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# Reform and Practice of University Physics Experimental Teaching Based on OBE Concept

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**Abstract:** Aiming at the problems of unclear teaching objectives, obsolete content, and single method in the experimental teaching of university physics at our university, we have implemented a series of reform initiatives. It mainly includes clarifying the student-centered teaching objectives, optimizing the experimental content, innovating the teaching methods, improving the assessment and evaluation system, and improving the experimental conditions [1,2]. After the implementation of the reform, the learning effectiveness of students has been significantly improved, the teaching level of teachers has been significantly enhanced, the curriculum system has been optimized, the efficiency of teaching management has been enhanced, and social recognition has been strengthened. Practice shows that the teaching reform based on the outcome-based education concept effectively improves the quality of university physics experimental teaching and lays the foundation for cultivating innovative talents.

**Keywords:** Outcome-based education concept; University physics experiments; Teaching reform; Efficacy

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## 1. Introduction

University physics experiment is an important basic course for science and engineering majors, which has an irreplaceable role in cultivating students' scientific literacy, innovation ability, and practical skills [3-5]. With the rapid development of science and technology and the change of social demand for talents, the traditional university physics experimental teaching mode has been difficult to meet the requirements of the new era. Prevalent problems include unclear teaching objectives, outdated content, single methods, and imperfect evaluation systems, which have seriously constrained the improvement of teaching quality and the cultivation of students' comprehensive ability. Outcome-based education (OBE), as an advanced educational philosophy, emphasizes the centering on student learning outcomes and focuses on the development of students' comprehensive abilities and professionalism [6,7]. This is highly compatible with the goals of university physics experimental teaching and provides new ideas and methods for teaching reform.

## 2. Current situation of university physics experimental teaching at our university

University physics experiment is an important basic course for students majoring in science and engineering, which has an irreplaceable role in cultivating students' scientific literacy, innovation ability, and practical skills [8]. However, the experimental teaching of university physics at our university has also revealed some problems in the long-term development, mainly in the following aspects.

### 2.1. Unclear teaching objectives

Traditional university physics experimental teaching often focuses too much on knowledge transfer and skill training, neglecting the cultivation of students' comprehensive abilities [9]. Teaching objectives are often limited to completing experimental operations, obtaining experimental data, and writing experimental reports, and there is a lack of consideration for students' innovative thinking and scientific literacy. This kind of goal-oriented teaching mode is inadequate to meet the requirements of talent training in the new era.

### 2.2. Outdated teaching content

At present, most of the teaching contents of university physics experiments have been inherited for many years, which is unaligned with the development of modern science and technology and the needs of students. The experimental program lacks contemporary characteristics, and it is difficult to stimulate students' interest in learning and desire to explore. At the same time, the connection between the experimental content and the theoretical courses is not close enough, which makes it difficult for students to apply what they have learned in practice.

### 2.3. Single teaching methods

The traditional teaching method of university physics experiments is based on teacher's explanation and student's operation, which lacks interactivity and inspiration [10]. Students are often in a state of passive acceptance in the experimental process, it is difficult to develop independent thinking and problem-solving skills. In addition, insufficient attention is paid to the individual needs of students in the teaching process, making it difficult to stimulate students' creativity and potential.

### 2.4. Inadequate appraisal and evaluation system

The existing assessment and evaluation system mainly relies on experimental reports and operational assessment, which is difficult to comprehensively reflect students' learning achievements and skill levels [11]. Evaluation standards focus too much on the results and ignore the process, it is difficult to motivate students to take the initiative to learn and explore [12]. At the same time, there is a lack of assessment of students' soft power, such as their ability to innovate and work in teams, which is inconducive to students' overall development.

## 3. Initiatives to reform the teaching of university physics experiments

In order to solve the above problems and improve the quality of university physics experimental teaching, our university has launched a series of teaching reform initiatives based on the OBE concept.

### 3.1. Clarifying student-centered teaching and learning objectives

Based on the concept of OBE, we have reformulated the teaching objectives of university physics experiments, taking the cultivation of students' comprehensive ability as the core orientation, as shown in **Figure 1**.

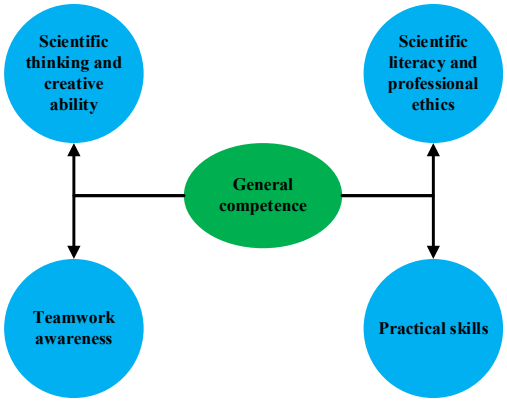


**Figure 1.** Teaching objectives of OBE philosophy

The formulation of these objectives takes full account of the future development needs of students and the requirements of society for talents and points out the direction for subsequent teaching reforms.

## 3.2. Optimizing teaching content

The teaching content of university physics experiments has been comprehensively reorganized and updated, as presented in **Table 1**.

**Table 1.** Optimization of teaching content

| Teaching content | Examples |
|---|---|
| Introducing a modern physics laboratory program | Programs such as Hall effect experiments, thermistor temperature characteristics experiments, etc., enhance the experimental content of the cutting-edge and attractive. |
| Designing comprehensive, designed experimental programs | Programs such as physical modeling and simulation, interdisciplinary application experiments, etc., develop students' innovative thinking and ability to solve complex problems. |
| Strengthening the link between experimental content and theoretical courses | Designing a series of validation experiments to help students deepen their understanding of physics concepts and principles. |
| Increasing open lab programs | Encouraging students to design their own experimental programs to develop their independent thinking and scientific research skills. |

## 3.3. Innovating teaching methods

In order to improve the effectiveness of teaching, we have adopted the following innovative teaching methods, as illustrated in **Figure 2**.

