RESEARCH AND PRACTICE OF A BLENDED TEACHING MODE BASED ON SMALL PRIVATE ONLINE COURSES

Yan Li, Zhuoqun Lu and Heyun Liu

School of Energy and Mechanical Engineering, Hunan University of Humanities, Science and Technology, Loudi, China

ABSTRACT

The rate of education digitization is accelerating due to the ongoing development of information technologies. The demands of student learning cannot be fully met by the conventional classroom-teaching method. Due to the emergence of new teaching forms in the post-pandemic era, rapid development of IT applications, national education-informatization policies and deployment, and the plight of the traditional teaching mode, there is a need to explore new ideas and patterns of integrating information technologies and teaching approaches. This study elaborates on a blended teaching mode based on small private online courses (SPOC) on course goals, teaching contents, teaching methods, and evaluation approaches against the background of information technology by using the course of Heat Transfer as an example. The results demonstrate that this instructional strategy can enhance students' learning effect and comprehensive ability effectively. The rules of blended teaching were explored to guide teaching improvement.

KEYWORDS

SPOC, Blended Teaching, Informatization

1. INTRODUCTION

Every industry is evolving as a result of the quick growth of artificial intelligence, the Internet of Things, the 5G network, and other technologies. The e-evolution or e-revolution includes e-mails, e-commerce, e-government, and now e-education. Our approach to teaching and learning is changing as a result of e-education, commonly referred to as online education [1]. In order to achieve digitization, networking, intelligence, and multimedia in classroom instruction, teachers attempt to integrate cutting-edge information technologies with instructional ideas by putting into practice a variety of new measures, such as massive open online courses (MOOC), small private online courses (SPOC), micro courses, and inverted classes. Blended teaching, which is the most popular form of delivering courses in higher education [2], frequently blends face-to-face and online methods and technologies [3] in order to best achieve the learning objectives of the course.. Therefore, various methods are needed to achieve effective blended teaching [4]. As institutions around the world adapt to changes, there is a developing body of knowledge that examines the potential and difficulties of online education [5-7].

As a new online educational model, MOOC represents a new form of online course developed based on teaching theories and network/mobile intelligent technologies. In the post-MOOC era of mixed modern online teaching and learning models, MOOC had progressed through multiple stages of cMOOCs, hMOOCs, and xMOOCs [8, 9]. MOOC started in 2012. Due to the numerous benefits of being large, open, online, interactive, and abundant in learning resources, it gained popularity swiftly throughout the world. After a rapid-growth period, MOOC gradually became

rational in its development [10]. SPOC was first proposed by Professor Armando Fox from University of California in 2013. SPOC refers to small-scale limited online course which has become a more efficient and popular teaching mode in the post-MOOC era[7, 11, 12]. The International Financial Times Dictionary regards it as a competitive teaching mode of MOOC, while Anant Agarwal sees it as a branch of MOOC [13], and Rolf Hoffmann holds that it is a mode of "classroom + MOOC" [14], Robert Lue argues that SPOC has replaced MOOC and represented a post-MOOC era[15].

Education professionals from around the world have been forced to study and consider the downsides of online learning, which are becoming more and more clear. These provided a solid foundation for the concept of "blended learning," which was defined as the combining of the benefits of traditional classroom instruction and network instruction [16] in order to improve educational outcomes. Chinese academics formally introduced the idea of blended learning in 2004[17]. Blended learning aims to develop abilities in practical innovations by fusing conventional instruction with online instruction against a backdrop of digitization.

Heat Transfer is one that deals with the law of heat transfer and has many applications..This course is a core and specialized basic course in Energy and Power Engineering major. At present, the teaching reform of the Heat Transfer course in most universities in China mainly focus on removing teaching contents and changing teaching methods. The use of information technologies to implement thorough and organized teaching reform was very uncommon.

According to the teaching experience analysis accumulated for many years by the authors of this study, the traditional teaching mode of the Heat Transfer course has some issues in terms of teaching goals, contents, and methods. To solve these problems and realize an integration of information technologies and traditional education, general rules of the blended teaching mode with online and offline approaches based on SPOC were explored in this study by using this course as a demonstration example.

In the article, we first analyzed the necessity of curriculum reform, and then introduced the innovative teaching mode of Heat Transfer. Through analyzing the effectiveness of teaching reform and practice, we finally concluded that the teaching mode is highly operable and worth promoting.

