The Blended Teaching Design under the OBE Concept —Taking Conductors in Electrostatic Fields as an Example

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Abstract: *Amidst the ongoing reform of engineering education and the development of emerging engineering disciplines, the Outcome-Based Education (OBE) concept has been widely adopted to enhance the effectiveness of fundamental course instruction. To address the disconnection between theoretical knowledge and practical application, as well as the insufficient cultivation of higher-order competencies in traditional university physics teaching, this study takes the topic of "Conductors in Electrostatic Fields" as a case to design and implement a blended teaching model deeply integrated with information technology under the OBE framework. A closed-loop instructional system encompassing "objective planning, activity organization, multi-dimensional assessment, and feedback-driven improvement" is constructed, supported by a three-dimensional learning objective system that integrates knowledge, skills, and qualities. Leveraging smart teaching platforms, the design enables precise diagnosis of learning readiness, dynamic in-class interaction, and evidence-based refinement of teaching strategies. Teaching practice demonstrates that this approach effectively facilitates students' conceptual understanding, fosters engineering thinking, and enhances comprehensive problem-solving abilities. The study provides an operable and evaluable instructional model that aligns with student-centered and outcome-oriented principles, offering valuable insights for the reform of university physics courses and the integration of foundational and professional education in engineering disciplines.*

Keywords: *Outcome-Based Education (OBE), blended teaching; university physics, conductors in electrostatic fields, instructional design*

1. Introduction

In the context of current higher education reforms, the concept of "Outcome-Based Education" (OBE) has gradually become an important direction for engineering education and science teaching reforms. Currently, China's higher education is in a profound transformation period from scale expansion to internal development. The OBE educational concept, centered on "student-centeredness, outcome orientation, and continuous improvement", has become an important guiding principle for engineering education and basic science course teaching reforms [1-2]. In the field of physics, although the traditional "lecture-and-reception" teaching mode can systematically impart knowledge, it often fails to effectively achieve the goals of cultivating high-level abilities and comprehensive qualities due to its disconnection from students' professional practice and its single evaluation method. When students face complex engineering practical problems, they often struggle to activate and apply the physical principles they have learned [3]. Therefore, exploring a new teaching model that can deeply integrate physical principles, scientific thinking, and engineering practical abilities has become an urgent issue for the reform of university physics teaching.

Meanwhile, the information technology revolution represented by big data, artificial intelligence and mobile internet is reshaping the educational ecosystem with an unprecedented depth. Information technology not only enriches the presentation methods of teaching resources as a tool, but also fundamentally promotes the transformation of teaching concepts, structures and processes [4]. Against this backdrop, blended teaching has emerged. It organically integrates the flexibility of online self-study and the depth of offline physical classrooms, providing an ideal framework and path for implementing the OBE concept. Through smart teaching platforms, teachers can achieve precise push of learning resources, real-time data collection and dynamic analysis of the learning process, as well as multi-dimensional and process-oriented evaluation of learning outcomes, thus truly realizing "learning-based teaching" and "tailored teaching" [5].

Specifically in the university physics course, the deep involvement of information technology makes it possible to implement the OBE concept in a closed loop. On one hand, digital resources such as micro-videos and simulation animations can visualize abstract physical phenomena (such as the dynamic redistribution of charges within a conductor), reducing cognitive load and laying the foundation for concept construction. On the other hand, the data feedback function of the teaching platform enables teachers to accurately diagnose the degree of students' achievement in each learning objective, thereby promptly adjusting teaching strategies and achieving a continuous cycle of "evaluation - feedback - improvement". More importantly, project-based learning and collaborative exploration supported by information technology can seamlessly connect classroom theory with engineering practice (such as electromagnetic shielding, medical instrument safety, etc.), comprehensively cultivating students' knowledge application ability, engineering thinking and innovative consciousness in the process of solving complex problems.

