

Exploration of the Application of "BOPPPS+PBL" Teaching Mode in The Basic Course of Circuit Analysis

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Abstract: In response to the common problems of insufficient learning initiative and lack of engineering application and practical ability among college students in the course of "Fundamentals of Circuit Analysis", this study focuses on cultivating high-quality applied innovative talents, deeply integrating the effective teaching structure of the "BOPPPS" model with the "PBL" teaching concept, and constructing a "BOPPPS+PBL" hybrid teaching mode. This model relies on the Rain Classroom intelligent teaching tool and combines professional characteristics to innovate and practice the teaching objectives, content, activities, and evaluation of the course, aiming to stimulate students' learning motivation, strengthen their ability to analyze and solve complex engineering problems, effectively improve the quality and effectiveness of classroom teaching, and provide a reference path for the teaching reform of basic engineering courses in universities.

Keywords: Models of teaching, BOPPPS, PBL, Fundamentals of circuit analysis.

1. Introduction

With the deepening of national strategies such as "Made in China 2025" and "New Engineering Construction", new and higher requirements have been put forward for the quality of higher engineering talent training. Higher education urgently needs to transform traditional teaching models and cultivate high-quality talents with solid theoretical foundations, excellent engineering practical abilities, and innovative spirit. As a core foundational course in electrical engineering, the teaching quality of "Fundamentals of Circuit Analysis" is directly related to the learning of subsequent professional courses and the career development of students. Reforming its teaching is an inevitable requirement in line with the development of the times.

PBL teaching method is a student-centered teaching model that is driven by problems in real or simulated situations. In this process, teaching has shifted from a lecture style to a method that triggers students' independent exploration through specific questions. Students use their existing knowledge system to search for the information and knowledge they need, collaborate in teams, discuss together, and seek answers. The BOPPPS model consists of six elements: Bridge in, Objective, Pre assessment, Participation, Post assessment, and Summary. This model is the crystallization of many excellent teachers' teaching practices, which extracts the core elements of a lesson into a modular framework with clear structure, strong operability, and easy mastery. Reference [1][2] elaborates on the basic theory and methods of PBL model, the content and mechanism of students' learning in PBL are extensively explored in reference [3-5], Reference [6] systematically introduces the BOPPPS model and its applications, A large number of active learning strategies applicable to engineering education are proposed in reference [7][8], Under what conditions is PBL more effective, as discussed in reference [9-11].

The core objective of this study is to explore the integration path of BOPPPS teaching model and problem-based learning (PBL) teaching method, and to apply it to the teaching practice of the undergraduate course "Fundamentals of

Circuit Analysis" by combining it with the Rain Classroom intelligent teaching tool. Through this integration model, we strive to stimulate students' intrinsic learning drive, promote the connection between theoretical knowledge and practical problem-solving abilities, and enhance students' level of independent exploration and teamwork skills.

2. Situation Analysis

2.1. Discipline Introduction

Circuit Analysis Fundamentals is a fundamental course for undergraduate students majoring in electronics, communication, electrical engineering, and other related fields. The knowledge system of this course (Table 1) can be briefly summarized as follows: one relationship, two constraints, three types of circuits, and four basic methods.

A relationship: the relationship between "motivation" and "response". Given the circuit structure, component parameters, and independent power source (excitation), solve for the voltage, current, or power (response) of each part in the circuit. This is the essence of analysis that runs through the entire course.

Two types of constraints: topological constraints and component constraints are the fundamental basis for writing circuit equations and solving circuits. Topological constraints Kirchhoff's law (KCL, KVL); Element Constraint Voltage Voltage Relationship (VCR).

Three types of circuits: resistive circuits, dynamic circuits, and sinusoidal steady-state circuits. These are three major analysis objects divided according to circuit components and excitation properties, with increasing difficulty.

Four basic methods: equivalent transformation method, system equation method, decomposition method, and phasor method. The core idea of equivalent transformation method is to simplify complexity. Replace a complex part of the original circuit with a simpler circuit (equivalent circuit) to simplify the analysis. The core idea of system equation method is "solving equations". Such as branch current method, mesh current method, and node voltage method. The core idea of the decomposition method is to "break down the whole into

smaller parts". Decompose complex circuits into several simple problems and solve them separately, then synthesize

them through superposition. The core idea of phasor method is "solving in transform domain".

Table 1. Overview of Core Circuit Analysis Concepts

	Category	Name	Description	Details
1	Core	Input & Output	Find output (V, I, P) from input (source, parts).	Main goal.
2	Rules	Structure (KCL/KVL) Parts (VCR)	Laws from how parts are connected. How each part behaves (e.g., $V=IR$).	Topology constraints. Element constraints.
3	Types	DC/Resistive	Has resistors. Simplest.	Linear, instant response.
		Dynamic	Has C or L. Uses calculus.	Differential eqns.
4	Tools	AC/Steady-State	Sine waves, stable. Uses phasors.	Complex numbers.
		Simplify	Replace complex part with simple one.	Equivalent circuits.
		Solve Equations	Write & solve system of eqns.	Node/Mesh analysis.
		Split Up	Solve parts separately, add results.	Superposition.
		Phasors	Use complex numbers for AC.	Transform domain.

