Reform and Practice of Data-Driven Blended Teaching:Taking Automatic Control Theory Course for Example

Shengping Zhao[1,a],Yali Su[2,b],Xiuxian Yin[2,c],Jingrui Li[3,d*],Pingzhen Zhang[1,e]

{[a]zsp4321@163.com,[b] yxsyl@yxnu.edu.cn,[c] yinxiuxian@yxnu.edu.cn,[d] papernew@163.com,
[e] zpz@yxnu.edu.cn}

Yuxi Normal University,school of physics and electrionic engineering,Yuxi,Kunming,China[1]
Yuxi Normal University,school of Mathematics and Information Technology,Yuxi,Kunming,China[2]
Honghe University,school of Engineering, Mengzi, Honghe,China[3]

Abstract: In the context of the construction of new engineering disciplines, blended learning serves as an important breakthrough and reform direction for enhancing the integration, practicality, and advanced nature of courses. However, due to the differences in institutional and student contexts, local undergraduate institutions cannot simply adopt existing mature solutions and reform measures. Based on the specific situation and conditions of Yuxi Normal University, this paper conducts an in-depth analysis of the problems in talent cultivation. Taking the course “Automatic Control Theory” as an example, it carries out teaching reform practices and proposes a “Three-Dimensional Six-Step” blended learning reform with a “Three-Dimensional” teaching concept and a “Six-Step” blended learning design. Firstly, the Feynman learning method (CTRS) and the Outcome-Based Education (OBE) are utilized to integrate practice with theory and achieve effective integration between online and offline learning. Secondly, a comprehensive and continuous evaluation mechanism is designed to monitor the learning process. Additionally, the assessment of ideological and political education is emphasized, highlighting the importance of collaborative and interactive ideological and political education between teachers and students. Finally, by comparing the learning outcomes of three classes in 2018, 2019, and 2020, the feasibility and effectiveness of this reform approach have been demonstrated.

Keywords: blended teaching; teaching design; full-cycle autonomous; teaching reform

1 Introduction

Since the Massachusetts Institute of Technology (MIT) put forward "Engineering education has entered a period of rapid and fundamental change" [1],in its report on "The Status of the Development of Global First-Class Engineering Education", in-depth discussions and researches have been carried out at home and abroad in the field of engineering education and the construction of engineering disciplines. The "Fudan Consensus" on the construction of "new engineering science" reached in 2017 is a milestone in the construction of new engineering science in China, after the "Tianda Action", After a series of measures such as the "Tianda Action" and the "Beijing Guidelines", a consensus on the concept of "New Engineering Science" has been formed, the construction of "New Engineering Science" has been deepened,

ITEI 2023, November 24-26, Zhengzhou, People's Republic of China

DOI 10.4108/eai.24-11-2023.2343545

and universities and regions are actively carrying out the construction of "New Engineering Science"[2]. All universities and regions are actively carrying out the innovation of "New Engineering Science" and promoting its comprehensive construction and development, gradually forming the official "Chengdu Electricity Program", "Plan F", "Tianda Program", etc. for the construction of "New Engineering Science", realizing the "New Engineering Science" concept and the "New Engineering Science" concept. Program", etc., realizing the transformation from ideological initiatives to strategic goals, and then to the enhancement of standards and initiatives. Among them, what is common is "results-oriented, competence-centered", as well as the thinking on breaking down the barriers of professional division and realizing cross-integration of disciplines, emphasizing that in practicing the construction of "new engineering", the integration with modern information technology should be strengthened, and "Internet + education" should be developed. Internet + Education", "Intelligence + Education", accelerate the application of network platforms, virtual simulation experiments, artificial intelligence (AI) and other technologies in the construction of the curriculum, so that blended teaching becomes the "new normal". ". In addition, the Horizon Report 2022 (Teaching and Learning Edition) also re-emphasizes the development trend of blended and online learning and its important role in modern education[3].

