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RESEARCH AND PRACTICE OF A BLENDED TEACHING MODE BASED ON SMALL PRIVATE ONLINE COURSES UNDER AN INFORMATIZATION BACKGROUND

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ABSTRACT

With the continuous development of information technologies, the pace of education informatization is accelerating increasingly. The traditional classroom-teaching mode cannot fully meet students' learning demands. 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. With the course of Heat Transfer as an example, this study expounds a blended teaching mode based on small private online courses (SPOC) on course aims, teaching contents, teaching methods, and evaluation approaches under the background of informatization. The results show that this teaching model 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

With the rapid development of artificial intelligence, Internet of things, the 5G network, and other technologies, every industry is changing. E-mails, E-commerce, E-government, and now e-education have all been part of the E-evolution or E-revolution. E-education, also known as online education, is altering our approach to teaching and learning[1]. Teachers attempt to combine advanced information technologies with teaching ideas by implementing many new measures such as massive open online course (MOOC), small private online course (SPOC), micro course, and inverted class to achieve digitization, networking, intelligentization, and multimedia in classroom teaching. As a result, an open-sharing, interactive, and collaborative learning environment can be created for students. Online education can be used as a supplement to traditional face-to-face teaching. In order to best meet the learning aims of the course, blended teaching, which is the most popular method of delivering courses in higher education[2], frequently combines face-to-face and online methods and technologies[3]. 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

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based on teaching theories and network/mobile intelligent technologies. In the post-MOOC era of mixed modern online teaching and learning models, such as SPOC, pMOOC (personalized MOOC), dlMOOC (deep learning MOOC), and so forth, MOOC had progressed through multiple stages of cMOOCs, hMOOCs, and xMOOCs[8, 9]. MOOC started in 2012. Since then, 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].

The increasingly obvious disadvantages of online education have prompted education experts from all over the world to analyze and reflect to gradually form two mainstream viewpoints: (1) online learning can achieve certain educational goals but cannot replace traditional classroom teaching; (2) online learning cannot replace school education but can greatly improve the goal and function of classroom teaching. These points of view laid a good foundation for the proposal and development of "blended learning", which referred to a combination of the advantages of traditional classroom teaching and network teaching[16], so as to obtain better teaching effects. The concept of blended learning was first proposed formally by Chinese scholars in 2004[17]. The purpose of blended learning is to combine traditional teaching and online teaching under the background of informatization to cultivate talents in applied innovations.

Heat Transfer is a subject on the law of heat transfer with a wide range of applications. It has become a basic technical course in many engineering-degree programs. This course is a core and specialized basic course in Energy and Power Engineering major. The students take this course in their early stage of specialized course learning. They need to transition from traditional theoretical-foundation courses to specialized courses. 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 practice of applying information technologies to carry out comprehensive and systematic teaching reform was very limited.

According to the teaching experience analysis accumulated for many years by the authors of this study, there are some problems in the traditional teaching mode of the *Heat Transfer* course in terms of teaching aims, 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.

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 creatively implemented the measure of "no suspension of learning during the absence of classroom teaching." The universities in China adopted the online teaching mode by fully utilizing online resources, teaching platforms, and information tools. These efforts forcibly overturned the traditional "face-to-face" teaching mode. As a part of the fight against the pandemic, online education not only accelerates the promotion of Internet-based information technologies to reshape the new form of education but also changes the teaching methods of teachers and the learning methods of students. Online education also promotes the transformation of the teacher’s role[30]. However, the sudden appearance of online education revealed many limitations. Faced with the cold information tools, students had difficulties entering into immersive learning. Specifically, they had problems of emotional-communication barriers, weak presence, and inadequate monitoring[31].

After the pandemic became stabilized, students returned to school and most teachers returned to classroom teaching. 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]. The blended teaching mode is characterized by function diversification of the course platform, diverse online resources construction, the autonomy and flexibility of students’ learning methods, the spatio-temporal extension of the teaching process, and multidimensional exam methods[33].

2.2. Information Technology Development

The rapid development of information technologies has a profound impact on all aspects of education. In recent years, education informatization in China has grown from a weak start to a strong presence. The information technology continuously promotes educational modernization, promotes reform and innovation of teaching modes, and extends the breadth and depth of education.