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In summary, this work takes the core content of university physics, "conductors in electrostatic fields", as the specific carrier, and designs and implements a blended teaching case that deeply integrates information technology and the OBE concept. The research aims to explore how to integrate knowledge objectives, ability objectives and quality objectives through systematic information-based teaching design, how to use technological tools to promote deep interaction and meaning construction among teachers, students and among students themselves, and how to achieve continuous optimization of the teaching process through data-driven methods. This research hopes to provide an operational, assessable and promotable practical model for the teaching reform of university physics in the new era, and also offers useful references for the effective connection between basic courses and professional education in the new engineering discipline construction.

2. Core Concept and Design Framework

The core of this design lies in systematically integrating the "outcomes-based, reverse design, and continuous improvement" principles of OBE with the "online autonomy, offline deepening, and technology empowerment" advantages of blended teaching. OBE requires that teaching begins with a clear plan for achieving graduation requirements and ultimately results in observable and assessable learning outcomes [6]. Blended teaching provides students with sufficient activity space and time guarantee to achieve high-level ability goals (such as analysis, evaluation, and creation) through flexible organizational forms [7]. Information technology plays the role of "adhesive" and "amplifier" in this integration: it makes the transparency and dataization of the learning process possible, thereby enabling evidence-based precise teaching and continuous improvement to be realized.

This design has constructed a closed-loop teaching system of "target planning - activity organization - multi-dimensional evaluation - feedback improvement" (as shown in Figure 1). This system takes the three-dimensional learning goals as its starting point and destination. All teaching activities are designed around the achievement of the goals. Multi-dimensional evaluation provides evidence for the degree of goal achievement, and the evaluation data drives the iterative optimization of teaching strategies, forming a dynamic and growing teaching organism.

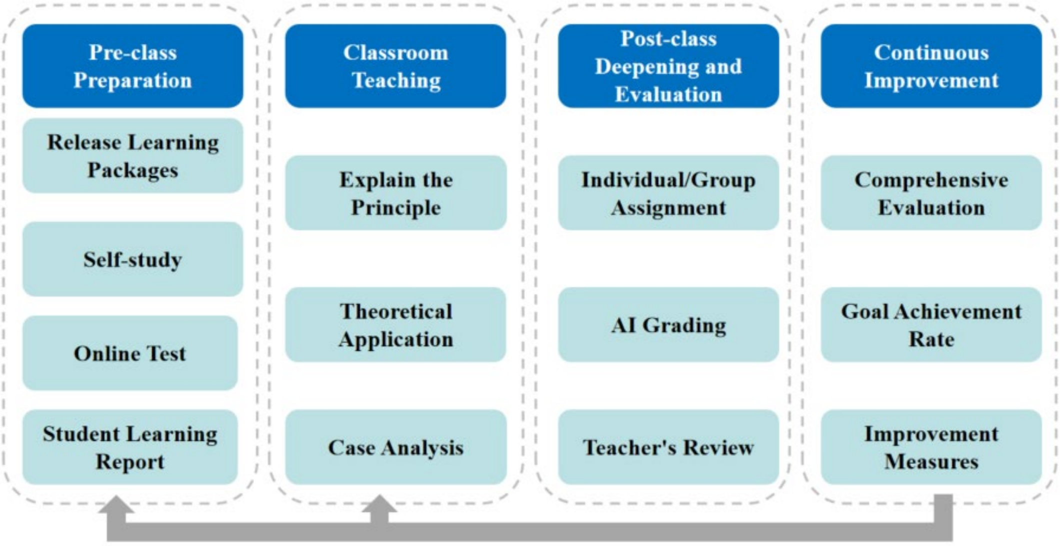

Figure 1 Flowchart of the Teaching Process

3. Design of Teaching Mode

This plan strictly follows the "reverse design" concept of Outcome-Based Education (OBE), with the graduation requirements of engineering education as the overall guideline, and the core physical content of the "Conductors in Electrostatic Fields" section as the specific anchor point. The content of this section not only deepens the theory of electrostatic fields, but also serves as a bridge connecting basic physics with electrical engineering, electronic technology, electromagnetic compatibility, etc.