MOOC was first proposed in 2005, and 2012 is the first year of MOOC, online courses have attracted attention from all over the world, and a wave of MOOC research and practice has been set off in China[4-7]. Online courses have brought great changes to higher education, and a variety of online learning platforms, such as edX, Udacity, and Xaitang Online have emerged. Online courses have brought great changes to higher education. The flexibility and openness of catechism learning "anytime, anywhere" helps to promote learning from teacher-centered to student-centered transformation [4], but there are shortcomings such as the reduction of teacher-student interactions and the lack of targeted online course design [8]. In recent years, the blended teaching of online self-study and offline flip has been proposed, and it has become the "emergency distance learning" method used in the pandemic, which has accumulated rich practical experience for online teaching and blended teaching. St. Mary's University School of Law established the first online J.D. program in 2022, which was recognized by the Bar Association, and a total of 791 applicants applied for the program that year, proving the interest and demand for online learning among learners.

2 The Problems Existing in the Teaching Process

2.1 Problems in the Practice of Blended Learning

1.The advantages and disadvantages of traditional teaching are obvious

The offline course design and teaching of blended teaching is still dominated by traditional didactic teaching, and it is necessary to deeply analyze the advantages and disadvantages of the traditional teaching methods, make the best use of the strengths and avoid the weaknesses, and combine the teaching content and teaching objectives with the online learning to carry out a practical blended teaching design [9-10].

2.Teaching resources are not targeted enough

The online learning resources of blended teaching are mainly video and e-book learning, and the

form of teaching resources is single, so it is necessary to deepen the development of course resources in combination with the learning situation and optimize the presentation of pre-course learning materials [11]. In addition, the tracking and analysis of pre-course learning effect is insufficient, and the connection between online and offline learning is not smooth enough [11]. How to ensure the mastery of basic knowledge and focus on the cultivation of higher-order thinking in the design of online and offline resources is a key problem to be solved.

3. Blended teaching "superficiality"

Domestic blended teaching research on online courses, pre-course learning design in detail less or unclear description [12]. The content of each teaching link is rich and "fancy", students are easily "tired to deal with", the actual depth of participation is not enough, but become a learning burden. At the same time, the impact of online learning on offline classroom teaching is not sufficiently analyzed.

2.2 Analysis of the Learning Situation

This paper takes the teaching reform of "Automatic Control Theory" course as the background to analyze the academic situation and reform practice. The course is highly theoretical and has many knowledge points, which is a core course that integrates basic knowledge and the theoretical foundation of engineering, and it is a higher-order course that connects the theory of engineering and the application of engineering practice. Take the lectures of the "Automatic Control Theory" course in our university in the past five years to be analyzed:

1.The pass rate of the main prerequisite courses is between 75% and 90%, and the course excellence rate is around 10%. It can be seen that the students' mathematical foundation and related theoretical foundation are not solid.

2. From the results of one employment intention statistics, 22.42% of the students chose to go on to higher education, but the rate of achievement is only about 5%. Professional related direction employment rate is only 45.26%, civil servants, institutions, special teachers and other test employment accounted for 32.31%, according to the data of previous years statistics graduation year did not succeed in the test flexible employment continue to prepare for the test accounted for 6.73% of students. From these data, it can be seen that students do not have enough knowledge about their majors and their career planning is not clear.

3 Data-Driven "Three-Dimensional Six-Step" Blended Teaching Reforms

After nearly five years of pedagogical reform and practice, the "Three-Dimensional Six-Step" blended teaching model has been formed. From the three dimensions of knowledge, ability and quality, the course objectives were reformulated to form a "Three-Dimensional" teaching concept, and correspondingly put forward the "Six-Step" hybrid teaching design method,together guarantee the vividness and flexibility of teaching, learning and assessment, the solidity of the results-oriented talent cultivation, and the principle of moral education.

