The Practice and Exploration of the "Dual-Line Integration Teaching" Model in the Course of Numerical Analysis

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Abstract: *Combining the advantages of online teaching and offline teaching, this paper constructs a "dual-line integration teaching" model, which is a complete set of "teaching-learning-evaluation" integrated closed-loop teaching mode. At the same time, the teaching mode is applied to the teaching practice of the course "Numerical Analysis", and good teaching results have been obtained, which not only improves the pass rate and excellent rate of the course, but also greatly improves the students' independent learning ability and practical innovation ability, so as to achieve the training goal of applied innovative talents.*

Keywords: *Dual-line integration teaching, Numerical analysis, Teaching evaluation*

Introduction

Teaching reform is an eternal theme in the reform and connotation development of university education. The new era has endowed university teaching reform with new missions: firstly, people's expectations for high-efficiency and high-quality higher education are increasingly rising; secondly, the competition for the internationalization of higher education is becoming more intense; thirdly, with the rapid development of information technology and artificial intelligence, the impact of new educational technologies on teaching environments, teaching forms, course construction, teaching models, and evaluation systems is becoming greater, even revolutionary [1]. The Ministry of Education's "Informationization 2.0 Action Plan" emphasizes the need to promote the deep integration of new technologies with education and teaching [2]. The "China Education Modernization 2035" issued by the Central Committee of the Communist Party of China and the State Council points out that modern information technology should be fully utilized to accelerate the reform of talent cultivation models [3]. Traditional offline classroom teaching and purely online teaching during the pandemic are two sides of university teaching, each with its advantages and disadvantages. Although many universities and teachers are striving to combine the two teaching methods, current university teaching still cannot break away from being teacher-centered, knowledge-centered, and classroom-centered. In practice, the two teaching modes are essentially in a state of superficial integration, which obviously can no longer meet the teaching requirements of university education in the new era. How to make up for the shortcomings of single-line teaching and achieve a "fusion of the two lines" is an important issue that university teaching urgently needs to address in the new era.

1 Construction of the "Dual-line Integrated Teaching" Model

The "Dual-line Integrated Teaching" model combines the advantages of online and offline teaching, integrating the two into a new teaching model. This model was proposed by Li Zhengtao, Dean of the Institute of Education at East China Normal University, in 2020. He emphasized the integration of online and offline teaching, highlighting their "dual-line symbiosis" where "you are in me" and "I am in you" [4]. This model integrates teaching resources, various teaching methods, online and offline integration, and diversified

evaluation measures, achieving mutual integration of teaching space, teaching time, teaching resources, teaching design, teaching management, and teaching evaluation. It transforms the "teacher-centered" teaching model into a "student-centered" teaching model. In the dual-line integrated teaching model, online teaching provides convenient learning resources and learning process management, while offline teaching offers face-to-face interaction and in-depth discussions. The two are intertwined, mutually dependent, and complement each other, forming an all-encompassing and innovative educational activity and behavior. This will become the new norm for future education in the "post-pandemic" era. The overall framework design of the dual-line integrated teaching model is shown in Figure 1.