Information technologies enable the transition of educational responsibility from the government to individuals and their parents. People’s expectations regarding education have transitioned from aiming toward the full success of everyone to individualized development. Educational content has changed from subject knowledge to mastering the learning approach, and the educational method has changed from indoctrination to interaction. Likewise, educational evaluation has changed from examination to embedded evaluation, the place of education has extended from the school to everywhere, and the educational culture has changed from peer culture to mixed-age culture[34].

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[35].

Education informatization was stipulated for the first time at the third plenary session of the 18th CPC Central Committee. Its implementation requirements were detailed at the fifth plenary session of the 18th CPC Central Committee. The 19th National Congress of the Chinese Communist Party emphasized the importance of online education. In "The Outline of the 13th Five-Year Plan of National Economic and Social Development of the People’s Republic of China," eight major informatization programs were proposed. All of them were closely related to the development of education informatization. Under the guidance of the national policies, China’s Ministry of Education successively issued "The Ten-Year Development Plan for Education Informatization (2011-2020) "and "The 13th Five-Year Plan of Education Informatization, " and also jointly issued the "Notice on Several Key Tasks of Accelerating the Promotion of Education Informatization" with nine ministries. Seven key tasks have been deployed, including "three links and two platforms," full coverage of digital education resources at teaching locations, universal application of high-quality digital education resources, and application-capacity improvement of educational information technologies. 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.

On the teaching aspect, there was a lack of sufficient analysis on learning situations and effectiveness. The previous information-collection tool of learning situations and effectiveness was only one instrument with limited capabilities and lack of pertinence. The cognitive characteristics of the students were rarely considered in the analysis. There was also a lack of a feedback-iteration mechanism. The teaching aims were usually ambiguous. The teaching was carried out by experience mostly and lacked a systematic design. The teaching content did not keep pace with the times. There are many crossover contents between the *Heat Transfer* course and other disciplines. The obsolete content cannot satisfy the requirements of new engineering education. The previous teaching style was tedious in assignments, and the students of different levels were taught the same content and assigned the same homework without sufficient differentiation. Such a teaching style is not conducive to the personalized development of students. The teaching method was outdated, with too much indoctrination in the traditional classroom and without in-depth communication between the teacher and students. The students passively accepted knowledge without independent thinking and innovation capabilities. The examination method was not sufficiently diverse. The final test and too many conceptual questions were used in the traditional teaching. They affect effective implementation of teaching aims and depress the students’ learning enthusiasm.

On the learning aspect, the students have a good cognitive capability to think, question, and explore. However, their self-learning ability and learning retention were poor. They need to strengthen their advanced thinking and innovation capabilities. There are great differences between different students in their cognitive and learning abilities.

Therefore, to solve the problems of the traditional teaching mode, it is necessary to adapt to the requirements of the new era and government to realize the integration between information technologies and traditional education. 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. Study groups need to be arranged according to the differences in the students' cognitive levels and learning abilities. Precisely refined teaching aims are assigned for different study groups to reasonably organize the teaching contents. The teaching tasks are tailored for different students. The students' learning behaviors are paid great attention. This approach can ensure that each student meets the basic teaching aim and encourage outstanding students to obtain advanced capabilities through extended learning and tailored guidance.

It is necessary to teach both the learning approach and the subject knowledge by open teaching. The "learning approach" refers to a combined capability of learning, research, and practical problem - solving. The teaching task should be designed to have reasonable aims and contents to cultivate students' open thinking and innovative capabilities.

It is necessary to insist on iterative feedback and strengthen the "dual loops" for continuous improvement. According to the concept of iterative feedback, the learning situation and effect analysis were promoted in stages with timely adjustment and optimization of teaching contents, tasks, and methods. The effects of learning situations and teaching aims were evaluated via feedback based on comprehensive assessment. A dual-cycle continuous-improvement mechanism was established to focus on the following two parts: the cycle of evaluation, feedback, and improvement in the class as a focus; the same cycle before and after the class as mutual support. This mechanism can continuously and iteratively optimize the entire teaching process to achieve consistency in teaching aims, activities, and evaluations.

