Online Live Teaching is Effective: An Empirical Study

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Abstract—This research is single-group quasi-experimental teaching research, which controls the teaching form of the course for the participants. Based on literature analysis, it is pointed out that online live teaching is a vital teaching form, and the research on it has both theoretical value and practical significance. The research framework and measurement tools are constructed. The researchers selected the course on mathematical methodology as the teaching content. Twenty-six pre-service mathematics teachers were taught 17 times with 51 class hours in online live teaching. Pretest and post-test were carried out. The study found that online live teaching is effective. However, the interview result shows that most participants hope to combine online and offline learning. They prefer to communicate with teachers face to face in the classroom.

Keywords—online live teaching, distance education, empirical research

1 Introduction

Online teaching has become more and more popular in the last two decades [1]. Under the influence of the COVID-19 pandemic, many universities worldwide cannot start school usually. Traditional classroom teaching methods no longer work [2]. Many universities adopt online teaching methods to ensure that students can continue to study [3]. The latest trend in online teaching is to adopt and integrate web conferencing tools to enable real-time online classrooms and reproduce the spirit of traditional face-to-face meetings [4]. With the development of information and communication technology, online live teaching has gradually become an essential form of instruction.

In many countries, online live teaching has become a valuable method in emergencies. When students are isolated at home to prevent illness and cannot return to school, thousands of teachers use online live teaching to teach students. This teaching method has achieved outstanding results, but it also has a wrong side. A few years ago, researchers analyzed teachers' online live teaching behavior and pointed out that teachers who conduct online live teaching should change their traditional teaching concepts and strengthen their interaction with learners [5].

However, the research was not comprehensive. Although studies have pointed out that online live teaching is productive, many issues are still worth exploring [6]. A sur-

vey pointed out that online teaching cannot replace face-to-face teaching [7]. Understanding what students and faculty consider the most significant advantages and disadvantages of online courses is essential to developing new procedures for enhancing the learning experience [8]. Some studies have analyzed the advantages and disadvantages of online live teaching and proposed that the evaluation of courses and online live teaching platforms should evaluate the learning process in ordinary times [9]. Online live teaching is a valuable supplement to traditional classroom teaching. Educators can integrate theory into students' life experiences through online teaching forums, improving students' learning participation and motivation [10]. The era puts forward new requirements for teaching, and pre-service teachers should cultivate their sense of identity with online live teaching. The curriculum design of pre-service teachers should fully consider these recent changes. Pre-service teachers should understand online live learning and be willing to teach in this way [11]. For this reason, pre-service teacher trainers can try to use online live teaching as a demonstration of the teaching method.

The mathematical methodology is a subject of knowledge about mathematical thinking methods and the laws of discovery, invention, and mathematics innovation. The mathematical methodology is a basic course that pre-service mathematics teachers need to take. One of the critical purposes of the mathematical methodology course is to develop the problem-solving skills of pre-service mathematics teachers. This research explores how to use online live teaching to teach mathematical methodology courses to develop pre-service mathematics teachers' problem-solving ability. This research will provide evidence for the effectiveness and prospects of online live education and point out strategies for improvement.

The objective of the research is to answer:

1. Can the online live teaching of mathematical methodology course improve the problem-solving ability of pre-service mathematics teachers?
2. What is the attitude of pre-service mathematics teachers towards online live teaching of mathematical methodology courses?

2 Concept definition

2.1 Pre-service mathematics teacher

In this article, pre-service mathematics teachers refer to students who will become mathematics teachers, mainly undergraduate and junior mathematics normal students and postgraduates in curriculum and teaching theory (mathematics) and subject teaching (mathematics). There have been many research results on the training of pre-service mathematics teachers [12] - [15].

2.2 Mathematical problem solving

Mathematics problems in this research refer to the mathematics questions that are obstructive and exploratory, and the students need to think and explore to solve them.

Sound problems are the problems that the problem-solving process helps improve students' thinking ability and the problems that should be solved by severe thinking [16]. Mathematical problem solving is considered to be the most typical human intellectual activity. It requires finding ways to eliminate difficulties, bypass obstacles, and achieve goals that cannot be fulfilled immediately [17].

2.3 Mathematical methodology

Future mathematics teachers should have better problem-solving skills. Normal schools should appropriately increase mathematics problem-solving and teaching courses to improve pre-service mathematics teachers' mathematical problem-solving skills [18] and mathematical problem-solving teaching ability. The mathematical methodology is just such a course. The mathematical methodology in this research is about the theory of mathematical thinking methods.