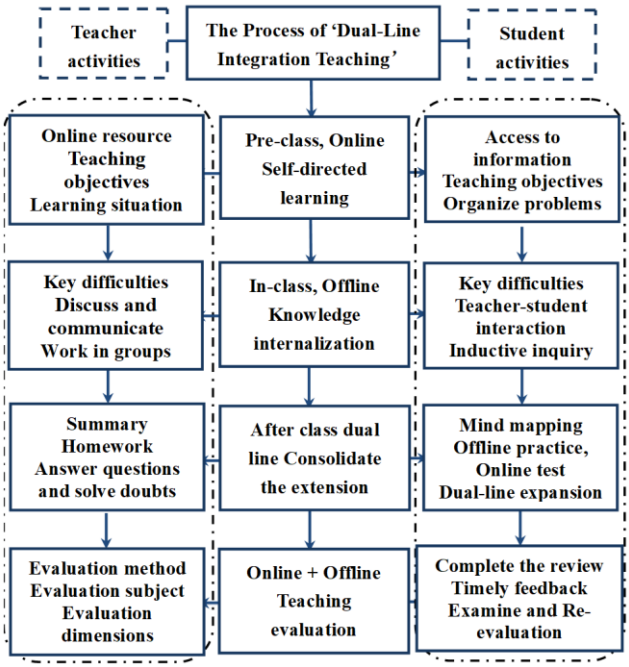

Figure 1. Framework Design of the "Dual-line Integrated Teaching" Model

1.1 Pre-class Online Teaching

Teachers should choose an appropriate interactive platform based on the nature of the course, available resources, and students' learning conditions. Before class, teachers can post "online learning resources," set "teaching objectives," and conduct "pre-class learning diagnostics." The content in this phase can vary and include videos, audios, quizzes, surveys, stories, and cases. The goal is to capture students' attention, stimulate their interest, enhance their participation, and cultivate good self-learning habits, thus serving as a "pre-class warm-up."

1.2 In-class Offline Teaching

In-class offline teaching is the core process of the "dual-line integrated teaching" model. It leverages flipped classrooms to achieve in-depth understanding and transfer of course knowledge, facilitating knowledge internalization. Teachers analyze the issues and results submitted by students in the online discussion forums and tests to estimate their knowledge grasp and provide targeted online assistance for individual problems. For common issues, teachers need to focus on key points and difficult concepts in offline classes, ensuring detailed explanations and exercises. Various teaching methods, such as case-driven, teacher-student Q&A, group discussions, and heuristic seminars, can be used to fully engage students, increase classroom participation, make students "busy," and bring the classroom "alive." This creates a supportive and positive learning environment, ultimately improving the effectiveness of offline classroom teaching.

1.3 Post-class Dual-line Extension

After the offline class ends, students are guided to summarize the key points of the lesson and create mind maps. Through offline assignments and online chapter tests, students can review and consolidate their knowledge, applying what they have learned. Students are encouraged to review online supplementary materials and take notes. They are also motivated to use the knowledge from the class to solve practical problems in their field or to complete a small group project, such as a mathematical modeling paper, thereby enhancing their practical innovation skills and teamwork abilities.

1.4 Teaching Evaluation System

Teaching evaluation is the most effective and direct method to assess teaching and learning outcomes. The "dual-line integrated teaching" model effectively combines online and offline evaluation methods to establish a "dual-line diversified comprehensive evaluation system." This system includes diverse evaluation subjects, varied evaluation content, and multi-dimensional evaluation methods, allowing dynamic tracking of students' learning conditions and a direct display of learning outcomes. Throughout the teaching process and activities, quantifiable "dual-line evaluation indicators" are set, making evaluations operational, realistic, and effective, thereby reflecting the true teaching results.[5]

2 Application Practice of the "Dual-line Integrated Teaching" Model in the Course of "Numerical Analysis"

2.1 Course Characteristics of "Numerical Analysis"

"Numerical Analysis" is a compulsory course for our school's mathematics and applied mathematics majors. It studies numerical computation methods and their theory for solving various mathematical practical problems using computers and is closely integrated with computer science. This course is characterized by extensive content and limited class hours, conservative and traditional algorithms, and abstract and uninteresting theories. For teachers to explain this course thoroughly and engagingly, they must continually update their knowledge structures and supplement a lot of information beyond the textbook, covering a wide range of disciplines and application areas. Consequently, this lengthens the time for classroom lectures and shortens the time for student exercises and computer operations, ultimately affecting teaching effectiveness.

2.2 Application Practice of the "Dual-line Integrated Teaching" Model

The teaching process of the "Numerical Analysis" course under the "dual-line integrated teaching" model involves three stages: pre-class online preparation, in-class offline flipped classroom, and post-class dual-line consolidation and extension. This approach integrates online and offline elements into a cohesive whole, connecting pre-class, in-class, and post-class phases into a comprehensive closed-loop teaching system.

Pre-class Online Preparation: During the pre-class autonomous preparation of "Numerical Analysis," teachers set online learning materials related to the lesson content on the Xuexitong platform. These materials may include important knowledge point videos, stories of mathematicians, the beauty of mathematics, case introductions, surveys, and pre-study self-tests, all completed on the Xuexitong platform. Before the offline class, teachers need to browse the platform's backend to understand students' task completion status, preliminarily assess their learning conditions, and tailor the in-class offline teaching process accordingly to improve teaching effectiveness and efficiency.