3.1 The "Three-Dimensional" Teaching Concept

In the knowledge dimension, adhere to the principle of student-centeredness, use CTRS and OBE to organically integrate engineering practice and self-directed evaluation into student-centered course teaching, and drive teaching reform with teaching innovation:

1.Organically apply the concepts of CTRS and OBE to the learning process of information input-cognitive processing-integration and output, break through the traditional classroom teaching, restore the essence of the learning process, guide students to participate actively, and realize the transformation to student-centeredness.

2. Based on the consolidation of professional knowledge and enhancement of professional cognition, students are guided to develop their thoughts and abilities, and college students' scientific and technological projects and disciplinary competitions are the main ways to help students gradually become lifelong learners.

3. Exercise knowledge migration ability with the help of practice platform, from textbook theory to on-site practice, to help the cultivation of application-oriented talents.Utilize the multi-information platform for student learning evaluation, break through the limitations of time and place, and build a full-cycle evaluation mechanism. Let students become the leader and judge of learning through self-assessment and mutual assessment, forming a full-cycle autonomous learning evaluation.

Achievement-oriented cultivation of application-oriented talents to meet the development requirements of "New Engineering" in the dimension of competence:

1.Guided by the integration of multiple disciplines, reflecting the concept of "Automation +" in teaching, introducing engineering cases to make the boring theoretical courses meaningful, reflecting the gradual and holistic nature of the course, and constructing a library of cases as a comprehensive design topics for students to choose and study.

2. Break through the single correspondence between laboratory and curriculum, fully mobilize and utilize the experimental resources, expand the practical application platform for students, promote the understanding, migration and application of knowledge, and ultimately achieve the unity of cognition and behavior; break through the "limitations" of schools and teachers with the help of collaborative cultivation, and show students a broader vision of the career and professional practice, and train students to adapt to future professional development. It also helps students break through the "limitations" of schools and teachers through collaborative education, showing them a broader professional vision and professional practice, and cultivating their vocational ability to adapt to future professional development.

In the quality dimension, emphasizing the principle of students' moral education, strengthening the construction of the course's ideology and politics, realizing the organic integration of the course and ideology and politics, and strengthening the sense of students' participation, so as to make students become the main body of the course's ideology and politics:

1. The complex and changeable environment of engineering application practice is a great test for the safety awareness, professional ethics and ability value of engineers. Moral education penetrates deeply into the teaching and learning process of the curriculum through the construction of Curriculum Ideology and Politics.

2.In order to strengthen students' participation, the Curriculum Ideology and Politics assess Module is added, which not only can grasp the students' moral education more accurately, but also provides data support for the reform of the Curriculum Ideology and Politics, so that the students gradually become the main body of the Curriculum Ideology and Politics.

3.2 "Six-Step" Blended Instructional Design

Combining the online classroom with the full use of information technology teaching means, integrating the concepts of CTRS and OBE into the teaching practice, and completing the teaching design through six student-centered steps: ① initial exploration of the case → ② independent learning → ③ seminar learning → ④ experimental practice → ⑤ post-course consolidation → ⑥ comprehensive design, as shown in Fig. 1.

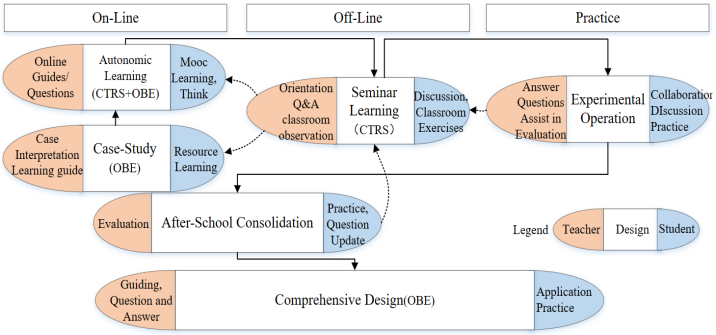

Fig. 1 "Six-Step" blended instructional design

The "Six-Step" blended teaching design specifies the design content and theoretical support of online, offline and practical modules, and specifies the specific behaviors of teachers and students. First, online independent learning and offline seminars form a complete closed loop of CTRS teaching. Then, in the experimental practice to complete the learning and application of practice, at the same time, the decomposition of engineering cases throughout the course learning, and finally through the comprehensive design of "progressive" practice, "advanced" learning, to realize the integration of OBE theory.