3 Online live teaching media

Some teachers use videos to provide students with online learning opportunities, such as teaching a statistics course for teachers and administrators [19]. However, video is a static medium, and a dedicated teaching platform is to realize online live teaching. The following platform is the teaching platform used in this study, and the research design is carried out after introducing the use of the platform.

3.1 Teaching platform

Most studies about online learning environments primarily focus on technology-related issues or instructional methods, and little attention has been given to online teachers and their teaching approaches. Still, this study is different [20]. Online teaching is considered distinct from traditional education [21], but the teaching platform used in this study retains the advantages of conventional teaching as much as possible. The teaching platform used in this research is based on the teacher's own choice, which can better achieve the teaching purpose.

This study's online live teaching platform is the *Tencent Classroom Application*. Teachers should check and adjust the camera and microphone before class. The teaching process of *Tencent Classroom* is: log in to the *Tencent Classroom,* → click *Start-Class*, enter the course name of this section, and click *Confirm* to join the live broadcast room → click *Invite students to attend a class*, and the link to the class is sent to the students, and the students can click on the link to enter the class through their mobile phones, flat computer or computers → after the course is over, click the *Class* button in the lower-left corner to dismiss the class, and the students will no longer receive the audio and video.

The teaching interface of *Tencent Classroom* includes a functional area, teaching area, and discussion area.

The functional area has five main functions:

1. drawing board, which can be marked on the screen, supports four types of drawing board tools: brush, text, circle, and rectangle;
2. sign-in and answer, post a sign-in or answer activity, students receive a bullets box, you can click to sign in and answer questions;
3. picture-in-picture mode, when the screen is shared, the camera will be turned on, and the camera screen will appear in the lower right corner of the student's screen;
4. raise your hand to turn on the microphone mode, and the student can apply for connection on the client; the students can use the microphone to interact with the teacher in real-time;
5. preview, open a small window to preview the current screen.

The teaching area displays the teaching content. The teaching area and the sharing area screen can be adjusted manually. In the discussion area, students can communicate with classmates and teachers.

Although the blended teaching method has existed in universities for decades, the ways teachers teach are inconsistent, so students' combined teaching experience varies greatly [22]. The function of the teaching mentioned above platform is to simulate traditional education, which can generate a face-to-face atmosphere so that students can adapt.

3.2 Teaching mode

A survey pointed out that there are some problems in online teaching: teachers and students are not suitable for online teaching methods; they are not familiar with network platform software; there are problems in the teaching process such as technical difficulties, inability to log in, and inability to open web pages [23]. Considering these issues, the teaching model of the platform should be operable and straightforward. The teaching model of *Tencent Classroom* is easy to operate. It has four main lesson modes:

1. screen sharing and teaching, click the *Share Area* button, and use the mark to select the area to share the screen in the area;
2. PowerPoint lesson, click the *Open PPT* button, Select the PowerPoint file; you can use PowerPoint to teach;
3. video lecture, click the *Add Video* button, select and open the video file; you can use the video file to teach;
4. camera lecture, click the *Open camera* button to use the camera to live the lesson.

Studies find that aside from technological and contextual factors, faculty's personal, incredibly motivational factors also play an essential role in their goals and attitudes towards changing teaching mode [24]. Researchers of this experiment believe that online live teaching is feasible; this study comprehensively fully adopts the above four clauses to motivate learners.

4 Research methodology

There has been a lot of research on online teaching, including teaching experiments. The characteristic of this research is to use the form of online live education throughout

the whole teaching process to discuss the effect of online live teaching. The study helps compare online teaching and traditional teaching to judge whether online teaching provides a new and independent teaching form. This part shows the research methodology and mainly introduces the tools to measure the learning effect of online live education, the research participants, and the research process.

4.1 Research tool

This study is a single-group quasi-experimental study. At the same time, the interview method is adopted. The mathematical problem-solving ability in the research refers to the actual ability, that is, the demonstrated problem-solving ability, which is described from the five sub-abilities of induction, analogy, reduction, construction, and transformation.

The measurement framework of pre-service mathematics teachers' problem-solving ability and corresponding measurement items are shown in Table 1 for pretest and post-test. The pretest problems consist of the odd-numbered items in the table, and the post-test problems consist of the even-numbered items. The pre-test and post-test are equivalent (the Spearman rank correlation coefficient is 0.953, and the significance coefficient (Two-tailed) $p = 0.000 < 0.01$). Both the pretest and post-test paper contain five problems, each question is assigned 20 points, and each test paper has a full score of 100 points. Both the pretest and the post-test are in the form of paper-based tests. Participants have 60 minutes to answer the questions.