3.1 Teaching Objectives Design

Therefore, the setting of teaching objectives should go beyond merely memorizing isolated conclusions, and focus on the students' comprehensive performance of applying the unique concepts and principles of this section, analyzing and solving practical problems. Before implementing the blended teaching based on Outcome-Based Education (OBE), conducting precise analysis of the students' learning situations is the starting point of "reverse design" and also the prerequisite for ensuring the rationality of the teaching objectives and the effectiveness of the teaching strategies. This design is targeted at sophomore students in university science and engineering who have completed the study of basic concepts of electrostatic fields (Coulomb's law, electric field intensity, Gauss's theorem, electric potential). Students have mastered the basic properties and description methods of electrostatic fields, and understand Gauss's theorem and its application in symmetric fields. This lays the foundation for analyzing the "disturbance" caused by the introduction of conductors to the original electric field. Students are accustomed to dealing with electric fields generated by free point charges or fixed charge distributions. Considering conductors as a special boundary condition, the charge distribution on them is determined jointly by the external field and the self-balancing condition. This mental shift is the key and also the difficulty of this section. However, they show strong interest in application examples related to life and high technology (such as lightning rods, Faraday cages demonstrations, mobile phone signal shielding). This provides a good opportunity to drive deep learning through engineering cases. Some students (especially those in electrical engineering majors) have already started to encounter subsequent courses such as circuits and electromagnetic compatibility, and have an inherent need to understand their physical basis. Based on the above learning situation, the teaching objectives of this section are set to resolve cognitive difficulties, promote mental shifts, and drive deep learning through interest points.

This work decomposes the teaching objectives into three mutually supporting dimensions: knowledge, ability, and quality. As shown in Table 1, the three-dimensional objective system is all based on and closely revolves around the core knowledge points and typical application scenarios of "conductors in electrostatic fields".

Table 1: Three-dimensional learning objective system for "Conductors in Electrostatic Fields"

Target dimension	Objective description	Evaluation method
Knowledge	1. State the three necessary conditions for the electrostatic equilibrium state of a conductor and explain the underlying physical logic. 2. Explain the basic principle of electrostatic shielding, and distinguish the differences in shielding effects between electrostatic fields and changing electromagnetic fields.	1. Online test: Evaluates the understanding of core concepts. 2. Classroom Q&A and In-Class Quizzes
Ability	1. Analyze the distribution of induced charges on the conductors in the given external field, and calculate the electric field and potential distribution. 2. Explain the working mechanisms of lightning rods and Faraday cages. Establish electrostatic models and analyze the requirements for shielding and protection. 3. The group should design a small experiment or research plan to verify the effect of electrostatic shielding.	1. Homework: Problem-solving questions and open-ended interpretation questions. 2. Classroom Case Analysis: The effect of the mesh size of the Faraday cage on the shielding performance. 3. Group Project Report:
Quality	1. Understand the core physical concept of "interaction between fields and matter". 2. Establish an awareness of engineering safety. 3. Stimulate interest in technological innovation and awareness of interdisciplinary learning.	1.Classroom discussion participation level: Depth of thinking and value judgment. 2.Classroom Case Analysis: Information integration ability, critical thinking.

3.2 The design of a blended teaching process based on the OBE concept

The teaching process of this design is not a linear stacking of teaching steps, but rather a dynamic cyclic system centered on achieving the learning goals, driven by data, and deeply integrated both online and offline. Its implementation begins with the precise diagnosis of the learning starting point, unfolds through the interlocking deep interactions in the classroom, and extends to the after-class ability expansion and the continuous improvement based on evidence.