In-class Offline Flipped Classroom: In-class teaching primarily takes place offline, forming the core of the dual-line integrated teaching model, acting as a "link between the preceding and the following." It serves as a cognitive retrieval of pre-class online preparation and the "source of living water" for post-class dual-line consolidation and extension. Classroom teaching is arranged using the flipped classroom teaching method, mainly adopting teacher-student Q&A, group discussions, detailed explanations of key points

and difficulties, and student exercises. This approach maximizes students' "main role" and teachers' "leading role," making students "busy" and the classroom "active." In offline classes, teachers should appropriately "let go," allowing students to handle tasks they can manage independently; if students cannot manage individually, group discussions can be held to find solutions. If the group cannot solve the problem, the teacher will then provide detailed explanations and ensure students practice until the problem is resolved and objectives are met.[6]

Post-class Dual-line Consolidation and Extension: After the offline class, teachers post relevant after-class learning resources on the Xuexitong platform, including assignments, mind map creation, replay videos of key and difficult points, application case video explanations, mathematics culture history, and postgraduate exam question extensions. Students must complete these tasks within the stipulated time. Teachers also provide real-time online assistance in the QQ learning group, where students post questions in the group for autonomous discussions, with course assistants (top-performing students in the class) providing help. This fosters a supportive, competitive, and collaborative learning atmosphere. After students complete tasks, teachers review and provide feedback promptly. For common issues, teachers provide unified explanations in the QQ group, ensuring each student resolves their doubts and understands the concepts, achieving the goal of learning, reflecting, understanding, and applying effectively.

3 Practical Results of the "Dual-line Integrated Teaching" Model

Teaching evaluation can measure the achievement of teaching objectives and determine the quality of teaching effectiveness, while also solidifying the core direction of dual-line integrated teaching. In the process of dual-line integrated teaching, aspects such as the correctness of the evaluation purpose, the diversity of evaluation methods, the comprehensiveness of evaluation subjects, and the application of evaluation results all influence the effectiveness of this teaching model.

3.1 Teaching Effect Evaluation System for the "Numerical Analysis" Course

The total score evaluation system for the "Numerical Analysis" course under the "dual-line integrated teaching" model includes regular performance (35%), midterm performance (15%), and final performance (60%). Regular performance is evaluated through four components: online comprehensive evaluation (10%), classroom performance (5%), dual-line assignments (10%), and lab performance (10%). The specific evaluation system is shown in Figure 2. Online comprehensive evaluation is achieved through student self-evaluation, classroom performance through peer evaluation, online assignments through student self-evaluation, offline assignments through teacher evaluation, and midterm and final exams through teacher evaluation. Finally, a comprehensive evaluation is given based on the respective proportions. This evaluation system is specifically quantified, highly operable, and provides accurate, reliable results, enabling precise assessment of students' actual learning outcomes.

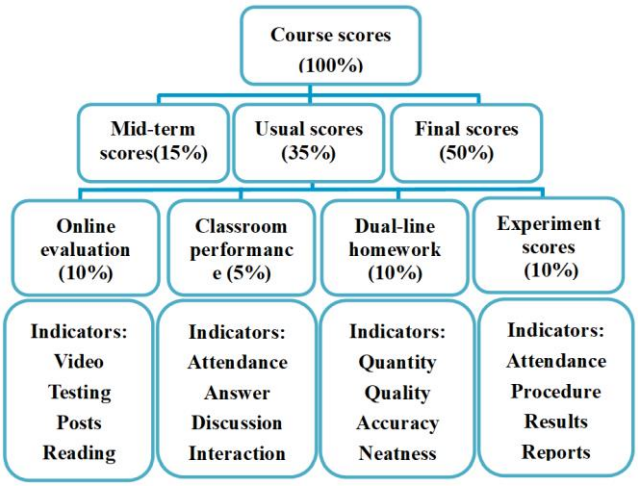

Figure 2. Evaluation Index System for "Numerical Analysis" Course Assessment

3.2 Practical Results of the "Dual-line Integrated Teaching" Model in the Teaching of "Numerical Analysis"

In the 2022 cohort of the Applied Mathematics program at our university, 52 students participated in the "Numerical Analysis" course, with an average score of 75.43 points. Among them, 5 students scored between 90-100 points, accounting for approximately 9.62%; 11 students scored between 80-89 points, accounting for 21.15%; 21 students scored between 70-79 points, accounting for 40.38%; 13 students scored between 60-69 points, accounting for about 25%; and 2 students scored between 0-59 points, accounting for about 3.85%, roughly following a normal distribution, as shown in Figure 3. The overall pass rate was about 96.15%, and the excellent rate was 30.77%. Compared to the previous traditional teaching mode, the pass rate increased by approximately 6 percentage points, and the excellent rate increased by about 3.5 percentage points. This fully demonstrates that the "dual-line integrated teaching" model can more effectively improve the quality of course teaching.