In this process, real-time student learning data are collected through the feedback of full-cycle evaluation data to assist teachers in timely adjustment and improvement of teaching design, forming a virtuous cycle. In summary, based on the "Six-Step" blended teaching, we have accomplished the three-dimensional learning design of online, offline, before class, during class and after class, which is student-centered.

4 Data-Driven "Three-Dimensional Six-Step" Blended Teaching Practice

4.1 Preparation of Teaching Resources and Design of Course Content

In the course, the national high-quality course textbook "Principles of Automatic Control" was chosen as the main reference material, and some teaching content of the course was deleted

according to the actual situation of the school situation and learning situation. We designed a case and decomposed it throughout the course teaching, combined the professional research hotspots and teachers' scientific research to form a course case base, and built a complete online course by using Super Star Pan-Asia platform, relying on the online course to carry out rich self-study, seminars, online discussions, project reports, literature sharing, etc. before class.

Comprehensive course characteristics and knowledge structure, the course content is decomposed into four modules: basic principles, mathematical modeling, comprehensive performance analysis, system design and correction, and clearly defined online and offline learning content, online self-study of basic knowledge, focusing on consolidating the foundation, offline learning to check the online learning effect, application analysis, focusing on the application of the ability to improve. At the same time, the analysis and design of single-capacity tank level control system tasks are decomposed against the course content throughout the course of study, and the course content is linked through practical cases, which not only visualizes the abstract concepts, but also clarifies the practical tasks. Finally, the difficulty of the practical case is upgraded to carry out the analysis and design of double-capacity water tank level control system, which can subsequently be docked to the programmable control, process control and other laboratories for hardware implementation and verification. The cross-relation between the course content and the practical case tasks is shown in Table1.

Table1 Course content decomposition and case task comparison

Course Content Decomposition			**Case Task**	
Course Content	On-Line Learning (solid foundation)	Off-Line Learning (application)	Project (practice)	Single Water Tank Control System
Basic principle	Basic concept	Concept application System analysis	Task 1 (10 points)	Single water tank level system analysis Drawing the system structure
Mathematical model	Differential equation Typical connection simplification System transfer function	Transfer functions Atypical connection simplification Diverse transfer functions	Task 2 (15 points)	Analyze the system transfer function
Performance analysis	Typical link time domain/root trajectory /Bode plo/Naïve's diagram analysis	Engineering case time domain/ root trajectory /frequency domain analysis	Task 3 (20 points)	Time domain analysis Frequency domain analysis
System design & calibration	Basic concept	Engineering applications	Task 4 (25 points)	Controller design
Summary and application			Task 5 (30 points)	coupled-tanks control system

4.2 Full-Cycle Autonomous Learning Evaluation

Utilizing the multi-information platform to build a full-cycle evaluation mechanism for learning evaluation not only adapts to the characteristics of blended teaching and learning time and location flexibility, but also enhances the participation of students in course evaluation, so that students become the leader and judge of learning.

Teaching evaluation comes from both online and offline, and the full-cycle evaluation corresponds to the "Six-Step" teaching design, as shown in Table 2, which gives the detailed assessment indicators, evaluation objectives and percentages.