The starting point of the teaching journey is in the cloud. Before the classroom meeting, students had already received a learning package through the intelligent teaching platform (SuperStarLearn app), which included clear learning objectives, core concept micro-videos (especially animations showing the dynamic redistribution process of charges within conductors, as shown in Figure 2), and diagnostic tests. The key point of this stage is "inspecting students' learning situations". The process of students watching the micro-videos independently is actually a process of initially constructing a physical picture and exposing pre-existing concepts; the subsequent online tests then serve as a "probe", accurately identifying cognitive blind spots - for example, test data may show that most students can remember the conclusion that "the field strength within the conductor is zero", but are confused about "why grounding is the key condition for achieving complete shielding". The learning situation heat map generated by the teacher's end ensures that the starting point of the offline teaching is no longer the teacher's assumption, but the real data of the commonality and individual differences of the entire class. This ensures that the subsequent offline teaching can be "precisely guided", directly hitting the pain points.

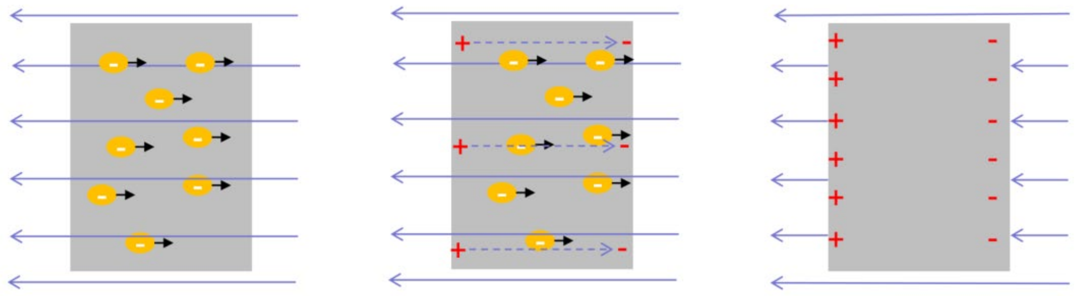

Figure 2 Dynamic redistribution process of charges inside the conductor

With insights into learning acquired from the cloud, classroom teaching naturally begins with "solving doubts". The teacher first presents the predetermined three-dimensional objectives and preview feedback data to the students, enabling them to reach a consensus on the "destination" and "current position" of this learning session. Subsequently, the teaching progresses layer by layer following the logical sequence of "constructing theory - applying theory - surpassing theory". The core of the classroom shifts from the traditional "lecturing" to "guiding inquiry". The teacher begins with a vivid question, "What kind of 'migration' will the free electrons inside a neutral metal sphere experience when placed in a uniform electric field, and what kind of 'new order' will ultimately form?" This question guides students to integrate the fragmented knowledge gained from their preview into a dynamic and logically coherent physical process, enabling them to independently deduce the three conditions for electrostatic equilibrium and their inherent unity. Immediately afterwards, through a classic example of "point charge and conductor sphere" (as shown in Figure 3), students are required to explore the total amount of induced charge on the surface of the conductor sphere. The focus of teaching shifts from "what it is" to "how to use it". The teacher deliberately guides students to use the most powerful condition, "the conductor is an equipotential body", to solve the problem, rather than getting entangled in complex superposition of field strength vectors. This move is specifically targeted at addressing the weakness in the application of the concept of electric potential in the learning situation. Students submit their problem-solving approaches through the teaching platform in real time, and the teacher demonstrates typical approaches on the spot and provides comparative comments, externalizing the thinking process and highlighting the methodology.

