Constructing a College Physics Curriculum Group Based on the concept of "Theory+Practice+Application"

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Abstract. Based on the concept of "theory + practice + application", the reform of the college physics curriculum group is carried out from three aspects: theory, practice, and application, in order to solve the main teaching problems of the college physics curriculum group. The reform is guided by the "teaching objectives" and the "pain points" of teaching, and combines traditional teaching with SPOC, flipped classroom, and online teaching. Integrating cases into classroom teaching to achieve hierarchical classification of course content, and combining theory and practice through three-stage practical activities to stimulate classroom interest and cultivate students' ability to apply what they have learned The goal is to form an engineering physics teaching system with our own characteristics.

Keywords: Layering; Classification; Practice; Application

1. Analysis of Curriculum Status and Background

1.1 Research Background. National Background: In order to deeply implement the spirit of the National Education Conference and "China Education Modernization 2035"[1], adhere to the principle of "building character and educating people", focus on deepening the reform of undergraduate education and teaching, cultivating socialist builders and successors with all-round development of moral, intellectual, physical, aesthetic, and labor education, on October 8, 2019, the Ministry of Education issued the "Opinions of the Ministry of Education on Deepening the Reform of Undergraduate Education and Teaching and Improving the Quality of Talent Cultivation" (Teaching [2019] No. 6)[2], which emphasizes encouraging students to study hard, increasing the challenge of academic studies, strengthening the quality requirements of talent training programs, teaching processes, and teaching assessments. Comprehensive improvement of curriculum quality construction, strengthening the overall design of the curriculum system, improving the planning and systematization of curriculum construction, avoiding informality and fragmentation, focusing on creating a large number of high-level, innovative, and challenging offline, online, online-offline mixed, virtual simulation, and social practice "gold courses".[3] .

Our university background: The university responds to the national call, focusing on the fundamental task of "establishing morality and cultivating people", adhering to "focusing on talent cultivation", closely revolving around deepening the reform of innovative and applied-oriented talent cultivation in teaching.

The background of the freshman college: It is responsible for the education and management of first-year undergraduate students, cultivating students' good study and life habits with the initial intention of "comprehensive improvement of talent cultivation quality" and the mission of "innovating breakthroughs, laying a solid foundation, and facing challenges." It is committed to providing a comprehensive platform for college students to learn broad basics and develop wide horizons, improving students' ability for sustainable development.

1.2. Current Situation of the College Physics Curriculum Group

1.2.1 Overall Curriculum Group Situation. The college physics curriculum group includes College Physics I and College Physics II, totaling 96 class hours. There are also College Physics Experiment I and College Physics Experiment II, totaling 48 class hours, which can offer experimental projects. The College Physics open experiment is an optional experiment project for students.

1.2.2 Basic Information of the Physics Experiment Course Hardware Platform. The Physics Experiment Center is responsible for teaching college physics experiments to undergraduate students of science and engineering. It is a key laboratory at the university level. In 2007, it was named a provincial-level experimental teaching demonstration center in Shaanxi Province. The Physics Laboratory currently has a total area of 1105 square meters for experimental use, with over 820 pieces of experimental equipment worth approximately 2.45 million yuan. There are 10 basic laboratories and one open physics laboratory. The college physics experiment course can offer 20 basic experiments and nearly 30 optional experiments. Each year, approximately 7000 students are welcomed for classes and labs.

1.2.3 About Students. There are about 3000 students of science and engineering in our university, with approximate 105 classes. The total hours of theoretical learning for the college physics are nearly 5000 hours per academic year, and the practical learning hours for physics experiments are also about 5000 hours per academic year. Each teacher completes an average teaching workload of 588 per academic year.

2. Major Teaching Problems

(1)Limited course time restricts the path of individualized teaching and the cultivation of talent diversity, as well as the development of students' innovation.(2) Students have weak ability to integrate theory with practice and need to improve their hands-on practice ability.(3) Students' low participation in class, and their interest in learning and personal initiative are not fully expressed.

3. Main Measures

3.1 Research approach: The reform of the university physics course group closely focuses on the training objectives of excellent engineers and advanced specialized application-oriented talents in national defense industry. In combination with the subject characteristics under the background of large-scale enrollment, it takes solid foundation as the foundation and takes "teaching objectives" and teaching "hot issues" as the guidance. It combines traditional teaching with SPOC, flipped classroom, and online teaching to reform the university physics course group from three aspects of theory, practice, and application, and strives to form an engineering physics teaching system with characteristics of our university.

3.2 Main measures

3.2.1 Blended Online and Offline Teaching Model [4][5]. To address the issue of limited course time that cannot meet the diverse talent development needs and cultivate students' innovative abilities, we aim to establish high-quality "online + offline" college physics course resources, adopt six step and fifth orderteaching methods to solve teaching problem (1).