3.2. Innovative Methods and Paths

In the current information era, the course team followed Бабанский's teaching optimization theory, Taylor's curriculum theory, and Bloom's taxonomy of educational aims. Social constructivism and humanism were also integrated into the course of *Heat Transfer* as teaching philosophies. A "1-5-6" teaching mode was constructed and implemented. This teaching mode emphasized the importance ofthe 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. "1" Center

Student growth was treated as the focal point of the new teaching approach. The students were classified to receive differentiated guidance with continuously optimized teaching goals, contents, tasks, and methods. In this way, the students with poor learning capabilities and weak foundations can meet the course requirements. Meanwhile, the students with strong learning capabilities can acquire advanced abilities.

3.2.2. "5" Combinations

In order to achieve the teaching aims, this course was designed to highlight the following five combinations: (1) the integration of classroom teaching and ideological and political education; (2) the combination of online and offline teaching; (3) the combination of theory and practice; (4) the combination of independence and cooperation; and (5) the combination of the process and the outcome. The goal is to create a new situation in which the students want to learn, and are able to learn.

3.2.3. "6" Optimized Elements

- Staged-learning situation and effect analysis

The traditional analyses of learning situations and effectiveness lack pertinence and feedback-iteration mechanism. Before the class, staged analysis was implemented in the teaching reform to analyze the students' cognitive levels, knowledge reserve, learning habits, methods, and tools. The learning motives, willingness, and expectations were also analyzed for targeted screening and design of teaching aims and contents. During the class, the students' participation, performance, questions, and encountered difficulties were analyzed to optimize the teaching process and adjust teaching strategies in a timely manner. After the class, the consistency of "goal-activity-evaluation" of the course was analyzed by using actual data and qualitative materials to evaluate the reliability, validity, and objectivity of assessment tools. The students' capability enhancement was also analyzed to facilitate the next iteration of curriculum reform.

Based on an analysis of the completion of factual and conceptual knowledge aims, the course team discovered that students' understanding of knowledge such as categories, principles, and models was not well mastered during the learning process, which could be attributed to students' generally low cognitive level. According to the analysis of the completion of procedural and metacognitive knowledge aims, it is discovered that procedural and metacognitive aims include cognitive processes in which students perform poorly, which reflects the students' lower actual cognitive level and has an impact on the realization of relevant cognitive aims.

- Precise teaching-target design

Due to the lack of systematic design and fuzzy teaching aims in the traditional teaching approach, precise target design was carried out through an analysis of the cognitive process and knowledge dimensions (as shown in Fig. 1). The core conceptual knowledge aim was emphasized in teaching to adapt to the students' actual cognitive levels. Applied procedural knowledge and metacognitive 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.

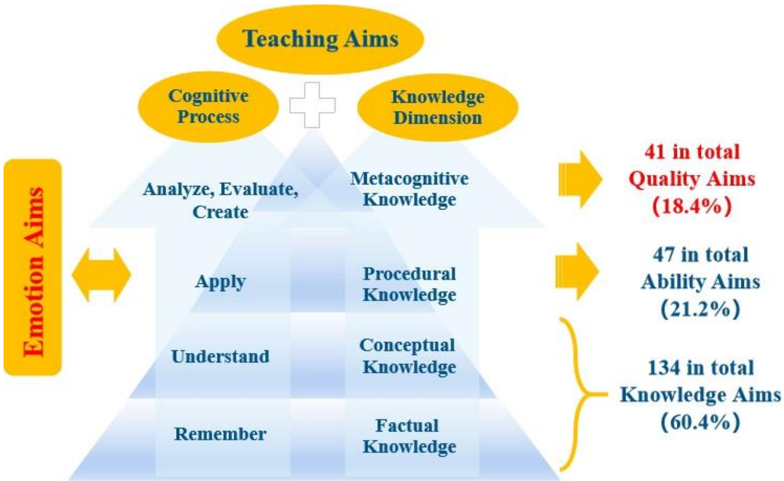

Figure 1. Pyramid of Teaching Aims

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

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

According to the actual cognitive levels of local undergraduate students and training aims of professional talents, the teaching contents were selected and organized based on the epochal curricular characteristics and the requirements of new engineering education. The course was divided into four main teaching modules to clearly define key and difficult contents (as shown in Table 2). At the end of each module, a corresponding staged test and review sessions were arranged. Each class included three parts: pre-class, in-class, and post-class (as shown in Table 3) . Through various stages of efforts, the teaching content was organized to achieve the standards of Golden Course.