2. NECESSITY OF COURSE REFORM

2.1. New Forms of Education and Teaching in the Post-Epidemic Era

The COVID-19 outbreak at the end of 2019 has led to massive changes in global education. The pandemic has affected most countries around the world, forcing nearly 1.6 billion students out of school. They must quickly adapt to a more challenging environment [18]. Numerous academics started looking into how the COVID-19 affected higher education [5, 19-23]. As highlighted in the case studies of China [24], Philippine [25], India [26], Italy [27], Ukrainian[28]and Germany [29], after the COVID-19 outbreak, colleges in numerous nations underwent a change from "face-to-face" teaching to various types of online teaching.

The Chinese Ministry of Education ingeniously put into practice the policy of" no suspension of learning during the absence of classroom teaching. " By utilizing online tools, platforms, and resources to the fullest extent possible, Chinese universities have embraced the online learning trend. These initiatives violently dismantled the conventional "face-to-face" teaching method. As part of the effort to combat the pandemic, online education not only quickens the spread of

Internet-based information technologies to reshape the new form of education, but it also transforms how teachers teach and how students learn. The transformation of the teacher's role is another benefit of online education [30]. However, the sudden emergence of online education exposed many drawbacks, including weak presence, inadequate monitoring, and barriers to emotional communication [31].

After the pandemic became stabilized, the teachers used their experience of online teaching to innovate and reform classroom teaching. Although the combination of online and offline methods seemed to be a helpless move under the pandemic, it created a great opportunity for comprehensive implementation of educational informatization [32].

2.2. Information Technology Development

All facets of education have been significantly impacted by the information technology industry's quick development. The use of information technology expands the breadth and depth of education while also supporting ongoing reform and innovation in teaching methods.

The transfer of educational responsibility from the government to individuals and their parents is made possible by information technologies. People's expectations for education have changed from focusing on everyone's full success to individualized growth. While the educational approach has changed from indoctrination to interaction, the educational content has shifted from subject knowledge to mastering the learning approach. The place of education has expanded from the school to everywhere, embedded evaluation has replaced examinations, and peer culture has been replaced by a mixed-age culture in education [33].

2.3. Policies, Systems, and Strategies of Education Informatization

If a country's education system is prosperous, the country will also become prosperous. If education is strong, the country will become strong. The report of the 19th National Congress of the Chinese Communist Party put forward a strategic task of" speeding up modernization of education and building a strong country in education. " On February 27, 2014, at the first meeting of the Network Security and Informatization Leading Group, General Secretary Xi Jinping emphasized that informatization is an important prerequisite of modernization, which is the premise, support, and foundation of informatization [34].

The Chinese government issued several guiding documents on education informatization in recent years, e.g., "Education Informatization 2.0 Plan of Action," "Guidance on Promoting the Development of the Internet and Education," The 14th Five-Year Plan of Education Informatization, " and "The Medium and Long-Term Development plan of Education Informatization (2021-2035). " Moreover, the annual work focus of education informatization was issued every year to form a comprehensive overall deployment of the policy and construct a blueprint for promoting education informatization in the new era.

The relevant educational policies and practice of informatization promote the integration of information technologies into the entire educational ecosystem to ushering education into a new era.

2.4. Dilemma of the Traditional Teaching Mode

The following problems were found by the authors' team after the analysis on the teaching status of the course with years of experience.

There wasn't enough analysis of learning situations and effectiveness in the teaching context. The previous tool for gathering information about learning situations and effectiveness was only one, with few capabilities and little application. The analysis hardly ever took the students' cognitive traits into account. Additionally, there was no feedback-iteration mechanism. The goals of the teaching were frequently unclear. Most of the teaching was done through experience and lacked a systematic structure. The teaching content was out of date. There are many crossover contents between the Heat Transfer course and other disciplines. The requirements of modern engineering education cannot be met by the outdated content. The previous teaching method was tedious with regards to assignments, and without enough differentiation, students of various levels were taught the same material and given the same homework. Such a teaching style does not support the individual growth of students. The teaching approach was archaic. There was too much indoctrination taking place in the traditional classroom, and there was little in-depth communication between the teacher and the students. The examination strategy lacked enough variety. The traditional teaching method included the final exam and an excessive number of conceptual questions.

As a result, in order to address the issues with the traditional teaching approach, one must adapt to the demands of the modern era and the government to make traditional education and information technologies more seamless. This task is a challenge for the teaching team of the Heat Transfer course.