Table 2 Full-Cycle Evaluation

Evaluation source	Evaluation link	Subject of evaluation	Evaluation objective	Index	Proportion
On-Line	Case-study	Mutual-evaluation	Autonomic learning	Group discussion Ideological and political tasks	5%
	Seminar learning	Teacher evaluation		On-line learning Pre-class test	
	Discussion learning	Teacher evaluation	Knowledge transfer	Classroom performance quiz	5%
	Comprehensive design	Teacher evaluation Mutual-evaluation	Innovative application	Integrated design	10%
Off-Line	Experimental operation	Teacher evaluation	Practice	Experiment	10%
	After-School consolidation	Teacher evaluation Mutual-evaluation	Knowledge transfer Application ability	Exercise	5%
	Mid-term exam	Teacher evaluation	Knowledge transfer Application ability	Closed-book exam	15%
	Final exam	Teacher evaluation	Knowledge transfer Application ability	Closed-book exam	50%

The evaluation results of pre-class test, quiz, case-study and comprehensive design are displayed graphically, which is more intuitive and can arouse students' awareness of challenge. The evaluation results directly point out the problems existing in the learning process, guide students to find out the gaps and make up for them, and help improve the learning effect.

4.3 Interactive curriculum ideological and politics construction

Organic integration of moral education and curriculum content, emphasis on value shaping and application-oriented "New Engineering" talent training, on the basis of the construction of ideological and political case database, scientific research literature learning, red culture immersion experience and other forms to carry out ideological and political interaction between teachers and students. In the course evaluation, the ideological and political assessment is added:

1.Collection of professional related literature, collation and completion of scientific research literature notes.

2. Ideological and political case design.

3. School red culture immersive experience tube, study hall visit education, experience the national folk culture. The specific tasks and assessment standards of curriculum ideological and political evaluation are shown in Table 3.

Table 3 Curriculum ideological and political evaluation structure

Content	Form	Subject	Requirement	Notes
Scientific research literature learning	Individual task	Teacher evaluation	One topic study note	Compulsory
Ideological and political case design	Group task	Mutual-evaluation Teacher valuation	One case design	Compulsory
Visit education	Group task	Mutual-evaluation	Red culture immersive experience Ethnic Culture hall visit	Optional (2 points)

5 Reform Results

Students of grade 2018 adopt the traditional teaching method, while students of grade 2019-2020 adopt the reformed blended teaching method. The scores of students of grade 2018-2019 are shown as Fig. 2. The average score of the 2018-2019 class is between 70 and 71, and the highest and lowest scores change little but show an increasing trend. Related curriculum teacher's evaluations were 75,80, and 81, showing significant improvement. To sum up, there is little change in the overall score, but the learning effect of students has been improved to a certain extent, the enthusiasm of students in class has been significantly improved, and the online participation rate of each project is above 90%.

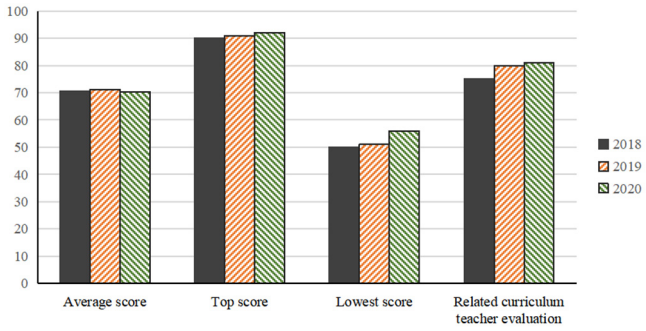

Fig. 2 Comparison of course scores

In the past two years, under the influence of blended teaching reform, the communication between teachers and students has become closer. we have guided students to form research teams, applied for 2 provincial college student innovation training projects, participated in professional competitions such as Blue Bridge Cup and National Electronic Design Competition and won 2 provincial and above awards, participated in innovation and entrepreneurship competitions and won 3 provincial and above awards, and comprehensively counted more than 40 students. Students' comprehensive application and practical ability has

been significantly improved. The enthusiasm of the 2019 students for major-related employment has been significantly improved, and the current employment rate of students is 71%, of which the major-related employment rate is 100% (as of July this year).

