The Exploration and Practice of the Mixed Teaching Model of Multiple Integration

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Abstract. With the development of the strategic action of education digitalization, the application of online and offline mixed teaching has become more and more extensive, and the deep integration of online and offline teaching has become the focus of educators' research. Combining the concepts of connectionism, constructivism, OBE, PBL, etc., the article puts forward a mixed teaching mode and teaching design of multiple integration. This paper takes the higher mathematics course as an example, and compares the results of the mixed teaching with the traditional teaching horizontally and vertically, and analyzes the advantages and disadvantages of the mixed teaching with multiple integration for the improvement of learning performance; In addition, a questionnaire survey is also used to analyze the teaching situation of mixed teaching with multiple integration. The research shows that the mixed teaching of multiple integration can not only improve students' performance, but also stimulate students' enthusiasm for learning, improve students' ability to learn independently, analyze and solve problems, and achieve better learning results. I hope to provide useful reference for the continuous improvement of mixed teaching.

Keywords: Connectionism · Constructivism · Multiple integration · Mixed teaching

1 Introduction

Yan Wu, Director of the Higher Education Department of the Ministry of Education, pointed out that to solidly promote the digital strategy of higher education, it is crucial for China's higher education to truly adapt to the needs of diversified quality, lifelong learning, personalized training, and modern governance in the popularization stage [1]. This action not only puts forward requirements for students, but also brings challenges to higher education teaching. With the progress of information technology, especially under the influence of the COVID-19 in recent years, in response to the national concept of "suspending classes without stopping classes", online teaching played a great role during the epidemic because it was not limited by the time and place of teaching. However, due to its lack of communication and interaction, the teaching quality could not be guaranteed, which affected the teaching effect to a certain extent. In today's normalized epidemic prevention, universities continue to consider the deep integration of online and offline

teaching, fully utilizing various learning theories, learning from each other's strengths and weaknesses, and exploring the most suitable teaching mode for students' learning. How to apply modern technologies and means in the classroom, cultivate students' ability of autonomous learning and collaborative learning, and combine online teaching with offline teaching has become a problem for more and more colleges.

2 Learning Theory in the Digital Era

Connectionism is a learning theory proposed by Simmons for the network era [2], which introduces the learning characteristics of the network era, the abilities that learners should possess, and emphasizes that the purpose of learning knowledge is to connect knowledge, form knowledge paths, and ultimately form a knowledge network [3]. The personal knowledge network is integrated into various organizational structures, and in turn, the knowledge of organizations and institutions is fed back to the personal network, providing individuals with continued learning. This process of circular development of knowledge enables each person to maintain their own domain through the connections they establish, constantly updating their knowledge within the domain. Connectionism believes that learning is a process, utilizing resources that can be shared and interacted with online courses. Therefore, this learning method is generally applicable to fields such as distance education and informal learning, and has recently gradually entered online teaching in higher education. It focuses more on the external processes of learning and belongs to the field of socialization.

Constructivism theory is one of the important contemporary learning theories [4]. This theory suggests that learning is a process in which learners construct new understanding and cognition through interactions with the outside world based on their existing experiences [5]. It emphasizes that teaching is student-centered, with students as active constructors of knowledge, and teachers as organizers, guides, and promoters of the process [6]. By utilizing learning environment elements such as context, collaboration, and conversation, students' initiative, enthusiasm, and initiative are fully utilized, ultimately achieving the goal of effectively constructing the meaning of the current knowledge. Constructivism focuses more on students' learning itself, which is an internal process of learning and belongs to the field of personalization.

In addition to the two teaching theories mentioned above, there are also two teaching methods: OBE and PBL. OBE (Output based education), also known as result oriented education, is an advanced educational concept that is goal oriented, student-centered, and adopts a reverse thinking approach to construct a curriculum system [7]. In learning, teachers need to clarify the learning and the content they need to master, and use the results to drive students' learning. The ultimate goal of students is to acquire knowledge, not only in terms of understanding the content, but also in terms of the ability to apply knowledge to practice. PBL (Problem Based Learning), also known as Problem Driven Learning, is a problem-based teaching method. It is a learning method that takes students as the main body, takes various problems within the professional field as the starting point, and plans learning content with problems as the core, allowing students to seek solutions around problems. The role of a teacher in this process is to raise questions, design courses, and evaluate outcomes [8]. In terms of learning, teachers use problems to

promote students' learning enthusiasm, allowing them to propose solutions to problems through discussions, exchanges, and other activities.