Table 1. Teaching Mode of College Physics Course Group

A hybrid teaching model of "online+offline" for college physics course groups

Course name		《College Physics I/II》	《College Physics Experiments I/II》
Online	Before class	Watch preview videos , complete task points	Watch experimental instruments and project introduction videos
	After class	Discussion, mutual evaluation, exam, quiz	Questionnaire filling, selection of the most beautiful experimental report, etc
Offline	Knowledge+case-based teaching+interactive activities		Basic experiments, practical classroom operations for students, and open laboratories for extracurricular training
			Students verify the optimization plan and conduct practical operations, and open experiments for extracurricular research
			Innovative experimental projects are student-centered, supplemented by teacher guidance, and related projects are completed in an open manner

Teaching link	Teaching process	Teaching methods		Teaching objectives
Exploring knowledge before class	Task-driven Knowledge-exploration Interest-exploration	Learning Communication Theme discussion Problem oriented Preclass quiz		Cultivate students' autonomy exploration of learning and the ability to study-cooperation
Case Introduction	Introduction of interesting experiments, Introduction of cutting-edge cases, Introduction of student activities	Student operation Observation experiment Student Watch video		Maximizing students' interest in learning
Discovery Thinking	Problem oriented Reflection and Discussion Guiding and inspiring	Informationization means Teacher-student interaction		Inspire students' thinking and unleash their subjective participation role
Modeling Analysis	Physical modeling Analyze and solve	Simulation animation Demo teaching aids Informationization means Student activities		Visualize theoretical explanations to inspire students Intelligence and Potential
Application expansion	Student explanation Practice calculation Summary Frontier expansion	Lectures by teachers and students speech Teacher led and student calculation Quizzes after class		Students' deep participation in the classroom enhances their ability to analyze, solve, and summarize problems
Practice after class	Design and production Experimental measurement Investigation and research Research after class	Design and production Experimental measurement Investigation and research Research after class		Cultivate students' autonomyExploration of Learning and CooperationThe ability to study

Figure 1. Six Step Teaching Method

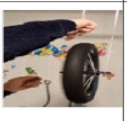
Procedure	Task	Teacher	Student		Means
Observation	Observating physical phenomenon In scenario cases	Students personally demonstrate helicopter flight and guided to observe the structure, flight status, and characteristics of the helicopter model		Observe Carefully the rotation of the helicopter fuselage and the direction and attitude of the wing rotation	multimedia+ Physical teaching aids
Thinking	Ponder over scientific problems In physical phenomena	Guide students to think: Why do helicopters have two wings? What would happen if there was only one?		Thinking question through observation:Why is the rotation direction of helicopter wings opposite through physical observation? What would happen if they were the same?	Informatization interaction
Create	Stablishphysical model In scientific issuese	Guide students to simplify research objects; Establish physical model: rigid body, sort out motion characteristics: fixed axis rotation		Establish a physical model based on analysis the object	Physical modeling
Analysis	Analysis Physical issues In the physical model	Guide students to solve problem by physics principle:1. System force analysis;2. Analysis of various moments;3. Is angular momentum conserved?		Analyze the model. Scan the QR code to view the prompts and calculation	QR Code Small Brocade Bag send the detailed explanations
Generalization	Generalize the analysis ideas in the application of principles	Summarize the process of problem-solving ideas, and extend them appropriately to advanced complex problems: rigid body precession		By analyzing and summarizing, solving complex problems	Informatization+Physical teaching aids

Figure 2. Five order Teaching Method

3.2.2 Optimize and integrate to enrich online and offline teaching resources. We plan to investigate the online and offline resource construction of the university physics course group, integrate and optimize existing teaching resources to improve their utilization efficiency. We aim to solve the following teaching issues: (3).

Table 2. Resource Construction for University Physics Courses

《University Physics I/II》Course Resource Construction							
Question Bank	Exercise Bank	Knowledge points					
		Type	Multiple Choice	Gap filling	True/False	Calculation	Short Answer
	Exercise Video	Record Videos for Difficult Exercises					
Course Material	Courseware	1.Teaching courseware for《University Physics I/II》 2.Teaching courseware for《University Physics Experiment I/II》					
	Micro lesson	1. Record micro-lessons, and expand micro-lesson videos for some knowledge points. 2. Record micro-lessons explaining the basic principles of all experiment projects, and demonstrating the experimental procedures for all experiment projects.					
	Engineer-ing case	Designing University Physics Curriculum Engineering Application Cases for Four Categories of Enrollment, Building Curriculum Application Case Resources (including teaching design, case videos, pictures, literature, etc.)					
	Ideological cases	Build a resource library for such cases (including teaching design, case videos, images, etc.)					
	Expansion materials	Collect audio, video, and literature resources related to interesting, advanced, scientific frontiers, and practical applications in daily life that are suitable for extracurricular expansion.					
Question naire survey	Design course questionnaires according to course needs (including questionnaire, teaching process and evaluation feedback questionnaire, etc.).						

3.2.3 Teaching Content Reform. Reforming the teaching content of university physics courses, studying the basic knowledge system of university physics courses, and analyzing the application of knowledge points in engineering[6]-[9]. Intend to solve teaching issues (1) and (2).