3. CONSTRUCTION OF AN INNOVATIVE TEACHING MODE

3.1. Creative Ideas

It is necessary to treat the student as the center of teaching and strengthen guidance during the entire course. According to the variations in the students' cognitive levels and learning capacities, study groups must be set up. To logically organize the teaching materials, various study groups are given precisely defined learning objectives. The instructional tasks are customized for students.

It is necessary to teach both the learning approach and the subject knowledge by open teaching. The term "learning approach" describes a combination of learning, research, and real-world problem-solving skills. The teaching exercise should be planned with reasonable objectives and materials to develop students' capacity for creative thinking and open-mindedness.

For continuous improvement, it is essential to insist on iterative feedback and strengthen the "dual loops". The learning situation and effect analysis were promoted in stages in accordance with the iterative feedback concept while the teaching materials, tasks, and methods were promptly adjusted and optimized. Based on a thorough assessment, the outcomes of learning situations and teaching objectives were evaluated through feedback. The evaluation, feedback, and improvement cycle in the classroom was the main focus of the dual-cycle continuous-improvement mechanism, which also focused on the cycle before and after the class as a means of mutual support.

3.2. Innovative Methods and Paths

The course team adhered to Taylor's curriculum theory, Bloom's taxonomy of educational goals, and Бабанский's teaching optimization theory in the current information age. Social constructivism and humanism were also integrated into the course of HeatTransfer as teaching

philosophies. The teaching mode was constructed and implemented. This teaching mode emphasized the importance of the mutual influence between emotional and cognitive goals based on the analysis of teaching status, learning situation, and effectiveness. The teaching aims, contents, tasks, methods, and evaluation tools were designed to continuously improve teaching effects.

3.2.1. Student-Centered

The new teaching strategy made student development its central concern. The students were divided into groups in order to provide differentiated instruction with continuously improved learning objectives, curricula, tasks, and strategies. Students with weak foundations and poor learning skills can still complete the course requirements in this way, and students with strong learning skills can develop advanced skills.

3.2.2. Specific Implementation

- Staged-learning situation and effect analysis

Traditional analyses of learning environments and efficacy are inapplicable and lack feedback-iteration mechanisms. The teaching reform used staged analysis to examine the students' cognitive levels, knowledge reserves, study habits, techniques, and tools prior to the class. For targeted screening and the creation of teaching objectives and lesson plans, the learning motives, willingness, and expectations were also analyzed. To improve the teaching process and swiftly modify teaching strategies, the students' participation, performance, questions, and problems were analyzed throughout the class. Following the lesson, the "goal-activity-evaluation" consistency of the course was examined using real data and qualitative materials to assess the objectivity, reliability, and validity of the assessment tools. The development of the students' abilities was also analyzed in order to aid the subsequent revision of the curriculum.

- Precise teaching-target design

Due to the traditional teaching approach's lack of systematic design and hazy teaching objectives, precise target design was carried out through an analysis of the cognitive process and knowledge dimensions..In order to adjust instruction to the actual cognitive capacities of the students, the core conceptual knowledge goal was emphasized. Applied procedural knowledge and meta cognitive knowledge-related aims were highlighted to match the requirements of professional competence and literacy training. For example, the teaching aims in Chapter 3, Lesson 1 of Heat Transfer course were shown in the following table (red indicates Cognitive Process, green indicates Knowledge Dimension), as shown in Table 1.

Table 1. The teaching aims in Chapter 3, Lesson 1 of Heat Transfercourse

Unsteady heat conduction characteristics and zero-dimensional lumped parameter method	Factual and Conceptual Knowledge Aims	1.By comparing the differences between (unsteady) heat conduction, the definition and characteristics of unsteady heat conduction are obtained, and the classification is obtained
		2. Explain the characteristics of non-periodic and unsteady heat conduction (the first boundary) [Key]
		3. Compare the difference between unsteady heat conduction and steady heat conduction in system equations
		4. The influence of the other two cases can be deduced from the influence of one boundary condition on the unsteady heat conduction temperature distribution, and the three cases are compared [Difficult]
		5. Explain the physical meaning of Bi and deduce the relative size of Bi under three boundary conditions [Key]
		6. Infer the physical meaning of Fo and compare it with Bi [Key]
	Procedural Knowledge Aims	1. Deduce the mathematical model of lumped parameter through comparing with the learned mathematical model of heat conduction [Difficult]
		2. Explain the solution process of temperature distribution by lumped parameter method
		3. Summarize the general problem-solving steps of lumped parameter method [Key]
	Metacognitive Knowledge Aims	1. Check the applicability of lumped parameter method in specific heat conduction problems [Key, Difficult]