3 A Mixed Teaching Model with Diverse Integration

In the digital era, constructivism and connectionism are two learning theories that combine individual advantages and social advantages from the internal motivation and external integration of students' learning, respectively, to stimulate the power of $1 + 1 > 2$. Both OBE and PBL teaching methods cater to the student-centered approach in both learning theories, stimulating students' learning enthusiasm from the perspectives of push and pull. The combination of two teaching theories and two teaching methods allows students' learning to burst into different vitality.

The 3C (combine) mixed teaching mode combines two learning theories and teaching methods. The main teaching mode framework is shown in Fig. 1.
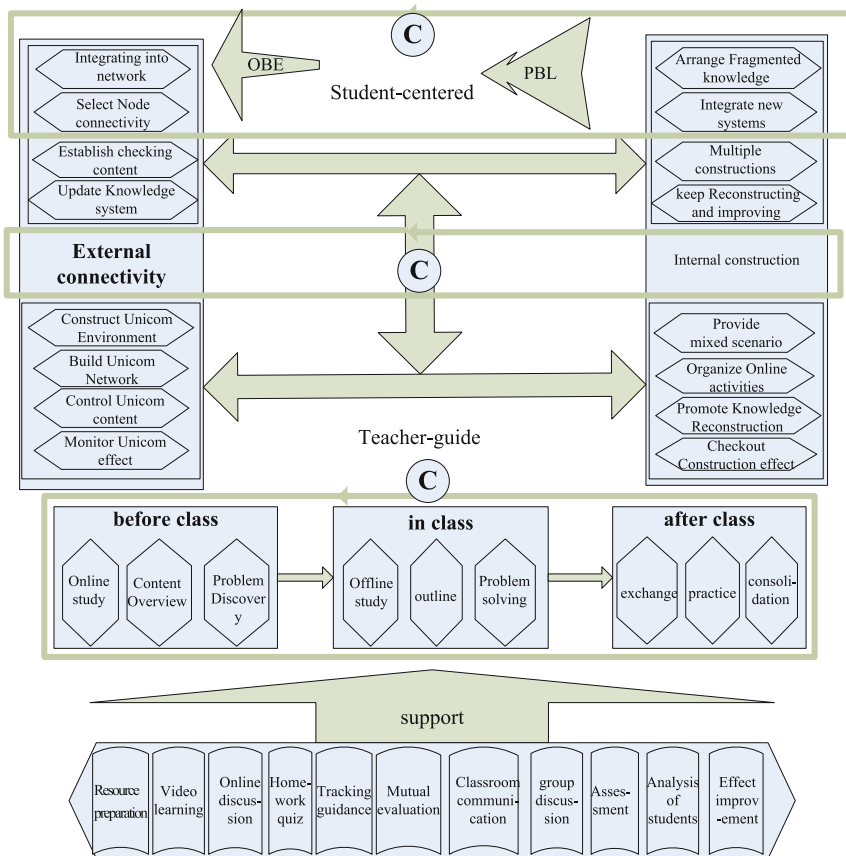

Fig. 1. The 3C (combine) mixed teaching mode

3.1 Combination of Online and Offline

In the mixed teaching of diverse integration, online learning and discussion are adopted, and offline summary and problem-solving are used. Before class, students conduct lead learning based on the video recorded by the teacher, understand the main content of the learning, summarize the problems that exist in the learning, and raise questions in the discussion area, so that the teacher can grasp the students' learning situation and prepare for the next offline learning step. In class, the teacher provides offline explanations based on the students' online learning progress and existing problems, emphasizing the key content of each chapter. Based on this, the teacher explains the students' problems and strengthens them through questions. After class, in addition to completing the questions in class, chapter exercises are also needed to strengthen knowledge, which can be consolidated through online discussion areas, offline consultation, and other methods.

3.2 Combination of OBE Pulling and PBL Pushing

In the learning process, a combination of two teaching methods was specifically adopted.