Table 2. Key and difficult contents and module division of Heat transfer course

Teaching Module	**Teaching Content**	**Number of Key Content**	**Number of Difficult Content**	**Class Hour Of New Theoretical Course**	**Periodic Review Module**	
Fundamentals of Heat Transfer	Chapter 1: Basic modes and analysis methods of heat transfer	10	7	6	**4**	**2 General Revision**
Heat conduction theory	Chapter 2: Steady state heat conduction	10	5	6		
	Chapter 3: Unsteady heat conduction	10	6	4		
	Chapter 4: Numerical solution of heat conduction problem	6	0	2		
Convective heat transfer theory	Chapter 5: Theoretical basis of convective heat transfer	5	4	4	**4**	
	Chapter 6: Experimental correlation of single-phase convective heat transfer	13	5	6		
	Chapter 7: Phase-change convective heat transfer	7	2	4		
Radiation heat transfer theory and heat transfer analysis	Chapter 8: Basic laws of thermal radiation and radiation characteristics	10	2	4	**4**	
	Chapter 9: Calculation of radiant heat transfer	10	2	4		
	Chapter 10: Analysis of heat transfer process and overview of heat exchanger	5	2	2		
Total		86	35	56		

- Hierarchical teaching-task setup

Different students have different cognitive levels and learning capabilities. 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 3 and 4).

Table 3.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

Table 4. Hierarchical tasks, feedback, and guidance

Modular	Specific Content
Inquiry Learning	· Standard answer questions for key knowledge (Compulsory Question) · Extensive non-standard answer questions (Optional Question)
"Concept Mind Map" Homework	· Basic Tasks: compulsory completion, self-evaluation and mutual evaluation score · Challenge Tasks: optional completion, teacher evaluation, flexibility of the homework plus points
Online Discussion	· Discussion Topics: Difficulties and Extensive Conceptual Knowledge · Free Discussion: Extensive Reading Materials - An Introduction to Frontier and Hot Issues
Periodic Review Module	Review and Answer Course · Key Conceptual Knowledge Aims and Procedural Knowledge Aims (for all students)
	Phased closed-book test · Main procedural knowledge aims and partial metacognitive knowledge aims (for all students)
	Exercise class · Targeted guidance on typical problems and errors encountered in exercises and phased tests (for all students) · Answer-rush and answer-type interaction on key conceptual and procedural knowledge with high error rates (for students who have achieved 50% of the final grade in the phased tests)

- Implementation of diversified teaching methods

The course mainly adopted the SPOC form and targeted learning characteristics of the university students in the new era with full utilization of information tools. The course deeply integrated the teaching method, demonstration method, flipped-classroom method, PBL (Project-Based Learning), BOPPPS, case-teaching approach, and collaborative tasks to stimulate the students' learning enthusiasm and improve learning effects. For example, through introducing cases such as drying quilts in winter and fogging glasses in daily life, as well as hot issues such as the greenhouse effect, we try to combinie obscure knowledge with real life to concretize abstract issues.

- Comprehensive evaluation of the entire process

The process examination was strengthened. The final tests, which were intensively crammed for, no longer determined the final course score. Attention was paid to the diversity and collaboration of the evaluated subject, so as to give the learning process a sense of participation, investment, gain, and improvement. The final course-score included a process examination score of 60 %: class attendance score of 10 %, homework assignment with non-standard answers of 20 %, and staged tests' flexible score of 30 %. The staged tests' flexible scores were included in the process-examination scores, with 60 points as a cap and 0 points as the minimum. It was composed of learning tasks of the new theory course, a self-assessment questionnaire before and after each teaching chapter, voluntary submission of homework assignments, online Q & A and discussion, racing answer in the staged review class, and racing answer in staged homework. The final test score accounted for 40 %. It adopted a closed-book form and had a certain number of questions without standard answers that attempt to test the capability of analyzing and solving practical problems.

