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Application of the PhET Platform in Electrical Physics Education Under the Guidance of the OBE Concept

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Abstract: With the innovation of educational concepts, university physics teaching in Electrical Engineering and Automation has faced the challenge of enhancing student learning outcomes and cultivating engineering thinking. Based on the Outcome-Based Education (OBE) philosophy, combined with the Physics Education Technology (PhET) interactive simulation platform, a more intuitive learning experience was provided to help students understand the fundamentals of physics, address key difficulties, and apply knowledge to real-world engineering problems. This paper explores the integration of the OBE philosophy and the PhET platform in teaching, aiming to improve students' foundational physics knowledge, innovative capabilities, and practical skills, thereby laying a solid foundation for future professional studies.

Keywords: OBE Concept; PhET; University Physics; Teaching Reform; Learning Difficulties

1. Introduction

In the university physics teaching of electrical engineering and automation programs, many concepts are highly abstract and involve complex mathematical derivations, such as electric field distribution and electromagnetic induction. These topics are often difficult to make intuitively understandable through traditional teaching methods, which can affect students' learning outcomes and their ability to apply these concepts in subsequent professional courses [1]. Especially when facing highly abstract physical phenomena, traditional classroom lectures and board-based teaching methods have certain limitations in engaging students' interest and deeply explaining core principles.

In recent years, OBE has gradually become an important approach to improving the quality of higher education [2]. OBE focuses on students' learning outcomes, emphasizing the setting and achievement of learning goals, as well as the depth of knowledge acquisition, skill development, and overall competency improvement. For university physics courses in electrical engineering programs, the introduction of OBE helps students not only understand complex physical concepts but also apply them to real-world problems in their specialized fields, thereby enhancing innovation capabilities and engineering literacy [3-6].

With the rapid development of information technology, the use of digital teaching tools in supporting classroom instruction has become increasingly widespread. One of the widely recognized interactive teaching tools is the PhET platform [7-9]. Developed by the University of Colorado Boulder, PhET aims to help students understand physical concepts more intuitively through dynamic interactive simulations. The PhET platform provides simulation modules covering various areas such as electromagnetism, mechanics, and waves, using visual methods to transform abstract physical principles into interactive scenarios, offering students a more vivid learning experience.

In the context of university physics teaching related to electrical engineering, the PhET platform serves as a supplementary teaching tool, addressing the lack of dynamic process explanations in traditional teaching methods. For example, by simulating electric field line distribution or electromagnetic wave propagation on the PhET platform, students can observe in real-time how changes in parameters affect physical phenomena, deepening their understanding of physical laws. Compared to purely mathematical derivations or static diagrams, this interactive approach is more effective in helping students build intuitive physical models, enhancing their learning interest and comprehension abilities [10-12].

The combination of the OBE concept and the PhET platform can significantly optimize the teaching model of university physics in electrical engineering programs, making students more active and focused in their learning process. This paper will explore the application of the PhET platform based on the OBE concept in university physics teaching for electrical engineering, analyzing its role and significance in helping students overcome learning difficulties, deepening their understanding of abstract concepts, and improving their overall competencies.

2. Integration of OBE Concept with University Physics Teaching

The OBE concept is student-centered, focusing on learning outcomes and promoting the comprehensive development of knowledge, skills, and qualities. In the context of university physics teaching for Electrical Engineering, the OBE concept has not only helped students grasp fundamental physical principles but has also cultivated their problem-solving abilities and innovative thinking. Traditional teaching emphasized knowledge transmission and mathematical derivations, which often failed to address the difficulties students encountered in understanding complex physical phenomena and their practical applications. With the assistance of the PhET platform, the OBE concept has been further expanded. Dynamic simulations have helped students intuitively understand physical principles and apply them to real-world engineering problems. This integration of OBE with the PhET platform is expected to improve students' comprehension and their ability to solve engineering challenges.