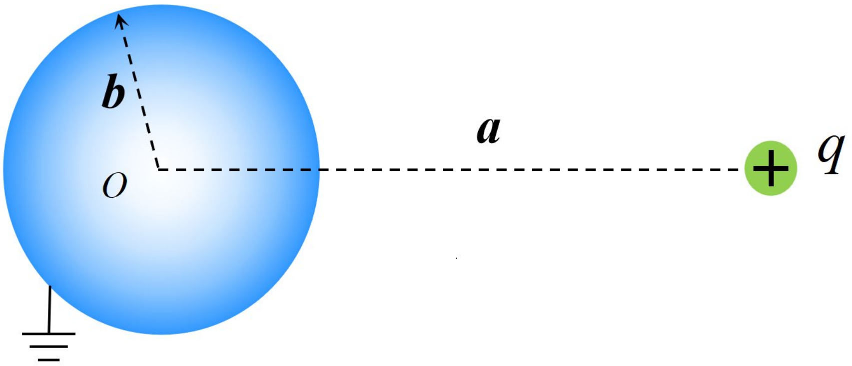

Figure 3: Point charge and conductor sphere model

When theoretical tools become handy, teaching naturally leverages them to address complex real-world situations. Classrooms are transformed into "micro-project workshops". Students work in groups, facing engineering and practical problems such as "how does a lightning rod attract and discharge lightning", "why can a Faraday cage isolate high voltage", and "how to assess the electromagnetic impact of high-voltage transmission lines on surrounding facilities". Here, abstract physical principles (such as the point effect and electrostatic shielding) are activated as powerful tools for analyzing problems. The focus of discussion is no longer on formula derivation, but on how to reasonably simplify practical problems into physical models and use principles to explain mechanisms and demonstrate solutions. For example, when analyzing the Faraday cage, the debate naturally shifts from "whether it is shielded" to "what is the quantitative relationship between shielding effect, mesh size, and grounding resistance", thus touching upon the trade-off thinking in engineering. This process not only solidifies ability goals but also naturally embeds the cultivation of engineering ethics and scientific spirit - adhering to safety norms stems from reverence for principles, and discussing the limitations of technology breeds the seeds of innovative exploration.

The classroom teaching concludes with new challenges. The teacher poses a deep question: "Is electrostatic shielding still perfect for time-varying electromagnetic fields?" and assigns related after-class extension tasks (such as researching the shielding design of precision medical equipment). This marks the extension of learning from a common classroom to a personalized and exploratory extracurricular field. After class, students complete computational assignments aimed at consolidating the foundation on the one hand, and carry out extension project research in groups on the other hand, ultimately forming research reports or design schemes. At this point, learning outcomes become diverse and visible.

The entire teaching process, from the diagnostic starting point online, to the gradual improvement of abilities through offline interaction, to the personalized exploration of post-class expansion, and finally to the scientific optimization based on data, constitutes a spiral growth loop that is connected end to end and iteratively progresses upwards. Within this loop, knowledge, ability, and quality goals are organically woven into every learning activity. Information technology, like a nervous system, makes the feedback and adjustment of the entire process sharp and efficient, ultimately strongly supporting the implementation of a student-centered and outcome-oriented educational philosophy.

3.3 Evaluation Method

Teaching evaluation is by no means an isolated, stage-based assessment process, but rather a seamlessly integrated and continuously ongoing system for evidence collection and feedback within the teaching process. It aims to capture the "traces" of students' learning outcomes from different dimensions through diverse and calculable methods, and transform quantitative data into actionable insights that drive teaching improvement and individual growth. The evaluation system closely revolves around the three-dimensional goals of "knowledge, ability, and quality", unfolding naturally in three stages: before class, during class, and after class, forming a dynamic evaluation network.

The starting point of the evaluation and the "navigator" of the classroom originate from the pre-class online diagnosis. The pre-class tests completed by students on the smart teaching platform have a significance far beyond a simple "attendance check". The automatic grading of objective questions (such as multiple-choice questions and true/false questions) by the platform can instantly generate quantitative data on the correctness rate of specific knowledge points (such as "Understanding the role of grounding conductors") in the class, as well as the distribution of incorrect options. These data are presented to the teachers in the form of visual charts (such as heat maps, bar charts), serving as a "diagnostic report" for precisely identifying the key points and difficulties of teaching. For example, the data may clearly show that "85% of the students can select that the internal field strength is zero in electrostatic equilibrium, but only 40% of the students can correctly explain the reason why the charge on the outer surface of the grounded conductor cavity is zero". This calculable and comparable data directly drives teachers to adjust the key points and strategies of classroom teaching, achieving the first and pre-intervention of evaluation on teaching.