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." This course was offered from 2014 to 2022 to the students majoring in Energy and Power Engineering as a core specialty course at the authors' university. In 2013, the course team began to explore the teaching pattern of combining offline teaching with interactive tools. In 2015, the course team cooperated with Leon Eco-Energy Company to establish an order class and explore the implementation of case teaching with enterprise engineers. After the preliminary attempt of reform, the course team adopted an innovation group and an academic tutor system in 2017 to explore the integration of class and competition to encourage students to participate in competitions and teachers' scientific-research projects. Since 2018, the course team implemented a pattern of "SPOC + Chaoxing" to mix the online and offline teaching modes. After continuous reform, significant improvements were achieved, which are detailed as follows.

4.1. Analysis of Student Course Learning Effect

4.1.1. Analysis of the Effect of Achieving Cognitive Aims

The overall scores are shown in Fig. 2, where Class 2016 had a merged class, with students coming from different classes. And Class 2018 used 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.

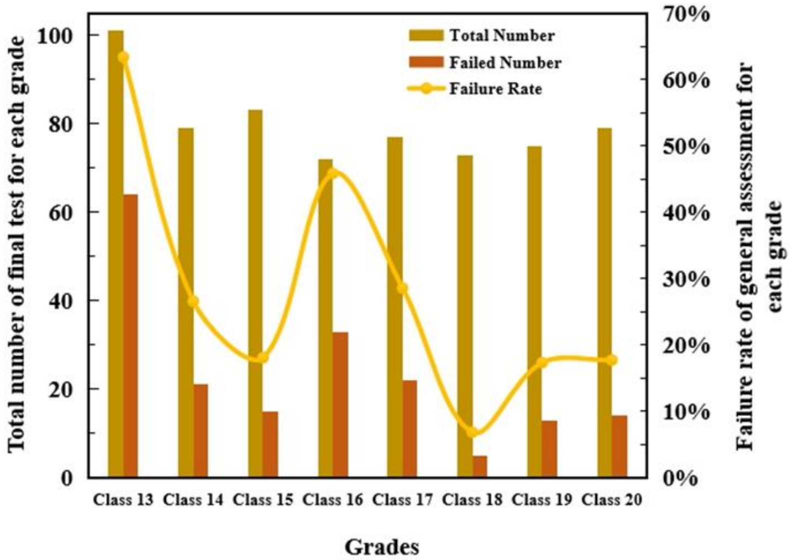

Figure2. Failure rate of general assessment for each grade of *Heat Transfer*

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

"Aim - Activity - Evaluation". As shown in Fig. 3, the statistical differences in the score samples of Class 2013 to Class 2020 in 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.

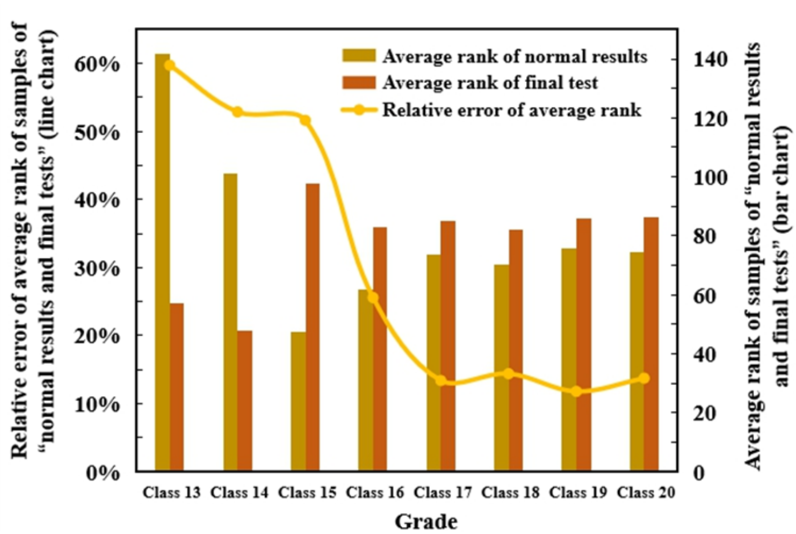

Figure 3. Relative errors of the average rank of normal results and final test scores.