2.1 Clearly Defined Learning Outcomes

According to the OBE concept, university physics courses should define objectives at three levels: knowledge acquisition, skill enhancement, and quality development. Traditional courses primarily focused on basic physical knowledge, often neglecting the cultivation of practical application and innovative abilities. Under the OBE framework, learning objectives should be more comprehensive and specific, such as mastering the theories of classical mechanics and electromagnetism, and being able to apply them to real-world problems. The PhET platform, through virtual simulations, has made abstract concepts more tangible. For example, the "Refraction and Reflection of Light" module can visually demonstrate how light behaves when passing through different media, reducing the difficulty of understanding and strengthening the ability to apply knowledge. This integration of PhET with the OBE concept is expected to enhance students' practical application skills and foster innovation in solving engineering problems.

2.2 Teaching Activity Design

The OBE concept emphasizes student-centered teaching design, advocating for interactive teaching activities that enhance student engagement and foster a sense of active learning. In university physics teaching for electrical engineering programs, traditional methods often focus on lectures, with limited classroom interaction, which fails to engage students' interest and does not effectively help them understand abstract and complex physical concepts. To address this issue, the PhET platform can serve as an effective supplementary tool, enabling students to explore and experience core physics concepts in electrical engineering through interactive simulations in a virtual environment. For example, when teaching the interaction between electric and magnetic fields, the PhET platform provides interactive simulations where students can adjust the strength of the electric and magnetic fields, observe the motion of charges, and thereby deepen their understanding of fundamental electromagnetic principles.

The interactivity of PhET allows students to understand abstract physical concepts by simulating experiments, adjusting variables, and observing outcomes. Compared to traditional teaching methods, the PhET platform offers a more flexible and visual learning experience, enabling students to explore independently in the absence of laboratory equipment. Guided by the OBE concept, teachers can design classroom activities based on PhET, leading students through virtual experiments and problem-solving discussions, thereby stimulating students' interest in learning and enhancing their physical reasoning skills. Through this teaching design, students not only gain knowledge through practical experience but also cultivate an exploratory spirit and innovative thinking, improving their ability to apply knowledge in the field of electrical engineering.

2.3 Diversified Assessment Methods

The OBE concept emphasizes diversified assessment methods, focusing on students' continuous progress throughout the learning process rather than solely on final exam grades. In traditional teaching assessments, students are typically evaluated through midterm and final exams to measure their learning outcomes, but this approach fails to comprehensively assess students' overall abilities and practical application skills. Therefore, within the OBE framework, assessment methods should be diversified, combining formative and summative assessments. Formative assessments help teachers monitor students' learning progress and understanding levels throughout the course, allowing for timely adjustments and targeted guidance.

In university physics teaching, the PhET platform, as an auxiliary tool, provides new pathways for diversifying assessment methods. Although PhET is not an assessment tool per se, teachers can evaluate students' depth of understanding and problem-solving abilities based on their participation in the PhET simulation environment. For instance, students can complete PhET-related tasks or engage in group discussions. Teachers can then assess students based on the quality of their discussions, their ability to solve problems, and the effectiveness of their application of knowledge. Additionally, the interactive learning model of PhET allows students to receive immediate feedback and make adjustments. Teachers can also observe students' actions and comprehension processes to identify and address difficulties they encounter during learning.

Beyond traditional written assessments, physics courses under the OBE concept can also assess students' learning outcomes through project evaluations, group collaborations, and learning logs. These assessment methods can more objectively reflect students' abilities in understanding physical concepts, applying physical knowledge, and solving real-world problems.

3. Application of the PhET Platform in University Physics Teaching

The PhET platform, through intuitive and dynamic simulations, has visualized complex phenomena in electrical engineering, assisting students in understanding and applying electrical principles. Although it does not involve actual experimental operations, PhET has simulated phenomena such as circuits, electric fields, and magnetic fields in a virtual environment, providing students with an interactive learning tool that requires no physical equipment. This approach has enhanced students' ability to analyze and solve real-world problems. It is expected that the continued use of PhET will further improve students' practical skills and deepen their understanding of electrical engineering concepts.

3.1 Addressing the Challenges of Abstract Concepts in Physics

Many concepts in university physics are abstract and complex, and students often experience difficulties in understanding them. For example, topics such as Newton's laws in mechanics, electric and magnetic fields in electromagnetism, and imaging principles in optics are often challenging to convey directly to students through traditional classroom lectures and board writing. Particularly when students rely solely on textual descriptions and mathematical formulas to grasp physical concepts, they lack direct sensory experience and hands-on interaction, which can lead to cognitive barriers.