- Modular teaching-content organization

The teaching materials were chosen and arranged based on the epoch-defining curricular characteristics and the requirements of new engineering education, taking into account the actual cognitive levels of local undergraduate students and the training objectives of professional talents. To clearly describe crucial and challenging concepts, the course was separated into four core teaching modules. A corresponding staged test and review sessions were scheduled for the conclusion of each module. Pre-class, in-class, and post-class were the three components of each class, as illustrated in Table 2. The instructional material was organized through a number of levels of work to meet Golden Course criteria.

- Hierarchical teaching-task setup

The learning capacities and cognitive levels of various students vary. A hierarchical design was used to assign teaching tasks. Various assessment tools were used to gather feedback (this will be explained in detail later). The students' enthusiasm of learning was encouraged. The students were guided to take their initiatives to acquire knowledge and capabilities. The hierarchical

teaching approach ensured that all students meet the minimum requirements of the course and some outstanding students learn more to acquire advanced abilities (as shown in Table 2).

Table 2.Hierarchical aims setup

Time	Activities	Hierarchical aims
Pre-class	MOOC, PPT, Self-assessment exercises	Basic Aims
In-class	Case analysis, Group discussion, Demonstration and communication, Interactive interpretation, etc	Advanced learning aims for improving cognition and solving key and difficult problems
Post-class	Mind mapping assignments, Unit tests, Extended reading, and Group discussions	The high-level aim of stimulating thinking, cultivating thinking abilities, concepts, and self-evaluation

- Implementation of diversified teaching methods

The course mainly adopted the SPOC form and focused on the learning styles of college students in the modern day while making full use of information tools. To pique students' interest in learning and enhance learning effects, the course effectively combined the teaching strategies, case-based instruction, demonstrations, flipped classrooms, PBL (Project-Based Learning), BOPPPS, and collaborative assignments. We strive to combine obscure knowledge with real life to concretize abstract concerns, for instance by providing situations like drying quilts in winter and fogging glasses in daily life, as well as trending topics like the greenhouse effect.

- Comprehensive evaluation of the entire process

The process examination was strengthened. The eagerly studied-for final exams no longer influenced the overall course grade. In order to instill a sense of participation, investment, gain, and growth in the learning process, special attention was paid to the diversity and collaboration of the evaluated subject. The final grade for the course includes a process exam score of 60%, a class attendance score of 10%, a homework assignment with non-standard answers of 20%, and a flexible staged test score of 30%. The final test score accounted for 40%. It used a closed-book format and included a set amount of questions with no predetermined solutions in an effort to test the student's aptitude for problem-solving and analysis.

4. EFFECT ANALYSIS OF TEACHING REFORM AND PRACTICE

A eight-year reform was carried out for the Heat Transfer course with the support of "the Hunan Provincial Comprehensive Reform Pilot Program during the 13th Five-Year Plan" and "the National First-Class Undergraduate Program. "After continuous reform, significant improvements were achieved, which are detailed as follows.

4.1.Analysis 0f Student Course Learning Effect

4.1.1. Analysis of the Effect of Achieving Cognitive Aims

The overall scores are shown in Fig.1, where Class 2016 had a merged class, with students coming from different classes. And Class 2018used the MOOC and virtual class due to the sudden outbreak of COVID-19. The examination difficulty was reduced for Class 2018. The class

failure rate basically decreased as a trend from Class 2013 to 2020. The satisfaction of meeting the course teaching aims increased gradually over these years. In the following figures, Class 13 is the abbreviation of Class 2013, and so are others.
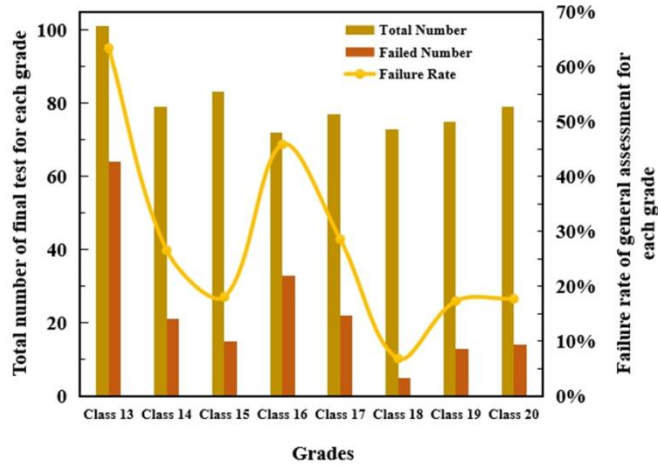