4.1.3. Analysis of Improvement Effect on Emotional Aim Achievement

As shown in Fig. 4, the attendance data showed that the lateness or absenteeism rates of the students of Classes 2017, 2019 and 2020 were basically controlled below 6 % after the course reform, reduced from the original peak-level of 25 % (Class 2016). This effect indicates that the students' attendance rate was effectively improved by the new teaching approach. Due to the sudden outbreak of the COVID-19, Class 2018 temporarily adopted live broadcast course. Under many unknown factors, the course had not been reformed, so Class 2018 will not be analyzed in the following analysis.
(2)

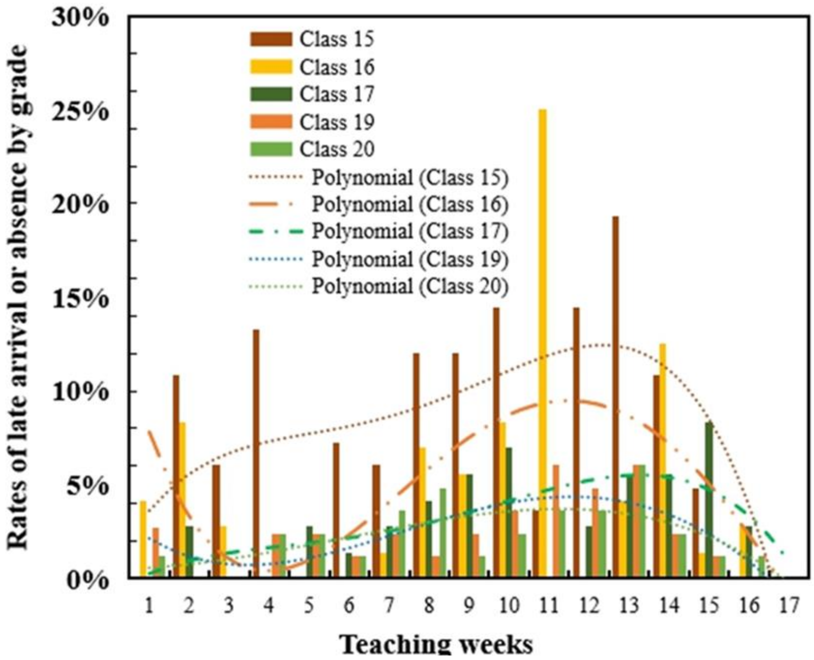

Figure 4. Trend of weekly lateness or absenteeism of students.

4.2. Analysis of Questionnaire-Survey Results

The results of course questionnaire surveys and interviews are shown in Fig. 5. It was found that the students could basically adapt to the modular teaching mode with 73.44 % in Class 2017, 73.50 % in Class 2019 and 74.60 % in Class 2019. The proportion of the students who thought they had achieved the course's conceptual knowledge aims continuously increased, reaching 69.38 % in Class 2017, 71.86 % in Class 2019 and 76.28 % in Class 2019. The proportion of the students who thought they had achieved the course's applied procedural-knowledge aims remained high. The proportion of the students who recognized the course's learning value improved every year and remained at a high level, reaching 92.19 % in Class 2017, 81.36 % in Class 2019 and 86.50 % in Class 2019.

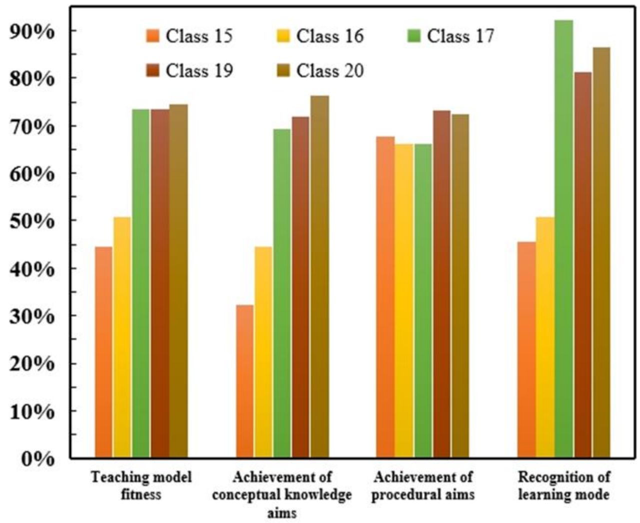

Figure 5. Survey results of students' perceptual materials.