The two questions for pre-service mathematics teachers' interviews are:

1. Please briefly evaluate the online live teaching adopted in this course. How do you want teachers to teach?
2. In your opinion, what are the deficiencies in the curriculum and teaching?

Table 1. Measurement framework of mathematical problem-solving ability

Target	Indicators	Measurement items
Math Problem Solving skills	Induction	It is known that there are 2020 points in triangle ABC and the three vertices of the total of 2023 points. How many non-overlapping triangle regions are divided by these points (any three points form a triangle)?
		$f(x) = x / \sqrt{(1 + x^2)}, f_n(x) = f\{f[f \cdots f(x)]\}$(the number of f is n, n is a positive integer), among them, $f_1(x) = f(x)$, Find $f_n(x)$.
	Analogy	Let $(z - x)^2 - 4(x - y)(y - z) = 0$, proof: $2y = x + z$.
		Proof: The sum of the distance from any point to each surface in the tetrahedron is a fixed value.
	Reduction	If $x_1, x_2, \cdots, x_n$ are all positive, proof: $x_1^2 / x_2 + x_2^2 / x_3 + \cdots + x_n^2 / x_1 \geq x_1 + x_2 + \cdots + x_n$.
		Let $a > b > 0$, proof: $a^2 + 1 / \sqrt{b(b - a)} \geq 4$.
	Construction	Knowing that a is a real number, and $x, y \in [-\pi / 4, \pi / 4]$, and meet the condition $x^3 + \sin x - 2a = 0$ and $8y^3 + \sin 2y + 2a = 0$, find the value of $\cos(x + 2y)$.
		Knowing that x and y are real numbers, meeting the condition $(x - 2)^5 + 2020(x - 2) = -2021$ and $(y - 2)^5 + 2020(y - 2) = 2021$, find the value of $x^2 + 2xy + y^2 - x - y$.
	Transformation	9. Knowing that x is a real number, find the value range of $\sqrt{(x^2+x+1)} - \sqrt{(x^2-x+1)}$.
		10. Knowing that k and θ are real numbers, proof: $\lvert k\cos\theta - \sin\theta \rvert / \sqrt{(1+k^2)} \leq 1$.

4.2 Participants

The research participant comes from 26 pre-service mathematics teachers who are taking the mathematical methodology course in a key provincial normal university in China. They have studied Mathematical Analysis, Advanced Algebra, Modern Algebra, Real Variable Functions, Complex Variable Functions, and Topology at the undergraduate level.

4.3 Research process

There has been some research on the teaching experiment of online teaching. Compared with the existing research [25] - [26], this research is more focused on teacher-student online interaction. The research process was: a pretest on the pre-service mathematics teachers' → intervention → post-test on the pre-service mathematics teachers. The pretest and post-test were both in the form of online exams. An interview was conducted after the post-test.

The form of intervention was online live teaching. The teaching intervention lasted for 17 weeks (51 hours, 3 hours per week). Teaching content includes Polya's problem-solving methods, mathematical intuition, induction and analogy methods, Descartes' methodology, axiomatic methods, abstract mathematical methods, mathematical proof methods, mathematical aesthetics methods, RMI methods, mathematical problem-solving psychology, Calculus method, probability and statistics methods, as well as specific middle schools mathematical problem-solving methods such as transformation, structure, and combination of number and shape.

5 Results and discussion

5.1 The development of the mathematical problem-solving ability

To describe the mathematical problem-solving ability of pre-service mathematics teachers, the researchers compared the score data of the pretest and post-test of their mathematical problem-solving ability (see Table 2).

Compared with the previous test, the total score increased by 11.15. The lower quartile difference was 7.50, and the median difference was 10.00, the upper quartile difference was 27.50, the maximum and minimum Increased by 20.00 in value. It can be seen that the post-test results of the subjects are better than the pretest results in the distribution of total scores.

Table 2. Basic statistics of subjects' problem-solving ability

Statistics		Post-test	Pre-test	Difference
Average		61.15	50.00	11.15
Median		60.00	50.00	10.00
Standard deviation		21.23	18.97	2.26
Minimum value		20.00	0.00	20.00
Maximum		100	80.00	20.00
Percentile (P)	25	47.50	40.00	7.50
	50	60.00	50.00	10.00
	75	80.00	52.50	27.50

The results of the matched-sample t-test for the total scores of the post-test and pre-test are shown in Table 3.