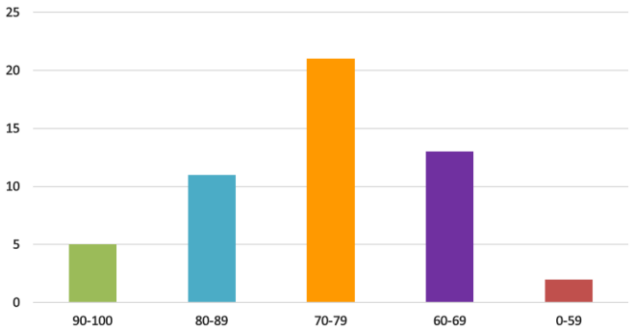

Figure 3. Bar Chart of "Numerical Analysis" Scores for the 2022 Cohort of the Mathematics Program

Under the "dual-line integrated teaching" model, not only can students' course grades be improved, but more importantly, their comprehensive practical abilities and independent innovation abilities can be cultivated and enhanced. Mathematics majors at our university participate in national competitions such as the National College Student Mathematics Competition and various mathematical modeling competitions, with an annual average of over 30 projects and about 55% of the mathematics majors participating. Additionally, according to a survey, after the implementation of the "dual-line integrated teaching" model, students' abilities in self-learning, independent problem analysis, teamwork, dialectical thinking, practical application, and exploration and innovation have been significantly enhanced, as shown in Figure 4.

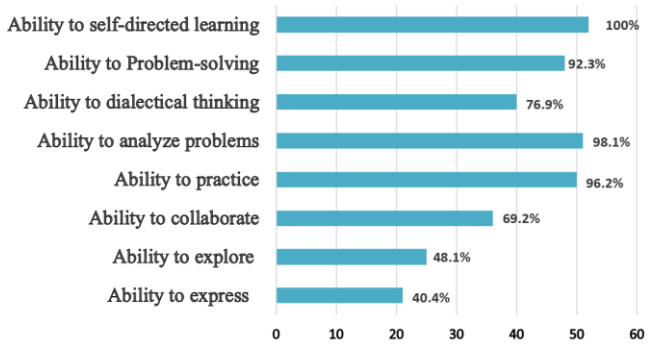

Figure 4. Impact of the "Dual-line Integrated Teaching" Model on Students' Comprehensive Abilities

4 Practical Effects and Feedback

Through practical exploration, the application of the "dual-line integrated teaching" model in the "Numerical Analysis" course has achieved significant results. Firstly, students' learning enthusiasm, participation, and self-learning abilities have been greatly enhanced. The online and offline learning resources and activities have provided students with more learning opportunities and choices. Secondly, the quality and effectiveness of teaching have been significantly improved, with more flexible and diverse teaching designs and more

remarkable student learning outcomes. However, there are also some problems and challenges in the practice process, such as balancing the proportion of online and offline teaching and ensuring the quality and authenticity of online teaching. Therefore, it is necessary to further research and explore the optimization and improvement directions of the "dual-line integrated teaching" model.

5 Conclusion and Outlook

The practical exploration of the "dual-line integrated teaching" model in the "Numerical Analysis" course provides new ideas and methods for the innovation of higher education teaching methods. By integrating and sharing teaching resources, designing blended online and offline teaching activities, providing personalized learning and tutoring, and applying diversified evaluation systems and feedback methods, the model effectively improves students' learning enthusiasm and participation, thereby enhancing teaching quality and effectiveness. In the future, further research on the theoretical basis and practical application of the "dual-line integrated teaching" model can be conducted to explore teaching models and methods that better meet the needs of students and teaching objectives, contributing to the cultivation of high-level talents with innovative abilities and practical application skills.

Fund Project

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