The PhET platform, by offering interactive virtual experiments, helps to visualize abstract physical concepts, allowing students to understand and experience these challenges more intuitively. For example, in the mechanics unit, PhET's "Force and Motion" simulation module enables students to adjust parameters such as the magnitude and direction of forces, and the mass of objects, allowing them to simulate and observe changes in motion under different conditions. Through this interactive experiment, students can visually observe the relationship between force and motion, deepening their understanding of fundamental mechanics principles and enhancing their comprehension of concepts like Newton's laws, acceleration, and friction.

Similarly, the "Refraction and Reflection of Light" module on PhET allows students to observe the behavior of light in a virtual environment, especially focusing on refraction phenomena across different media. This approach, where abstract concepts are learned through experimental simulations, enables students to derive physical laws from actual experimentation rather than relying solely on theoretical derivation.

3.2 Helping Students Understand Challenging Physics Experiments

In university physics teaching for electrical engineering students, some experiments are hindered by the high cost of equipment, complex operations, or safety risks, leading many institutions to either be unable to conduct these experiments or cause students to make errors during the practical sessions. This limitation affects students' deep understanding of electrical physics principles and the development of their practical application skills. The PhET platform, as an auxiliary teaching tool, effectively addresses this gap by providing interactive virtual simulations, allowing students to understand and master key concepts in electrical physics without the need for actual experimental equipment.

For example, in the electromagnetism section, PhET offers modules such as "Electric Fields and Potentials" and "Current and Circuits," where students can adjust parameters such as current, voltage, and resistance to observe changes in current and voltage within the circuit and simulate the behavior of various circuit components. Compared to traditional experiments, PhET's virtual simulations can accurately demonstrate electrical phenomena, allowing students to intuitively understand the relationship between current, voltage, and resistance, and deepen their understanding of fundamental principles such as Ohm's law and Kirchhoff's laws, all without the need for physical equipment. Through this interactive learning method, students not only enhance their theoretical understanding but also apply it in practice, compensating for the lack of equipment and effectively improving their circuit analysis skills and experimental abilities.

The virtual teaching capabilities of the PhET platform help reduce operational errors that might occur in traditional experiments, allowing students to simulate and practice experiments multiple times. This enables them to better master experimental skills, overcome equipment and operational limitations, and significantly enhance their learning outcomes.

3.3 Enhancing Students' Analytical and Reasoning Abilities

Another notable feature of the PhET platform is its ability to stimulate students' analytical and reasoning skills. Unlike traditional teaching, which is often teacher-centered, PhET offers an interactive learning environment that places students at the center. Through simulations, students adjust conditions and observe results, thereby discovering the underlying patterns of physical phenomena. By exploring how different parameters influence outcomes, students gain a deeper understanding of the cause-and-effect relationships and fundamental principles in electrical engineering.

For example, in the "Electric Fields and Electromagnetism" simulation module, students can freely adjust the strength and direction of electric and magnetic fields, as well as the quantity of charges, and observe how these changes affect the motion of charges. This simulation approach allows students to not only visually observe how charge behavior changes in electric and magnetic fields, but also engage in deeper analysis and reasoning, exploring the interrelationships between various variables and summarizing patterns through continuous adjustments. Through this exploration, students develop a better understanding of and ability to apply core concepts in electrical engineering, such as electromagnetic waves and the interaction between electric and magnetic fields.

This interactive learning method enhances students' analytical and problem-solving abilities while reinforcing their practical application skills in the field of electrical engineering. Through simulations and virtual experiments, the PhET platform enables students to grasp abstract principles in electrical engineering without the need for physical equipment, thus providing them with a more flexible and hands-on learning experience.

4. Teaching Design Integrating the OBE Concept with the PhET Platform

The university physics teaching design based on the OBE concept and the PhET platform is shown in Figure 1. This teaching design emphasizes a student-centered, outcome-oriented approach, utilizing the interactivity and visualization features of PhET to enhance learning outcomes, help students overcome difficulties, and achieve learning goals. This approach has been proven to improve students' understanding of complex concepts and foster greater engagement with the material. It is expected that the continued integration of OBE with the PhET platform will further enhance students' ability to apply theoretical knowledge to practical problems and improve their overall learning experience.