OBE (Output based education) goal oriented education is a curriculum system construction concept that is result oriented, student-centered, and adopts a reverse thinking approach [7]. PBL (Problem Based Learning) problem driven teaching method is a learning method that takes students as the main body, starts with various problems in the professional field, and plans learning content with problems as the core, allowing students to seek solutions around problems [9].

In mixed learning, the concepts of OBE and PBL complement each other. Both teachers and students have clear goals, with the goal of students acquiring knowledge and problem-solving skills, passing course exams, and earning course credits. In the process of teaching design, teaching, assessment, etc., teachers focus on learning objectives, stimulate students' learning, understand the goals, foundation, and progress of each student's learning, fully consider each student's learning opportunities, establish standards for the learning process, and apply them to teaching. Through exercises on questions, targeted evaluations are made for each student, and effective methods are adopted in a timely manner to drive each student forward.

In this process, the teacher sets the questions for each chapter by understanding the students' learning situation, based on the knowledge points of each chapter, and guides students to find answers to the questions in different ways through online and offline mixed learning. By setting different questions, students should not only pay attention to their learning outside of class, but also remind and guide them through mutual discussion and communication, promoting their learning chapter by chapter.

Through the combination of OBE and PBL, teachers not only pay attention to students' learning outcomes, but also improve their initiative in learning and stimulate their thirst for knowledge.

3.3 Combination of External Connectivity and Internal Construction

In the process of mixed learning, the combination of external connectivity and internal construction not only enhances the learning itself, but also strengthens the learning

process and results through external factors, achieving twice the result with half the effort. The learning of students is a process of knowledge system from unknown to known, in which students themselves and teachers play different roles. Through preview and video watching, students establish a certain knowledge foundation. At the same time, through the sharing of various resources by teachers, as well as the explanation of knowledge points by online and offline teachers, mutual discussion among classmates, timely testing and tracking guidance by teachers, students can form a new understanding and cognition of the learning content, and establish a more comprehensive knowledge system.

In the process of internal construction, students have gained a deeper understanding of existing knowledge, reconstructed the content they have learned, and formed a new understanding of knowledge through the teacher's concise explanation of knowledge, discussions and exchanges in class, as well as mutual writing and homework evaluation among classmates, in the context of the current learning video content, Explain from the four major attributes of constructivism: context, collaboration, conversation, and meaning construction. Situations are jointly established by students and teachers, where students' thirst for knowledge and teachers' guidance on students' learning complement each other, forming a constructive context suitable for students' learning. Collaboration occurs among students, from the beginning of the course to acquiring knowledge and achieving constructive results, throughout the entire learning process, from pre class previewing and online learning to online problem solving, offline discussion and explanation in class, including small exercises, exams, and final overall evaluation scores. Conversation occurs during the collaborative process, where classmates develop learning plans based on the outline provided by the teacher, and complete the process of previewing, learning, and communicating as required by the teacher. The ultimate goal of meaning construction is to acquire knowledge through curriculum.

In the process of external connectivity, everyone integrates their own knowledge into the external network through their own internal network learning and the external network connectivity established by teachers. Through learning and feedback, they constantly master and improve their own knowledge, and finally achieve the learning effect. Under the guidance, interaction, and communication encouragement of teachers in establishing online courses, a connected environment is created to enable students to autonomously integrate into the learning network, drive their learning enthusiasm, and actively establish their own connected network throughout the entire class network. Through video learning, seeking advice from teachers and classmates, summarizing and summarizing their own learning, sharing the learning process, and helping students solve problems, etc., Forming a knowledge path and ultimately forming a knowledge network. In the online learning outline provided by the teacher, clarify the required knowledge content, then identify the location of the knowledge, search for corresponding knowledge, and obtain knowledge.

4   Practice of a Mixed Teaching Model with Diverse Integration

This study was implemented from the spring semester of 2019 to the spring semester of 2022, with a duration of four years. Each spring semester offers Advanced Mathematics 1 retake courses for engineering majors at Suzhou Institute of Technology, with a total

of 80 class hours and a total of eight chapters 32 class hours are taught face-to-face, with two sessions per chapter, based on the principle of students' voluntary choice.

