Teaching Practice of an "Online - Offline Blended + Project-Based Learning" Model in Power System Courses

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Abstract: Power system courses are core subjects in electrical engineering programs. They are theory-intensive, highly abstract, and strongly engineering-oriented. In traditional lecture-based teaching, students often rely on passive learning. Their engagement is limited, and their ability to connect theoretical analysis with real power system operation remains weak. These issues negatively affect learning outcomes and practical competence. To address these problems, this study proposes and implements an "online-offline blended + project-based learning" teaching model for power system courses. Online learning modules are used to support the acquisition of foundational knowledge, including basic concepts, analytical methods, and typical calculation procedures. Offline classroom sessions focus on key theories, difficult points, and problem-oriented discussion, helping students build a structured understanding of power system operation. Project-based learning is introduced in the later stage of the course. Students work in small groups to complete engineering-oriented tasks, such as power flow analysis and fault calculation for typical power systems. Through project design, model establishment, calculation, and result evaluation, students are guided to apply theoretical knowledge in realistic engineering contexts. Teachers act mainly as facilitators and mentors, emphasizing analytical logic and engineering assumptions rather than numerical results alone. Teaching practice shows that the proposed model effectively improves student motivation, classroom participation, and engineering thinking ability. Students demonstrate stronger problem-solving skills and a clearer understanding of power system analysis. This teaching approach provides a practical reference for instructional reform in power system education and other engineering-oriented courses.

1. Introduction

Power system courses are core components of electrical engineering and related programs[1]. They provide a systematic introduction to power system structure, operating principles, and analytical methods[2]. Course content typically includes power flow analysis, short-circuit calculation, voltage stability, and system operation and control. The course plays a bridging role in the curriculum. It forms the foundation for understanding power grid operation and supports advanced study and engineering practice. However, power system courses are inherently theory-

intensive[3]. They rely heavily on mathematical models. Many concepts are highly abstract. As a result, the course places high demands on students' conceptual understanding and engineering awareness. In traditional teaching, instruction is mainly lecture-based. Emphasis is placed on theoretical derivation and formula-based calculation. Students learn primarily by listening and completing homework problems. Active participation in class is often limited[4,5].

From a learning-outcome perspective, many students can complete standard example problems[6]. However, their understanding of overall system operation remains superficial. Connections between engineering background, operating conditions, and analytical methods are often unclear. Students struggle to form a coherent system-level understanding. When faced with problems of moderate engineering complexity, they frequently show unclear analytical logic and unrealistic modeling assumptions. Practical engineering ability is therefore weak. In addition, the widespread availability of online learning resources has increased students' reliance on ready-made solutions and calculation results. Attention to analytical processes and engineering reasoning is often insufficient[7,8]. This fragmented and result-oriented learning style weakens students' understanding of the essence of power system analysis. It also limits the development of engineering thinking and problem-solving skills[9].

Overall, traditional teaching approaches show clear limitations. Student motivation remains low. Engineering orientation is insufficient. Comprehensive ability development is constrained. How to maintain theoretical rigor while encouraging active learning, and how to link abstract theory with real power system operation, have become key challenges in power system teaching reform.

2. Necessity and Advantages of Blended and Project-Based Teaching in Power System Courses

Power system courses are highly interdisciplinary and strongly application-oriented. They integrate knowledge from circuit theory, electrical machines, power electronics, control theory, and engineering mathematics. Students are required not only to understand theoretical models, but also to apply them to complex and dynamic power system scenarios. Traditional lecture-based teaching or single-mode online instruction cannot fully meet these learning demands.

Online-offline blended teaching combines the strengths of face-to-face instruction and digital learning. Online resources allow students to study foundational concepts at their own pace[10]. Key theories and calculation methods can be reviewed repeatedly. This flexibility helps reduce cognitive overload in class. Offline sessions focus on concept clarification, system-level understanding, and problem-oriented discussion. Teachers can respond directly to students' difficulties and guide deeper thinking. This interaction strengthens knowledge integration and conceptual understanding.

Project-based learning emphasizes learning through practice. Students work in groups to complete engineering-oriented tasks that reflect real power system problems. Typical projects involve power flow analysis, fault calculation, or operational scenario evaluation. During the project process, students search for information, establish models, make assumptions, and analyze results. Knowledge is acquired and reinforced through application rather than memorization. This approach promotes active learning and collaboration.

The combination of blended teaching and project-based learning creates a coherent learning pathway. Online learning builds the knowledge framework. Offline teaching connects and reinforces key ideas. Project tasks provide a context for comprehensive application. Students gradually shift from passive knowledge reception to active problem solving. Their system-level thinking and engineering awareness are strengthened.

Overall, the "online-offline blended + project-based learning" model aligns well with the characteristics of power system courses. It supports theoretical rigor while enhancing practical

relevance. The model effectively improves student engagement, learning depth, and engineering competence. It provides a feasible and effective approach for teaching reform in power system education.

3. Design of the "Online – Offline Blended + Project-Based Learning" Teaching Scheme

Considering the strong theoretical nature, complex engineering background, and high interconnection of knowledge in power system courses, an "online–offline blended + project-based learning" teaching scheme is designed. The scheme focuses on student ability development. It follows a three-stage structure: foundational knowledge preparation, engineering project practice, and summary and reflection. Through this structure, a systematic teaching reform is achieved.

3.1. Design of Online – Offline Blended Teaching

The primary goal of blended teaching is to help students build a solid understanding of power system fundamentals and analytical methods. This stage provides the knowledge foundation for subsequent project-based learning.

First, an online resource platform is established for the power system course. Online materials include short lectures on core concepts, videos explaining typical analysis methods, worked calculation examples, and supporting quizzes. Students complete online learning tasks independently according to their own learning pace. Key topics, such as power flow analysis and short-circuit calculation, can be reviewed repeatedly. This process improves comprehension of essential knowledge.

