committee of West China Second University Hospital of Sichuan University. All medical schools included approved the study.

Our study was performed according to STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for reporting observational studies.

Participation was voluntary, and we did not offer any compensation or incentive. We guaranteed both confidentiality and anonymity, and participating students completed an informed consent form.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

Figure 1

Review of offline learning and design of online learning Note: LBL: Lecture-based Learning; eTBL: express Team-based learning; CBL: Case-based learning; SPOC: Small Private Online Course, FC: Flipped Classroom.

Figure 2

Score distribution of two online eTBLs combined with learning 1=Full pre-class preparation, 2 = complete the pre-class test, 3 = great team contribution, 4 = concentration, 5 = active participation in class discussion, 6 = completion of after class test, 7 = active learning

Figure 3

The population distribution of workload, information (resource) sharing/retrieval and practice application of the two online combined methods

Figure 4

Time distribution of medical information retrieval in online eTBL combined learning on pediatrics

Figure 5

Comparison of the median score of medical information retrieval ability between before and after online learning