The course adopts a combination of online learning and offline teaching. Online learning mainly involves watching videos, online assignments, online Q&A, problem discussions, and other content. Offline teaching includes summarizing the content of the previous chapter, organizing and explaining online questions, answering discussion questions, learning points for the next chapter, and practicing in class and explaining the previous chapter in class. In both in and out of class, online and offline tests, not only do teachers understand students' weak points in the learned chapters and their level of mastery of knowledge, making it easy to set the next offline explanation points and online guidance points for students, but also enable students to understand their own shortcomings and determine the direction of their efforts. Through multiple online learning, offline teacher's explanations, and communication between classmates, they can master corresponding knowledge. In online and offline discussions, peace and other activities among classmates, students can integrate themselves into the learning network, which is an effective way to learn and test their mastery of knowledge.

This course is available on the Chaoxing Fanya course platform and can be learned through a computer or mobile app. The video used is from a video recorded by our school's teachers. The content is set according to the chapters, and small questions are interspersed in the video. In addition to setting the video, homework and discussions (between teachers, students, and students) are also set. In addition, during online and offline teaching processes, exams are set for classroom practice, and mutual evaluation is conducted during the homework section to facilitate mutual learning among students.

Over the past four years, we have continuously adjusted the integration of online and offline teaching, as well as the process of online connectivity and offline construction. In addition, we have continuously learned from all offline teaching in a single semester, created better learning methods and topics, promoted the achievement of results, and better carried out mixed teaching in two semesters. Especially through horizontal and vertical comparison, gradually seek the most effective mixed teaching method during the operation process.

5 Evaluation of the Implementation Effect of the Mixed Teaching Model with Multivariate Integration

The number of students who have participated in mixed learning and traditional offline teaching over the past four years is shown in Table 1. The first semester is a regular class for Advanced Mathematics 1, with a large number of students, while the second semester is a relatively small class that chooses to participate in the mixed teaching of the retake class.

5.1 Composition of Final Exam Scores

According to school management policies and a comprehensive analysis of the proportion of past grades, mixed learning adopts the same grade ratio as traditional teaching,

Table 1 Number of learners per semester

semester	number of people in mixed learning	Number of traditional teaching
1819–1		**1149**
1819–2	72	
1920–1		**1223**
1920–2	329	
2021–1		**1411**
2021–2	366	
2122–1		**1300**
2122–2	320	

with a ratio of 4:6 between regular and final grades. Unlike traditional teaching, the composition of daily grades is closely related to mixed learning, reflecting both students' online learning and offline teaching situations, as well as the PBL chapter problem node grades and the final results of OBE, demonstrating the effectiveness of external connectivity and internal construction.

In mixed learning, process evaluation and outcome evaluation are combined, and according to the characteristics of teaching, daily grades are composed of online learning and offline learning. The specific structure of students' total grades is shown in Table 2.

Table 2 Structure of Total Score Composition

Composition of grades	Assessment method	specific requirement
Final Exam (60%)	Final Exam	Closed-book exam
Online Learning (20%)	Online Quiz (10%)	Average Score (8 Chapter Quiz + Online Final Quiz)
	Online participation rate (10%)	Discussion (response to teacher's questions + self raised questions) + mutual evaluation (evaluation of test answer situation + participation)
Offline learning (20%)	Chapter assignments (10%)	Grades for assignments in 8 chapters + completion status for assignments in 8 chapters
	Chapter assignments (10%)	Offline attendance + participation in question discussions + answer to questions

Table 3 Vertical analysis of mixed learning performance

semester	Total number	Excellent number	Excellent rate	failed number	Failure rate	Distinguishability	Difficulty	average	standard deviation
1819–2	72	3	4%	18	25%	0.44	0.37	63	18.5
1920–2	329	29	9%	85	26%	0.5	0.45	59	21.5
2021–2	366	51	14%	73	20%	0.49	0.35	65	20.7
2122–2	320	70	22%	15	5%	0.3	0.26	74	13.1

5.2   Comparative Analysis of Comprehensive Scores

In order to demonstrate the characteristics of diversified and integrated mixed teaching, this study will analyze the comprehensive scores from both vertical and horizontal perspectives.