The evaluation of the classroom teaching process focuses on the embedded observation and recording of high-order thinking and collaborative skills. This is not based on subjective impressions, but is achieved through structured tools for semi-quantitative assessment. In the "Principle Exploration" section, the teacher provides immediate feedback through quick questions or by using the platform's "bullet screen" and "multiple-choice" functions. The system can automatically calculate the participation rate and accuracy rate of students, serving as an immediate indicator of the effectiveness of classroom interaction. In the core "Group Case Analysis" section (such as the Faraday Cage discussion), the evaluation relies on a pre-designed observation rubric that focuses on ability goals. This rubric may include dimensions such as "whether the principle of electrostatic shielding is accurately cited", "whether the analysis involves key variables (such as grounding, mesh size)", "the clarity of logical reasoning", and "the effectiveness of group collaboration". Each dimension is set with 3-4 levels (such as "not reflected", "initial reflection", "good reflection", "excellent reflection"), and corresponding scores are assigned. Teachers and trained teaching assistants can make quick records and ratings during the inspection, and the data on the performance of each group and individual in "Engineering Interpretation Ability" and "Collaborative Communication" can be summarized after class. At the end of the class, the "Brainstorming of Extension Questions" also allows students to submit keywords or short sentences through the platform. Through simple word frequency analysis, it can also reflect the students' thinking divergence and focus points.

The evaluation in the post-class stage is responsible for the consolidation, verification and comprehensive deepening assessment of learning outcomes. It consists of two parts: individual assignments and group projects. For the calculation questions in individual assignments, the platform automatically grades them and directly provides the score rates and typical error reports of the entire class in specific skill points such as "electric potential calculation" and "application of Gauss's theorem". The data is objective and comparable. For the open engineering explanation questions, an analytical scoring scale is adopted, with scoring criteria set around "accuracy of principle application", "completeness of explanation" and "clarity of expression", ensuring the consistency and fairness of the evaluation, and the scoring results are also quantified as analyzable data points.

A more comprehensive evaluation comes from the group project reports (such as "Research on Electromagnetic Shielding Scheme for Electrocardiogram"). For this, we have designed a multi-dimensional project evaluation scale, whose evaluation dimensions directly correspond to the higher-level ability and quality goals: application of knowledge and principles (40%), research and analysis skills (40%), report and presentation (20%).

Based on the class achievement report, teachers can decide whether to create remedial micro-lessons for weak knowledge points or to strengthen certain types of thinking training in subsequent courses. The individual profiles and detailed feedback received by students serve as personalized guidelines for their self-regulated learning and clear determination of their study direction. This comprehensive evaluation system, which is continuous, interlinked, and emphasizes evidence and calculation, ensures that the closed-loop of "continuous improvement" in the OBE concept can be firmly implemented, making teaching truly become a process based on data, precise, and promoting development.

4. Conclusion

Using "Conductor in Electrostatic Field" as an example, this article elaborates on a blended teaching model that integrates OBE (Outcome-Based Education) concepts with information technology. This model, through precise goal planning, activity design that seamlessly blends online and offline elements, and a data-driven evaluation and improvement system, aims to cultivate new-age science and engineering talents who not only possess solid physical knowledge but also have the ability to solve complex engineering problems and the correct values. Practice has shown that such reforms can effectively stimulate students' interest in learning and enhance teaching effectiveness. In the future, with the further development of intelligent education technology, how to more accurately identify individual learning profiles and provide more adaptive learning paths will be an important direction for the continuous deepening of this model. The reform path of college physics teaching will inevitably move towards a new stage that is more "student-centered, outcome-oriented, and continuously improving" with the deep integration of engineering education and the continuous empowerment of information technology.

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