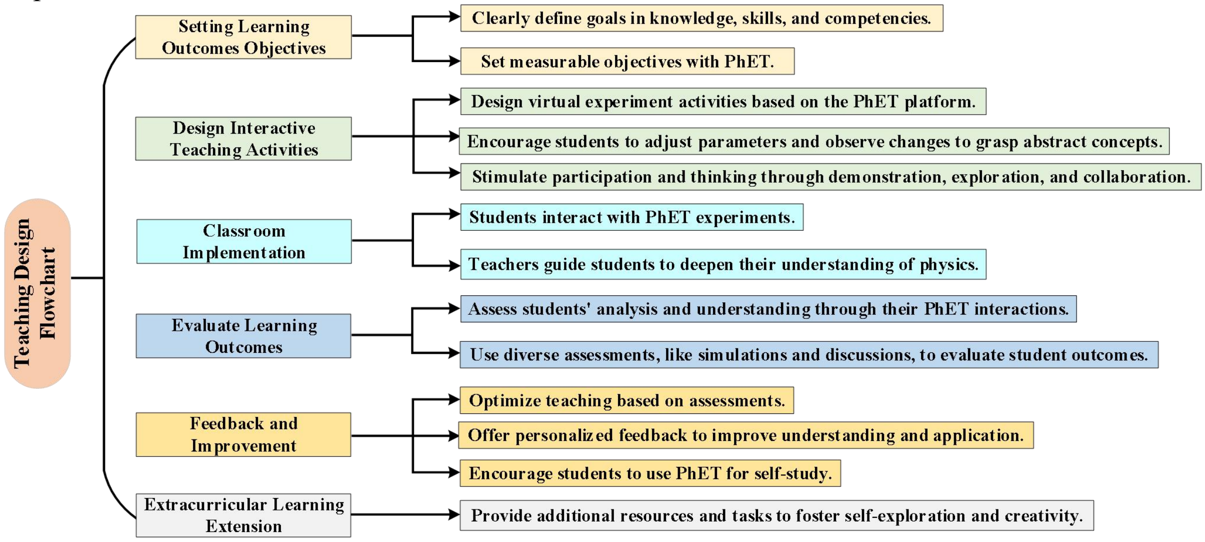

Figure 1. Teaching Design Flowchart Based on the OBE Concept and PhET Platform

4.1 Setting Clear Learning Outcome Objectives

According to the OBE philosophy, the goals of university physics teaching are not limited to the transmission of knowledge but should also focus on enhancing students' abilities and overall qualities. The teaching objectives for each physics unit should be set in conjunction with the supportive role of the PhET platform, ensuring that the goals are clear and can be achieved through specific learning activities. For example, in the optics section, the learning objectives should include students being able to understand the principles of light reflection, refraction, and imaging through PhET simulation experiments, and apply this knowledge to solve real-world physics problems.

Through such goal-setting, students not only learn the theory but also integrate theory with practice using PhET's interactive functions, helping them form a more intuitive understanding. This approach enables students to deepen their comprehension and apply their knowledge in practical scenarios, supporting their overall development in both theoretical and practical aspects of physics.

4.2 Designing Interactive Teaching Activities

The design of teaching activities should be centered around the principles of the OBE, focusing on the development of students' learning abilities and problem-solving skills in practical contexts. With the support of the PhET platform, teachers can design interactive learning activities that allow students to gain a deeper understanding of abstract physical concepts through virtual simulation experiments. While PhET does not involve actual physical experiments, it helps students "experience" physical phenomena through simulation. For instance, in electromagnetism teaching, the electric field and magnetic field simulation tools provided by PhET enable students to adjust the strength of electric and magnetic fields and observe the motion trajectories of charges. This interactive learning helps students better understand the fundamental principles of electromagnetism, and allows them to engage in effective learning and exploration even without physical experimental equipment.

In the teaching design, teachers can use the PhET platform for demonstrations, guide students in exploration, or encourage group collaboration. By adjusting parameters and observing changes, teachers help students understand physical phenomena from different perspectives. Through this interactive learning approach, students not only deepen their understanding of knowledge but also develop their thinking and problem-solving abilities.