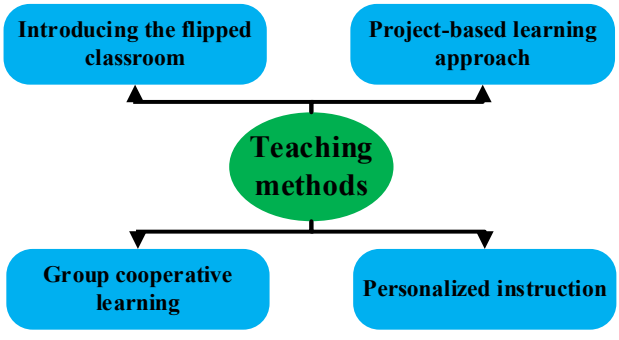


**Figure 2.** Innovative teaching methods

### 3.4. Improving the assessment and evaluation system

In the teaching process, a diversified, whole-process assessment and evaluation system was constructed, as shown in **Table 2**.

**Table 2.** Appraisal and evaluation system

| Evaluation aspects | Examples |
|---|---|
| Introduction of process evaluation | Students' performance in all aspects of laboratory preparation, operational procedures, and data analysis will be included in the assessment. |
| Adoption of a diversified approach to evaluation | It includes lab reports, oral presentations, hands-on exercises, peer evaluations, etc., reflecting the full range of student learning outcomes. |
| Formation of innovative evaluation indicators | Indicators such as the innovative degree of the experimental scheme, the uniqueness of the problem-solving, etc., stimulate students' creative thinking. |
| Establishment of student growth profiles | Students' characteristics such as skills improvement, thinking innovation, problem-solving, teamwork, etc. |

### 3.5. Improvement of experimental conditions

In order to support the implementation of the pedagogical reform, the following measures have been taken to improve laboratory conditions:

(1) Upgrading laboratory equipment and introducing a number of advanced laboratory instruments and equipment to provide hardware support for conducting modern physics experiments.

(2) Improvement of the laboratory environment to create a more comfortable and safer laboratory atmosphere and to enhance the students' experimental experience.

(3) The construction of a virtual simulation experimental platform, expanding the breadth and depth of experimental teaching through information technology means.

(4) Developing an experimental teaching management system, realizing the functions of experimental reservation, resource sharing, online guidance, etc. to improve the efficiency of teaching management.

## 4. Effectiveness of the reform of university physics experimental teaching

Through the implementation of the teaching reform based on the OBE concept, the experimental teaching of university physics at our university has achieved remarkable results, which are mainly reflected in the following aspects.

### 4.1. Increased student learning outcomes

(1) Students' experimental skills have been significantly enhanced: (a) Improved laboratory skills and reduced error rate by 30%; (b) Improvement in data processing and analytical skills, and general improvement in the quality of laboratory reports; (c) Students are able to design and complete simple physics experiments independently, cultivating their innovative ability.

(2) Significant increase in learning motivation: (a) Student attendance increased from 85% to more than 95%; (b) 50% increase in the percentage of students actively participating in discussions and asking questions; (c) 40% year-over-year increase in the number of students taking open lab programs.

(3) Comprehensive development: (a) Students' ability to work in teams has been enhanced, and the

efficiency of group experiments has increased by 25%; (b) Scientific literacy and professional ethics have been generally enhanced, and experimental integrity problems have been significantly reduced; (c) The number of awards won by students in various science and technology innovation competitions increased by 35% year-on-year.

### 4.2. Improvement of teachers' teaching skills

(1) Renewal of teaching philosophy: (a) Teachers have generally established a "student-centered" teaching philosophy; (b) More than 90% of teachers are proficient in utilizing the OBE philosophy to guide their teaching practice.

(2) Innovations in teaching methods: (a) Teachers are able to flexibly utilize modern teaching methods such as flipped classrooms and project-based learning; (b) Improvement in personalized instruction and a 20% increase in student satisfaction.

(3) Scientific research capacity enhancement: (a) 50% increase in the number of faculty participating in teaching research projects; (b) 40% year-on-year increase in the number of published teaching research papers.

### 4.3. Optimization of the curriculum system

(1) Updating of experimental programs: (a) Two new modern physics experiments, accounting for 20% of the total number of projects; (b) The proportion of comprehensive and design experiments is increased to 40%; (c) The number of open experiments increased by 30%.

(2) Keeping the content up to date: (a) 40% of the laboratory projects are closely linked to the latest scientific and technological developments; (b) 50% increase in the articulation between theoretical and experimental courses

### 4.4. Increased efficiency of teaching and learning management

(1) Increased level of information management: (a) Online management of the whole process of experiments is realized, and the efficiency has increased by 40%; (b) The utilization rate of teaching resources sharing platforms reaches 95%.

(2) Well-established quality control system: (a) Establishment of a multi-dimensional teaching quality evaluation system, with objectivity increased by 30%; (b) Timely handling rate of student feedback reaches 100%.

(3) Increased resource utilization: (a) 25% increase in lab utilization; (b) 15% reduction in equipment maintenance costs.

## 5. Conclusion

The reform of university physics experimental teaching based on the OBE concept is a systematic project, which involves teaching objectives, contents, methods, evaluation, and other aspects. Through this comprehensive teaching reform, the quality of university physics experimental teaching has been significantly improved, and students' comprehensive ability and innovative spirit have been effectively cultivated. This not only lays a solid foundation for the future development of students but also makes an important contribution to the cultivation of high-quality and innovative talents in our university.

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## Disclosure statement

The authors declare no conflict of interest.

## Author contributions

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