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

Through innovation teams, academic tutors, and integration of the class and competitions, the students have completed more innovative projects in recent years In the past three years, an average of 18.85 % of the graduates have been admitted to postgraduate programs. High scores were frequently obtained by our students in the past two years' postgraduate admission exams of Heat Transfer; for example, two students achieved a score of 149 out of 150 on the exam. Approximately 45 % of the students have been employed by large energy-production enterprises such as 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. Bing Fan is another excellent example — a 2015 graduate who was named "Ten People of the Decade" of Leon Ecological Energy Co., Ltd. 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

The course-reform exercise in this study addressed deficiencies in the previous teaching process by fully utilizing information technologies. Within the context of the course, learning situations, course goals, teaching contents, task settings, teaching methods, and examination approaches were studied. The results showed that the students' learning effects and comprehensive capabilities were enhanced. We tried to practice and summarize this innovative teaching mode, so as to develop a more adaptive and flexible hybrid teaching method in the context of an unprecedented global health crisis (such as COVID-19 epidemic). The proposed new teaching mode is highly operable and conducive to the teaching-quality improvement of the basic courses represented by Heat Transfer course in the degree of Energy and Power Engineering.

AUTHOR CONTRIBUTIONS

Data curation, Zhuoqun Lu, Yan Li; Investigation, Zhuoqun Lu, Yan Li; Methodology, Heyun Liu; Project administration, Yan Li, Heyun Liu; Writing-original draft, Yan Li; Writing-review & editing, Yan Li, Heyun Liu.

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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.

REFERENCES

[1] S. C. J. Palvia, "Editorial preface article: E-evolution or e-revolution: E-mail, e-commerce, e-government, e-education,". vol. 15: Taylor & Francis, 2013, pp. 4-12.
[2] B. Alexander, K. Ashford-Rowe, N. Barajas-Murphy, G. Dobbin, J. Knott, M. McCormack, J. Pomerantz, R. Seilhamer, and N. Weber, "EDUCAUSE Horizon Report: 2019 Higher Education Edition.," Educause, 2019.
[3] D. R. Garrison and N. D. Vaughan, Blended learning in higher education: Framework, principles, and guidelines: John Wiley & Sons, 2008.
[4] T. C. Reeves and P. M. Reeves, "Designing online and blended learning," in University teaching in focus: Routledge, 2012, pp. 112-127.
[5] P. Paudel, "Online Education: Benefits, Challenges and Strategies During and After COVID-19 in Higher Education," International Journal on Studies in Education, vol. 2, pp. 70-85, 2021.
[6] N. L. Davis, M. Gough and L. L. Taylor, "Online teaching: advantages, obstacles and tools for getting it right," Journal of teaching in travel & tourism, vol. 19, pp. 256-263, 2019-01-01 2019.
[7] A. D. Dumford and A. L. Miller, "Online learning in higher education: exploring advantages and disadvantages for engagement," Journal of computing in higher education, vol. 30, pp. 452-465, 2018.
[8] Z. Zhu and M. Liu, "New style of online learning in post MOOC period," Open education research, vol. 20, pp. 36-43, 2014.
[9] J. Zhang and Y. Peng, "Construction and reflection of three-dimensional teaching materials in Colleges and universities in the post MOOC era," Education review, vol. No.229, pp. 142-145, 2018.
[10] S. Palvia, P. Aeron, P. Gupta, D. Mahapatra, R. Parida, R. Rosner, and S. Sindhi, "Online Education: Worldwide Status, Challenges, Trends, and Implications," Journal of global information technology management, vol. 21, pp. 233-241, 2018-01-01 2018.
[11] Y. Kang, "An Analysis on SPOC:Post-MOOC Era of Online Education," Educational Research of Tsinghua University, vol. 35, 2014.
[12] F. Scherjon, I. Romanowska and K. Lambers, "Digitally Teaching Digital Skills: Lessons Drawn from a Small Private Online Course (SPOC) on ‘ Modelling and Simulation in Archaeology ’ at Leiden University,"Journal of Computer Applications in Archaeology, vol. 2, pp. 79-88, 2019.
[13] T. Goral, "Make way for SPOCS: small, private online courses may provide what MOOCs can’ t," University business, vol. 16, p. 45, 2013.