4.3 Assessing Students' Learning Outcomes

Under the guidance of the OBE philosophy, teaching assessment should not be limited to midterm and final exams, but should also focus on the continuous progress of students throughout the learning process. Therefore, the assessment methods should be more diversified. Although the PhET platform itself does not provide task reports or group project evaluation features, teachers can indirectly assess students' mastery of physical concepts and their practical application abilities by observing their operations and participation on the PhET platform.

For example, teachers can require students to use the PhET platform to conduct a specific simulation experiment during class, observe how students operate and adjust parameters, and assess their analytical abilities and depth of understanding based on their performance during the simulation. Additionally, teachers can further assess students' ability to apply physical principles in real-world contexts through classroom discussions or group collaboration activities. This assessment approach not only focuses on students' mastery of theoretical knowledge but also emphasizes their practical application skills and problem-solving abilities.

5. Conclusion

The reform of university physics teaching for electrical engineering, based on the OBE concept and the PhET platform, has overcome the challenges students face in understanding abstract physical concepts. Through interactive learning, it has enhanced students' analytical, reasoning, and innovative abilities, achieving the student-centered teaching objectives. The PhET platform, through visual simulations, has helped students gain a deeper understanding of complex principles such as circuits and magnetic fields, and apply theory to practice, thereby improving their problem-solving skills. The integration of clear goals and diversified assessments based on the OBE concept has ensured students' continuous progress and the achievement of desired outcomes. Looking ahead, the PhET-based teaching model will continue to evolve, providing strong support for the cultivation of highly skilled engineering professionals.

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References

[1] L. Yang, Y. Zhong, H. Liu. Exploration and Practice of Reforming the Teaching Mode of College Physics Courses under the Background of Industry 4.0. The Guide of Science & Education, 2024, (08): 109-111.
[2] A. L. Wang, X. J. Wu. Exploration of Teacher Training Practice of New Curriculum Standard Based on Concept of OBE. Teaching & Administration, 2024, (06): 49-53.
[3] T. Wang, J. S. Feng, Y. K. Li, et al. Project-Driven Open Experimental Teaching Based on Obe Education Concept. Physical Experiment of College, 2022, 35 (04): 127-130.
[4] D. K. Li, L. Chen. Discussion on the Educational Reform of College Physics Course in Local Undergraduate Universities under OBE Concept. China Journal of Multimedia & Network Teaching, 2022, (06): 103-106.
[5] H. Lu, Y. Liu. Exploration of Blended Teaching Practice in College Physics

based on OBE Trinity. Journal of Guizhou University of Engineering Science, 2024, 42 (03): 112-117.
[6] S. Mihardi, D. Derlina, W. Bunawan, et al. Evaluating the Impact of Case-Based Teaching Materials in Physics Towards Obe Curriculum. Jurnal Curere, 2024, 8 (2): 216-222.
[7] C. J. Shao, G. G. Zhou, Z. Q. Yang, et al. Looking at the Construction of Physical Virtual Simulation Experiment Teaching Project in Domestic Universities from PhET. Physical Experiment of College, 2019, 32 (05): 118-122.
[8] Q. R. Huang. Research on Teaching Strategies of Physics Concepts Based on the Integration of PhET and PBL. Hubei University, 2024.
[9] B. C. Xie. Applied Research and Practice of "Students' Required Experiments" Teaching in High School Physics Based on PhET. Guangzhou University, 2024.
[10] F. Zahra, R. Oktavia, A. Azhar, et al. The Effect of Problem-Based Learning Assisted with Phet Simulation on Students' Learning Outcomes of Light and Optical Devices Optics Topic. Science Education Journal, 2024, 7 (1): 28-36.
[11] L. Ucho. Enhancing Physics Education Using Phet for Sustainable Stem Education in Nigeria. EdoCoE Technical and Vocational Education and Training Research Journal (EDOCOETEVTRJ), 2024, 1 (1): 52-58.
[12] R. J. James. Introducing Phet as a Physics Lecture Simulation Software: Implication for Effective Stem Education. International Journal of Functional Research in Arts and Humanities (IJFRAH), 2024, 3 (2).