Second, offline classroom teaching focuses on problem-oriented guidance and system-level integration. Based on feedback from online learning, instructors provide targeted explanations of key theories and commonly confused concepts. Classroom sessions emphasize the construction of a coherent knowledge framework for power system analysis. Several core questions are introduced in each class. Students are guided to discuss operating mechanisms, modeling assumptions, and analytical logic. Classroom interaction is therefore strengthened.

In addition, teaching content and pace are adjusted according to students' academic background and learning progress. Classroom quizzes, in-class questions, and open-ended assignments are used to monitor learning status. These measures increase student participation and learning initiative.

3.2. Design of Project-Based Learning

Project-based learning is introduced in the later stage of the course. The focus is on developing students' ability to apply theoretical knowledge to engineering-oriented problems. Projects are carried out in small groups of five to six students to ensure full participation.

(1) Formation of learning groups

Students are divided into several groups. A group leader is assigned in each group. The leader is responsible for task coordination, workload distribution, and progress management.

(2) Definition of project tasks

Project topics are designed based on course content and available teaching resources. Typical projects include power flow analysis of distribution networks and fault calculation with impact evaluation. Project difficulty is controlled at an appropriate undergraduate level. Emphasis is placed on engineering logic and analytical reasoning.

(3) Project assignment

Projects are assigned through random selection or instructor arrangement to ensure fairness and balance among groups.

(4) Project implementation

Project implementation is conducted in multiple stages. First, each group clarifies analysis objectives and collects system parameters and operating conditions. A power system model is then established. Appropriate analysis methods are selected based on engineering assumptions and relevant standards. Instructors organize stage-based discussions. Feedback focuses on modeling ideas, assumption validity, and result interpretation.

After calculations are completed, groups organize and analyze results. The influence of operating conditions and parameter variation on system behavior is discussed. A complete project report is prepared.

(5) Presentation of project outcomes

Each group presents its project outcomes through oral reports or short videos. Presentations include analytical approaches, calculation procedures, result discussion, and identified limitations. This process promotes peer learning and academic exchange.

(6) Summary and evaluation

Instructors conduct a comprehensive evaluation of each group's performance. Assessment focuses on analytical logic, engineering rationality, teamwork, and completeness of outcomes. Students are guided to reflect on challenges encountered during project implementation and possible improvement strategies.

3.3. Process-Oriented Course Assessment Design

To comprehensively evaluate teaching effectiveness, a combined assessment approach is adopted. Continuous assessment and final examination are equally weighted. Continuous assessment accounts for 50% of the total grade and includes online learning performance, classroom participation, and project outcomes. The final examination accounts for the remaining 50% and focuses on students' understanding and application of core power system theories and analytical methods.

This multi-dimensional assessment system emphasizes both knowledge mastery and engineering analysis ability. Based on assessment results, instructors conduct teaching reflection and make continuous improvements to the teaching scheme, thereby enhancing overall teaching quality.

4. Teaching Outcomes and Reflection

The implementation of the "online–offline blended + project-based learning" model has received positive feedback from both students and peers. Students participated in the course as active learners and problem solvers rather than passive recipients of knowledge. Their engagement in classroom activities and project tasks increased noticeably.

Through collaborative project work, students demonstrated stronger initiative and responsibility. They actively searched for information, discussed analytical approaches, and refined their modeling assumptions. The frequent interaction between instructors and students promoted deeper thinking. Students gradually developed a clearer understanding of power system operation and analysis. Their ability to integrate theoretical knowledge with engineering scenarios improved.

Project-based learning also enhanced teamwork and communication skills. Group members were required to coordinate tasks and share responsibilities. During project implementation, students learned to address challenges related to data availability, modeling simplification, and result interpretation. These experiences strengthened their problem-solving ability and engineering awareness.

Despite these positive outcomes, several issues were observed during teaching practice. Some students felt that the workload of project tasks was relatively high. A small number of students

showed limited motivation and relied excessively on group leaders. In addition, insufficient preparation before class affected the effectiveness of in-class discussion. During project execution, knowledge gaps sometimes led to superficial analysis and reduced project quality.

Based on reflection, several improvement strategies are proposed. First, the structure and workload of project tasks should be further optimized. Tasks with different levels of difficulty can be combined to accommodate students with varying abilities. Second, greater emphasis should be placed on pre-class preparation. Online learning data can be used to monitor student engagement and provide timely guidance. Third, communication between instructors and group leaders should be strengthened to ensure balanced participation. Fourth, a peer evaluation mechanism within groups can be introduced to enhance responsibility and motivation. Finally, project topics can be more closely connected to practical power system scenarios to increase relevance and learning effectiveness.

Overall, the proposed teaching model effectively improves student engagement and learning outcomes. Continuous reflection and iterative improvement are essential to further enhance teaching quality and support sustainable instructional reform.

5. Conclusions

This study explored the application of an "online–offline blended + project-based learning" model in power system courses. The teaching design integrates online knowledge acquisition, offline conceptual clarification, and engineering-oriented project practice. Teaching results show that the model improves student engagement and learning effectiveness. Students participate more actively in classroom activities and project tasks. Their understanding of power system analysis becomes clearer, and the connection between theoretical knowledge and engineering scenarios is strengthened. Project-based learning plays a key role in this process. Through collaborative tasks, students gradually develop analytical logic and modeling awareness. They learn to consider engineering assumptions and result interpretation rather than focusing only on numerical calculation.

Overall, the proposed teaching model provides a practical approach for improving power system course instruction. It supports the development of engineering thinking, teamwork, and problem-solving ability, and offers useful reference for teaching reform in other engineering courses.

Acknowledgements

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