6 Conclusion

This paper takes the cultivation of applied talents in local undergraduate colleges and universities as the research object, which also makes up for the status quo that the research on teaching reform is dominated by double first-class and high-quality running colleges and universities. On the basis of six years of teaching experience, targeted questionnaires and talks were carried out to collect students' information, analyze the students' learning situation and the current teaching situation, provide a clear goal for the subsequent teaching reform, and ultimately form a "Three-Dimensional Six-Step" blended teaching reform, which was extended to the teaching of other professional courses. By comparing the students of the 2018-2020 class, the application practice and comprehensive analysis ability of the students have been significantly improved, and the students' professional cognition is more profound, and their career recognition has been improved.

At the same time, this study can be continuously improved in the following aspects:

1.Taking the course "Automatic Control Theory" of our school as an example, the sample data is small and there is a lack of more in-depth data analysis. Coding analysis based on the American Deep learning item scale, mixed learning satisfaction Scale and information technologic-based Interactive Analysis System (ITIAS) can be added [13].

2.The increase of online and offline activities of students still cannot avoid the situation that students are "tired to cope with", so it is necessary to continue to streamline student activities.

3.The collection and analysis of online and offline learning data should pay more attention to the comparison and analysis between pre-school and post-school.

Acknowledgments. 1.Teaching research and reform project of Yuxi Normal University (202245); 2.Construction of first-class curriculum of Yuxi Normal University (2022kc03); 3.Construction of ideological and political demonstration project of Honghe University(SZKC202103);4.Construction of ideological and political demonstration project of Yuxi Normal University(2022sz15).

References

[1] Zhang Qianwei, Zhang Min, Yang Chunxia.(2022)Situation, Challenges and Suggestions of College Teachers' Blended Teaching Readiness. E-education Research,43:46-53.

[2] Wu Yan.(2020)Brave the Tide and Empover the Future—The reform of higher education led by emerging engineering education.Research in Higher Education of Engineering,2:1-5.

[3] Zhao Li,Zhang Hui.(2022)Flipped Classroom Teaching Behavior and Effect Analysis Based on ITIAS.China University Teaching,11:87- 95.

[4] Sang Xinmin,Xie Yangbin,Yang Manfu.(2014)Deep Interpretation and Future Prospect of the Influence of "MOOCs" on Universities,China Higher Education,3:12-15.

[5] Garrison DR,Anderson T,Archer W. (2001)Critical Thinking,Cognitive Presence and Computer Conferencing in Distance Education. American Journal of Distance Education,1:7-23.
[6] Tawfik, Andrew A, Christopher L. Using a flipped classroom approach to support problem-based learning[J]. Technology, Knowledge and Learning, 2015, 20(3): 299-315.
[7] Fautch J M. The flipped classroom for teaching organic chemistry in small classes: is it effective[J]. Chemistry Education Research and Practice, 2015,16(1):179-186.
[8] Wang Tianmiao,Zhang Yue.(2017)The Transition of Teachers' Roles in the Context of MOOC Education Based on a Narrative Research. Teaching Material and Method,3:110-115.
[9] Guo Jianping.(2019)Flipped Classroom Teaching Model:Variant- Unity.China Higher Education Research,6:8-14.
[10] Xu Fangfang.(2016)Study on the Design of Knowledge for Promoting Deep-learning Through the Flipped Classroom Model.China Modern Educational Equipment,21:80-82.
[11] Zhu Yonghai.(2021)Systematic Design and Systematic Mode Construction of Blended Teaching from the Perspective of Deep Learning.China Educational Technology,11:77-87.
[12] He Wei.(2022)Analysis of Teaching Behaviors in Vocational Education Golden Courses Based on Big Data Technology and Its Enlightenments.Vocational and Technical Education,20:41-48.
[13] Shen Xiajuan;Zhang Baohui;Zhang Hao.(2022)Construction and Empirical Research of Deep Blended Learning Design Model. Modern Educational Technology,32:50-58.