Table 3. Content Reconstruction of University Physics Course Group

《University Physics》Course Content Reform					
Sequence Number	Four Major Categories	Content	Engineering Application Case	Expansion reading	According to 'reason' Creating 'things'
1	Optics and Electronic Information	Full Coverage	Light, Electromagnetic	Light, Electromagnetic	Light, Electromagnetic

2	Intelligent Manufacturing	Force	Force, heat	Force, heat
3	Design and Construction	Forces, electromagnetic	Forces, thermal forces	Forces, thermal forces
4	Data and Computational Science	Near Objects, forces	Near Objects, forces	Near Objects, forces

《University Physics Experiment》Course Content Reform

Sequence Number	Layered	Content	Objective
1	Basic type experiment	Basic experimental instrument measurement methods and skills training	Enhance students' basic experimental skills
2	Comprehensive design type experiment	Selecting appropriate instruments based on experimental tasks, designing experimental processes, and completing experimental tasks	Enhance students' comprehensive application ability and practical ability
3	Innovative research-oriented experiments	Setting up competition experiment projects and tasks for the Chinese Undergraduate Physics Competition, and students collaborating to complete them	Enhance students' innovative research ability

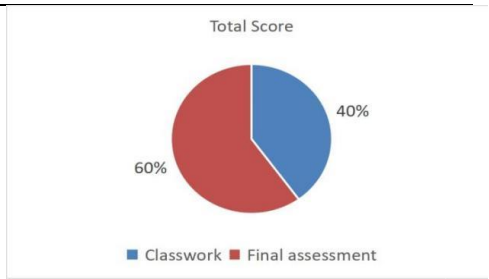
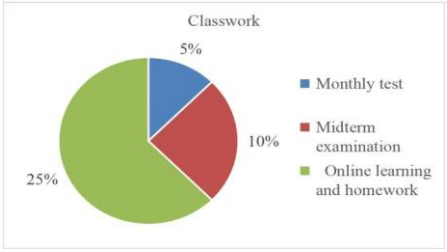
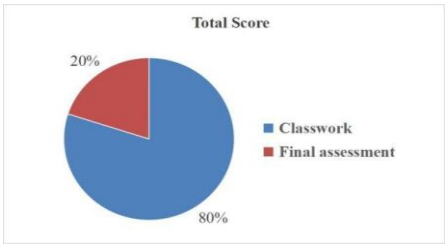
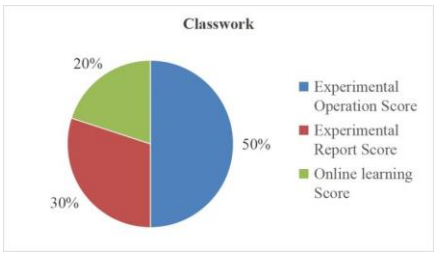
3.2.4 Informationized Teaching Means. Investigate the advantages and disadvantages of different information technology platforms and devices under the Internet, and find suitable teaching means based on the characteristics of the university physics course group. Intend to solve teaching problem (3).

Table 4. Teaching Means of University Physics Course Group

Sequence Number	Teaching Means	Purpose
1	Fanya "Yi Ping San Duan" (Learning Express)	Complete pre-class knowledge transmission
2	"Learning Express" classroom interactive platform	Carry out activities such as classroom testing, polling, and screen sharing.
3	Daily objects as teaching aids	Stimulate students' interest in the course and increase their familiarity with it
4	PPT	Summarize and organize knowledge, create immersion in teaching content with scenarios and stories.
5	Innovation Design Laboratory	Carry out practical innovation design activities.

3.2.5 Reconstructing the Course Assessment and Evaluation System. Comprehensive and Multidimensional Analysis and Research on Course Evaluation Methods, Reconstructing a Rational, Efficient, and Objective Course Evaluation System. Intended to solve teaching issues (1) (2) (3).

Table 5. Evaluation Mode of University Physics Course Group

Course category	Evaluation Model	
《University Physics》 Assessment Mode	Total Score	
	Classwork	
《University Physics Experiments》 Assessment Mode	Total Score	
	Classwork	

4. Summary

The paper focuses on the main teaching issues by taking the "teaching objectives" and "pain points" as the guide, combining traditional teaching with SPOC, flipped classroom, and online teaching. It constructs the course content for undergraduate physics and undergraduate physics experiments from three aspects of theory, practice, and application. Engineering cases and ideological and political cases are integrated into teaching, that will achieve hierarchical classification of college physics. Introducing demonstration experiments and teaching aids made by teachers and students into college physics classrooms, stimulating students' interest in learning, cultivating their ability to apply what they have learned, and combining theory with practice. Innovative teaching models are adopted using teaching methods such as the six step teaching method and the five step teaching method. With a focus on improving students' output, we are improving the detailed course assessment and evaluation system. It innovates teaching models, improves the course assessment and evaluation system, enhances the course's potential abilities, and strongly supports the overall goal of talent training.

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