Figure1. Failure rate of general assessment for each grade of Heat Transfer

4.1.2. Analysis of the Effectiveness of Improving the Consistency of the Course

"Aim - Activity - Evaluation". As shown in Fig. 2, the statistical differences in the score samples of Class 2013 to Class 2020in terms of the normal results and the final score basically show a decreasing trend. The average rank of the normal results of Classes 2013 - 2015 was higher than the final test score. There was generally a bad situation that the normal results were not good. The normal results cannot reflect the real learning situation of the students. This situation was improved with the reform in later years for Classes 2015 - 2020, where the increased difficulty in usual tests could reflect the real learning situation of the student, effectively changing the common habit of "end-of-term cramming" among the students.
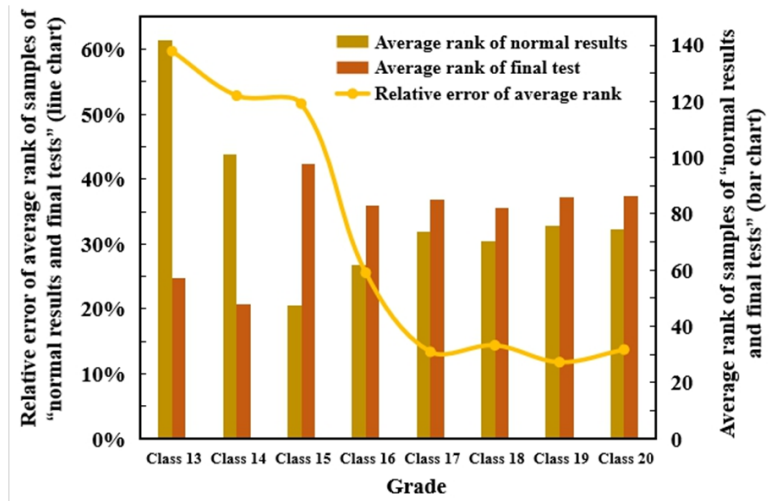

Figure2. Relative errors of the average rank of normal results and final test scores.

4.1.3. Analysis of Improvement Effect on Emotional Aim Achievement

According to Fig. 3, attendance statistics revealed that after the course reform, the lateness or absenteeism rates of the students in Classes 2017, 2019, and 2020 were essentially around 6 %, down from the initial peak-level of 25 % (Class 2016). This result shows that the new teaching strategy significantly increased the students' attendance rate. The COVID-19 epidemic that occurred suddenly led to the Class of 2018 temporarily adopting a live broadcast course. The course had not been reformatted due to a number of unknowable reasons, therefore the analysis that follows will not include the class of 2018.
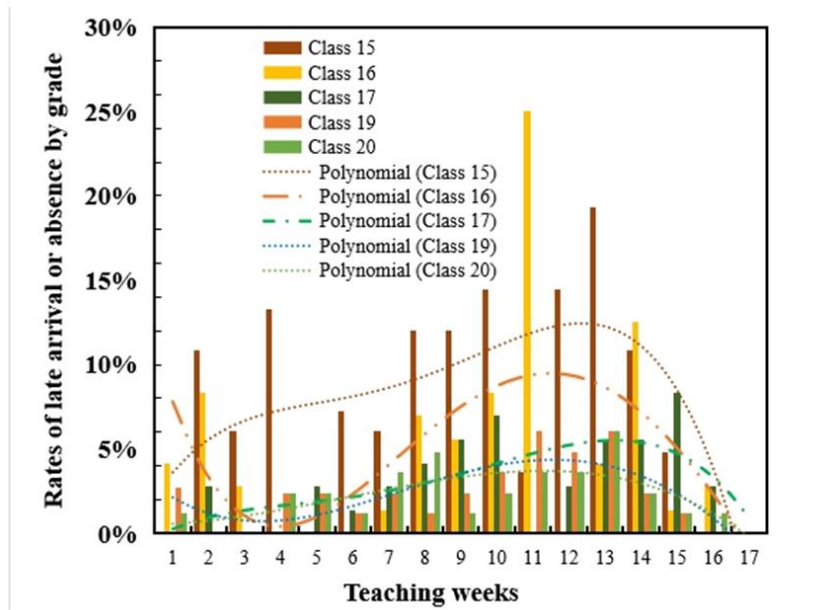

Figure 3. Trend of weekly lateness or absenteeism of students.