[14] R. Hoffman, "MOOCs-Best Practices and Worst Challenge,". vol. 2013, 2013.
[15] S. Coughlan, "Harvard plans to boldly go with'Spocs'," BBC News, vol. 24, 2013.
[16] C. Zhang, J. Shen and L. Qi, "Educational Reform of Optical Fiber Communication System in Flipped Classroom based on SPOC," China Educational Technology and Equipment, pp. 101-103, 2018.
[17] K. He, "Viewing the New Development of Educational Technology Theory from Blending Learning (Part 2)," E-education Research, pp. 22-26, 2004.
[18] J. R. Bryson and L. Andres, "Covid-19 and rapid adoption and improvisation of online teaching: curating resources for extensive versus intensive online learning experiences," Journal of geography in higher education, vol. 44, pp. 608-623, 2020-01-01 2020.
[19] A. Aristovnik, D. Keržič, D. Ravšelj, N. Tomaževič, and L. Umek, "Impacts of the COVID-19 Pandemic on Life of Higher Education Students: A Global Perspective," Sustainability, vol. 12, p. 8438, 2020-10-13 2020.
[20] T. Karakose, "The impact of the COVID-19 epidemic on higher education: Opportunities and implications for policy and practice," Education process: international journal, vol. 10, pp. 7-12, 2021-01-01 2021.
[21] D. Turnbull, R. Chugh and J. Luck, "Transitioning to E-Learning during the COVID-19 pandemic: How have Higher Education Institutions responded to the challenge?" Education and Information Technologies, vol. 26, pp. 6401-6419, 2021.
[22] S. Pokhrel and R. Chhetri, "A Literature Review on Impact of COVID-19 Pandemic on Teaching and Learning," Higher Education for the Future, vol. 8, pp. 133-141, 2021-01-01 2021.
[23] T. K. Burki, "COVID-19: consequences for higher education," The Lancet Oncology, vol. 21, p. 758, 2020-01-01 2020.
[24] B. Wei, "COVID-19 and online teaching in higher education: A case study of Peking University,"Human Behavior and Emerging Technologies, vol. 2, pp. 113-115, 2020.
[25] C. M. Toquero, "Challenges and opportunities for higher education amid the COVID-19 pandemic: The Philippine context.," Pedagogical Research, vol. 5, 2020.
[26] P. K. Jena, "Impact of Covid-19 on higher education in India," International Journal of Advanced Education and Research (IJAER), vol. 5, 2020.
[27] T. Agasisti and M. Soncin, "Higher education in troubled times: on the impact of Covid-19 in Italy,"Studies in higher education (Dorchester-on-Thames), vol. 46, pp. 86-95, 2021-01-01 2021.
[28] N. Stukalo and A. Simakhova, "COVID-19 Impact on Ukrainian Higher Education," Universal Journal of Educational Research, vol. 8, pp. 3673-3678, 2020.
[29] O. Zawacki Richter, "The current state and impact of Covid - 19 on digital higher education in Germany,"Human Behavior and Emerging Technologies, vol. 3, pp. 218-226, 2021.
[30] Y. Luo and X. Yang, "Discuss "Digitalization Transformation" of Higher Education in the Informatization Era —— Talking about the Possibility of Absolute Innovation from Traditional Universities to "Digitalization Universities"," Beijing Education, pp. 8-14, 2020-08-10 2020.
[31] Z. Zhong, L. Huang, Y. Fan, and L. Song, "Distance Education: Present Situation, Challenge and Development —— An Interview with Professor Michael G. Moore," China Educational Technology, pp. 14-18, 2014.
[32] Z. Zhu and J. Hu, "Technology Enabled Post-Pandemic Educational Transformation: New Patterns of Online-Merge-Offline (OMO) Schooling," Open Education Research, vol. 27, pp. 13-23, 2021.
[33] Y. Tan, "The basic characteristics and implementation strategy of blending teaching mode," Chinese Vocational and Technical Education, pp. 5-9, 2018-11-11 2018.
[34] A. Collins and R. Halverson, Rethinking education in the age of technology: The digital revolution and schooling in America: Teachers College Press, 2018.
[35] C. Lei, "Education Informatization: From the Version 1.0 to 2.0," Journal of East China Normal University (Educational Sciences), vol. 36, pp. 98-103+164, 2018.