Table 3. Examination of pre-test and post-test scores (*p < 0.05, **p < 0.01)

Total score	Correlation coefficient	p	Correlation significance	t	p	Difference significance
Post & pre-test	0.646	0.000	**	3.336	0.003	**

According to Table 3, there is a statistically significant difference between the subjects' post-test and pretest ($t = 3.336$, $p = 0.003 < 0.01$, $r = 0.27$), and the post-test score is significantly higher than the pretest.

5.2 Attitudes towards online live teaching

The researcher conducted interviews with students. The two questions asked were:

1. Please briefly evaluate the online live teaching adopted in this course. How do you want teachers to teach?
2. In your opinion, what are the deficiencies in the curriculum and teaching?

In the interview, 11 pre-service mathematics teachers commented on the online live teaching mode, and four pre-service mathematics teachers pointed out the shortcomings.

The interview records compiled by the researcher are shown in Table 4. Among the 15 interviewed pre-service mathematics teachers, three had a positive attitude, two had a negative attitude, three had a neutral attitude, three had an approved attitude, and four had a critical perspective. Institutions and educators should improve the satisfaction of teachers' online teaching and students' online learning.

Table 4. Results of interviews with pre-service maths teachers

Question	Interviewer's answer	Attitude
1	This combination of online, offline, pre-class, in-class, and after-class allows us to have sufficient time for thinking and learning about knowledge. Specifically, through the pre-class preview, you can clarify the questions in advance, and the teacher also gives answers during the class, which is very targeted. Secondly, the teacher gives us a more intuitive understanding of concepts through examples in class. Finally, in the form of homework, let us express our views or ideas and form our knowledge contract. Through the study of this course, I have a newer understanding of mathematical methods and have greatly improved my thinking, which has increased my deep learning. This method can promote timely communication between students, which is very pleasant.	Positive
	Affected by the epidemic this year, online live learning is rapidly expanding. It is a new type of class, a new way of taking the initiative to preview offline, discuss with group members when problems are found, and then class. The teacher's explanation will test the students' independent learning ability to a large extent and provide them with opportunities for independent thinking, communication, and cooperation. This learning method can be used well to benefit the students and teachers.	Positive
	We are now at the graduate level. I feel very comfortable with this online teaching and offline self-learning method, and it saves a little time.	Positive
	I prefer offline. If there are problems online, it is sometimes inconvenient to ask questions, and I speak a little faster. Sometimes I can't remember or think of it.	Negative
	Offline. Because there is less online interaction, mainly when the professor solves the problem, the teacher will be easy to talk alone if there is no immediate feedback from the students. The students' difficulties and unintelligible points cannot be communicated in time, and the teaching efficiency is not high. In addition, teachers and students do not pay much attention to online classes.	Negative
	The method is relatively new, but online teaching has advantages and disadvantages, and the efficiency of offline active learning is not the same. Both online and offline emphasize "autonomy." I think both are fine. Because students with solid learning initiative and high self-consciousness, no matter what type of course, can achieve the best results under the teacher's careful guidance.	Neutral
	I think both are ok. Because students with solid learning initiative and high self-consciousness, no matter what type of course, can achieve the best results under the teacher's careful guidance.	Neutral
	I hope that the teacher will combine these two methods.	Neutral
	The combination of online live teaching and offline active learning is more innovative. It has advantages and disadvantages.	Approved
	Combining online live teaching and offline active learning can meet our learning needs.	Approved
	Online live teaching is convenient for students to watch videos that they don't understand.	Approved
2	This course is challenging for me, and the teacher speaks very quickly.	Critical
	There is too much work to be done after class.	Critical
	The effect of online teaching is not ideal.	Critical
	This course regrets that it has always been online classes.	Critical

6 Conclusion

Pre-service mathematics teachers have significantly improved their mathematical problem-solving ability, and the online live teaching of mathematical methodology courses are practical. Pre-service mathematics teachers have positive and negative attitudes towards online live teaching mode. Among them, more people believe that the teaching model can be improved. They prefer the combination of online teaching and offline teaching, and they hope to communicate face to face with teachers in the classroom. The advantages of online live education are that it can save resources, be played back, and help students develop the habit of active learning. The disadvantage is that the teaching progress is too fast, students cannot discuss issues with teachers face to face, and they do not get timely feedback. Studies have pointed out that the interaction between students and online live teaching should be encouraged [27]. It is a pity that the teaching method adopted in this research ignores this point. The future of online live education should fully consider the multi-dimensionality of online interaction in technology and the teaching process. In addition, teaching knowledge and educational psychology knowledge in online teaching is very important for teachers, which is currently lacking [28]. The future curriculum design and implementation should pay attention to teaching and psychology knowledge.

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