4.2. Analysis of Questionnaire-Survey Results

The results of course questionnaire surveys and interviews are shown in Fig. 4.It was discovered that, with 73.44% in Class 2017, 73.50% in Class 2019, and 74.60% in Class 2020, the students could essentially adjust to the modular teaching approach. At 69.38% in Class 2017, 71.86% in Class 2019, and 76.28% in Class 2020, a growing percentage of students believed they had attained the course's conceptual knowledge objectives. The percentage of students who believed they had attained the applied procedural knowledge goals of the course remained high. Every year, the percentage of students who acknowledged the value of the course's learning increased and stayed strong, reaching 92.19% in Class 2017, 81.36% in Class 2019, and 86.50% in Class 2020.
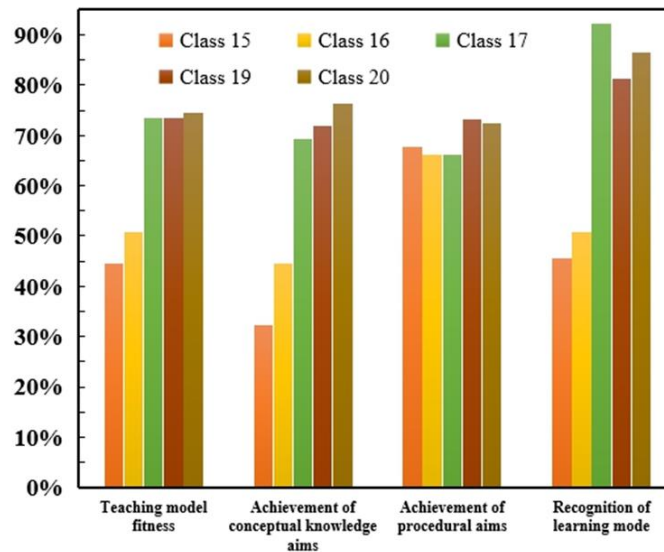
Figure4. Survey results of students' perceptual materials.

The students affirmed the effect, method, frequency, and overall difficulty of the staged test, and they believed that it could enhance their understanding and help them master the course knowledge, exercise the ability of team communication and cooperation, and improve their ability to correctly and fairly evaluate others' work.

4.3. Analysis of Students' Comprehensive Professional Capability

The students have produced more inventive ideas in recent years because to the innovation teams, academic mentors, and the combination of the class and competitions. An average of 18.85% of graduates over the past three years have been accepted into postgraduate. In the postgraduate Heat Transfer admission tests, our students frequently received high marks. A whopping 45% of the pupils hold jobs at significant energy-production companies like Datang and Huadian. Outstanding examples have emerged, such as Shijia Wang, a 2016 graduate who remained at the border of China for employment at the South Eight Immanuel Joint Station of Qinghai Oil Field, whose outstanding deeds were reported by mainstream media such as China National Radio. These achievements show that the comprehensive ability of the students has been improved by the course reform, and their employment rate and work quality have been steadily improved.

5. CONCLUSIONS

By making full use of information technology, the course-reform exercise in this study addressed flaws in the existing teaching method. Learning scenarios, course objectives, teaching materials, task environments, teaching methodologies, and examination procedures were all examined within the context of the course. The findings demonstrated that the students' comprehensive abilities and comprehensive capabilities were improved. To create a more adaptable and flexible hybrid teaching method in the face of an unexpected global health disaster (like the COVID-19 epidemic), we sought to put this novel teaching approach into practice and summarize it. The Heat Transfer course, one of the foundational courses for the degree in Energy and Power Engineering, is highly operable and conductive to the improvement of teaching quality.

Next, we plan to further deepen teaching innovation and practical levels, further explore and refine curriculum moral education elements, and improve feedback and evaluation mechanisms.

At the same time, we plan to gradually implement the promotion plan, improve the sharing mechanism of courses, and achieve the sharing and co-construction of high-quality teaching resources and advanced teaching methods.

DATA AVAILABILITY STATEMENT

All data used to support the findings of this study are included within the article.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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