Longitudinal analysis was conducted on the 4-year data, and the various indicators are shown in Table 3. From Table 3, it can be seen that after continuously optimizing teaching methods and methods, various indicators are getting better and better. When the difficulty level is similar, the average score gradually increases, but the increase in difficulty has a significant impact on the overall score. The smaller the difficulty, the higher the average score, the smaller the standard deviation, and the smaller the difference between students.

In order to facilitate the comparison of traditional teaching and mixed teaching, a horizontal analysis was conducted based on the academic year. The various indicators are shown in Table 4. Due to the fact that one semester is the first time for all students to take Advanced Mathematics 1 and there are various types of students, there is a high degree of differentiation in a single semester. The second double semester is for students who have not passed the exam in a single semester and need to retake it, so the overall differentiation is relatively small. With the further optimization of mixed learning, the average score is getting higher and the teaching effectiveness is becoming more and more obvious.

From the data of the past four years, it can be seen that the overall trend of mixed teaching in Advanced Mathematics 1 is getting better and better. In the process of external connectivity and internal construction, the establishment of external learning networks for teachers has become more mature, and the learning effectiveness of students in the network has become increasingly evident; Through the guidance of teachers, students have gained a new understanding of knowledge and improved their grades; The goals of students are becoming increasingly clear, and teachers are constantly exploring and improving the setting of problems, which is more in line with the level of understanding of knowledge and has achieved significant results.

5.3   Survey Questionnaire

In order to further verify the learning effectiveness of changing the mixed teaching mode, this study conducted a questionnaire survey on students at the end of each course. The questionnaire is conducted from three aspects, mainly focusing on the situation

Table 4 Horizontal Analysis of Achievements in Four Academic Years

school year	Teaching type	Excellence rate	Failure rate	discriminative power	difficulty	average	standard deviation
1819	Traditional	**21%**	**21%**	**0.53**	**0.34**	**66**	**22.2**
	Mixed	4%	25%	0.44	0.37	63	18.5
1920	Traditional	**13%**	**29%**	**0.52**	**0.4**	**60**	**23.1**
	Mixed	9%	26%	0.5	0.45	59	21.5
2021	Traditional	**7%**	**31%**	**0.55**	**0.43**	**57**	**22.1**
	Mixed	14%	20%	0.49	0.35	65	20.7
2122	Traditional	**15%**	**15%**	**0.46**	**0.35**	**65**	**19.2**
	Mixed	22%	5%	0.3	0.26	74	13.1

of online and offline teaching, as well as comprehensive teaching. Questions are set from two aspects: achieving teaching results and raising teaching questions. The survey results indicate that the mixed teaching method of diverse integration has been recognized by the majority of students. This mixed teaching method based on the combination of OBE and PBL, with the support of connectionism and constructivism, provides students with different learning experiences. The diversified and integrated mixed teaching model emphasizes self-centered learning, enabling students to better grasp the knowledge they have learned, which is beneficial for improving their overall learning ability and enhancing their mastery of knowledge. The question setting and results of the student questionnaire survey are shown in Table 5.

In the survey, 500 questionnaires were distributed to the classes participating in mixed learning over the past four years, with a recovery rate of 95% and a valid rate of 89%. The survey results are valid. The survey focuses on the reflection of constructivism and connectionism in teaching, while considering the application of PBL and OBE teaching methods. The survey results show that students have a high recognition of mixed learning, reaching 85.4%. This diversified and integrated mixed teaching model, whether it is the external guidance of teachers, the setting of content splitting problems in learning, or the construction of students' own learning network, can provide students with a good experience of satisfaction with the final learning goals, help them better grasp the course, and play a good driving role in students' growth and later learning.

5.4 Appointment

In order to gain a deeper understanding of the effectiveness of mixed teaching with diverse and integrated approaches, and to compare the advantages and disadvantages of traditional teaching and mixed teaching, based on students' past learning experiences, this study selected 30 students who had participated in both traditional and mixed teaching, as well as 30 students who had only participated in mixed teaching, to conduct interviews, In order to further understand the differences between the two teaching methods and further enhance the effectiveness of mixed learning. The interview is mainly

Table 5 The question setting and results

type	queations	Results (%)				
		A	B	C	D	E
online	Video viewing rate	96.6	2.2	1.1	0.0	0.0
	Content comprehension rate	0.0	64.9	33.7	1.3	0.0
	Recognition of pointing homework	95.3	4.5	0.2	0.0	0.0
	Completion rate of pointing homework	40.4	53.9	5.6	0.0	0.0
	Accuracy of pointing homework	2.2	44.9	51.7	1.1	0.0
	Participation rate in discussions	94.4	4.5	1.1	0.0	0.0
	Contribution rate of homework and quiz to knowledge	97.8	2.2	0.0	0.0	0.0
offline	attendance	95.5	4.5	0.0	0.0	0.0
	Understanding rate of content	13.5	60.7	22.5	3.4	0.0
	Recognition of Difficulties	92.1	6.7	1.1	0.0	0.0
	Completion rate of Difficulties	85.4	13.5	1.1	0.0	0.0
	Teacher-student interaction effect	9.9	84.5	5.6	0.0	0.0
	Contribution rate of offline	0.0	44.9	53.9	1.1	0.0
together	Satisfaction rate of mixed teaching	9.7	89.9	0.4	0.0	0.0
	Compared to traditional teaching, course recognition	85.4	13.5	1.1	0.0	0.0
	Compared to traditional teaching, easy for learning	96.6	3.4	0.0	0.0	0.0
	Compared to traditional teaching, Knowledge mastery rate	8.8	85.4	5.8	0.0	0.0
	Compared to traditional teaching, Goal achievement rate	94.4	5.6	0.0	0.0	0.0
	Recognition of teachers' questions	87.6	12.4	0.0	0.0	0.0

Note: A-100%, B-75%, C-50%, D-25%, E-0%

conducted through comprehensive evaluation to further understand the advantages and disadvantages of mixed learning, as well as the willingness to participate in such teaching in the later stage, as well as suggestions and opinions on such teaching.

Through interviews with 30 students who have participated in both teaching methods, the advantages and disadvantages of mixed teaching methods are summarized in Table 6.

After completing the course, most students will choose courses with similar teaching methods for learning in the future. There are many knowledge points in Advanced Mathematics 1. Through the teacher's precise setting of goals and the problems set for knowledge points during the learning process, students have clear goals and more precise mastery of knowledge points. Therefore, students subconsciously feel that learning is

Table 6. The advantages and disadvantages of mixed teaching

advantages	Freedom of study time
	Control learning progress
	No course conflicts exist
	many online materials
	Looking back at the video
	Problem-based learning makes it easier to master knowledge points
	Better goal oriented fit for exams
	Teacher guidance promotes learning
disadvantages	Students with poor self-discipline have poor learning outcomes
	Questions cannot be answered immediately
	cheat in watching video

easier. During the learning process, by building a knowledge network, everyone can integrate into the learning environment and play a positive role in promoting the construction of their own knowledge.

The disadvantage of mixed learning mentioned is also a common problem in online teaching. For the vast majority of students, it will not affect their learning outcomes. With the further optimization of online teaching, such problems can be further solved. In addition, some students have proposed increasing interaction time with teachers, including pre class Q&A and post class question analysis, which will be further optimized in the future implementation process. Due to the strict nature of higher mathematics, students hope to increase the fun of the classroom, which needs to be further strengthened in the future.

In short, most students strongly agree with the mixed teaching method of Advanced Mathematics 1, and in the future, efforts will need to be made to improve online teaching and classroom fun.

6 Conclusion

Mixed teaching is a kind of teaching form under the background of Internet plus education, and it is a manifestation of human-computer integration education. The theory of connectionism can guide students to establish a network of knowledge through problem-based learning. Through the sharing of teacher's teaching content, teaching priorities, and students' learning methods and communication processes, as well as feedback on learning issues and communication between teachers, students, and students, knowledge can be integrated and formed into a knowledge network of Advanced Mathematics 1. Constructivism theory can guide teachers to organize and design curriculum teaching processes using result orientation, making it easier for students to gradually accept new knowledge.

Based on the mixed teaching approach of diverse integration, it can be seen from the teaching practice of this study over the past four years that the learning effectiveness is relatively significant, students' recognition is relatively high, their mastery of knowledge is enhanced, and the overall effect is good. In higher education, there are many courses such as Advanced Mathematics 1 that are explained based on chapters, which have a certain reference value for other similar courses and are suitable for promotion in similar courses.

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