2.2. The main problems in current course teaching

The disconnect between teaching and students' cognitive foundation: a "castle in the air" style of teaching. Theoretical teaching often starts directly from abstract circuit theory and complex mathematical formulas, believing that students "should know". Lack of problem introduction (such as "in order for mobile phones to receive signals at specific frequencies, we need to first learn to analyze the resonant circuit we are talking about today") is not conducive to cultivating students' innovative thinking ability, comprehensive application ability of multidisciplinary knowledge, and computational thinking ability. In addition, during experimental teaching, it is also believed that students have "mastered" theoretical knowledge, separating experiments from theory. Experiments and projects should be tools for theoretical mastery, helping to deepen students' understanding of theoretical knowledge and further apply it in practice.

The teaching content is disconnected from professional applications: the course content is becoming 'lazy'. The course content is limited to theoretical deduction and ideal model calculation within the discipline, and fails to establish clear and strong connections with the professional background of communication engineering and other disciplines. Teaching outside of application scenarios can easily lead to 'lazy knowledge', which students forget after taking the exam and cannot access, such as learning about resonant circuits but not understanding how they can be used for frequency selection in RF communication. Students cannot see the usefulness of the knowledge they have learned, cannot feel the guidance for future career development in related majors, and lack a sense of meaning and purpose in learning.

The assessment method lacks process evaluation: 'One exam determines the universe'. The course evaluation system overly relies on a one-time final written test, with

assessment content emphasizing calculation and formula memory, which cannot comprehensively measure students' practical ability, innovative thinking, and problem-solving process. In the long run, it is not conducive to students becoming qualified "engineers". When exams become the determining factor, the greatest external motivation for learning becomes passing exams, which in turn reinforces

teachers' "cramming" teaching and students' "brushing" learning, further exacerbating the disconnect between theory and application, knowledge and foundation.

3. Application of the "BOPPPS+PBL" Teaching Mode

This teaching model injects PBL as the core content into each stage of BOPPPS, and the teaching process is shown in Table 2. Taking the section on "Thevenin's Theorem" as an example, explain the specific teaching implementation process.

3.1. Bridge in (3 minutes): Create real-life problem scenarios to stimulate interest

PBL problem import: Show a real engineering scenario: "A technology team is making an external speaker (speaker) for an old phone. They found a speaker, but don't know its optimal working point. Now there is only one adjustable power supply and multimeter. How to quickly find the power supply voltage and internal resistance that can make this speaker output the maximum sound (obtain the maximum power)"

Purpose: To quickly capture students' attention and make them realize the practical application value of the knowledge in this chapter, shifting from "I have to learn" to "I want to learn".

3.2. Objective (2 minutes): Clear learning objectives and clear navigation

Clearly inform students that after the end of this lesson, they will be able to:

Knowledge objective: To state the content of the Thevenin theorem.

Ability objective: Solve the Thevenin equivalent circuit of any linear source containing two terminal network.

Literacy objective: Apply this theorem to solve practical engineering problems such as maximum power transmission.

Purpose: To enable students to learn with clear objectives and targeted learning.

Table 2. “PBL+BOPPPS” teaching process

	BOPPPS Phase	PBL Integration Strategy	Teacher's Role	Students' Role
1	Bridge-in (B)	Create an authentic engineering scenario and pose a driving question.	Scenario Creator	Problem Perceiver
2	Objective (O)	Clarify knowledge objectives and competency objectives.	Goal Setter	Goal Acceptor
3	Pre-assessment (P)	Diagnose gaps in prerequisite knowledge required to solve the problem.	Diagnostician	Self-Assessor
4	Participatory Learning (P)	Core Phase. Group collaboration: analyze the problem, break down tasks, learn knowledge, calculate/simulate/validate solutions.	Facilitator, Consultant, Resource Provider	Active Investigator, Collaborator
5	Post-assessment (P)	Evaluate problem-solving outcomes.	Evaluator	Presenter of Results
6	Summary (S)	Summarize key knowledge points, refer back to the initial problem, and facilitate extension and transfer.	Synthesizer	Reflector

3.3. Pre assessment (5 minutes): Diagnose learning situation and determine teaching based on learning

Publish 2-3 multiple-choice questions through Rain Classroom: What is a 'two terminal network'? Review the equivalent transformation of "voltage source" and "current source".

Purpose: To quickly diagnose students' mastery of key prerequisite knowledge, provide a basis for subsequent intensive lectures, and achieve precise teaching.

3.4. Participatory Learning (30 minutes): PBL project driven, exploring new knowledge

Task Release: Transform the initial "external speaker" question into a specific project task - "Exploring the Best Companion for Speakers: Unveiling the Davinan Equivalent Circuit".

Exploration Practice (15 minutes): Students work in groups and use Multisim simulation software to build a linear network with a source (simulating a mobile phone audio output circuit) and a speaker (resistor) as a load: Task 1: Measure the power under different load resistances and find the maximum power point; Task 2: Attempt to use different methods (experimental and computational) to find the "simplest equivalent circuit" that can generate the same maximum power.

Discovery and Summary (15 minutes): Each group shares their findings. The teacher guided the students to compare the results and ultimately concluded that "any complex linear two terminal network with a source can be equivalent to a series connection of a voltage source and a resistor. On this basis, the teacher will elaborate on the formal expression of the Thevenin theorem and the standard method steps for solving the equivalent circuit.

Purpose: To enable students to experience the complete process of discovering problems, practical exploration, and summarizing laws like "scientists", and to deeply understand the essence of theorems rather than memorizing formulas.

3.5. Post assessment (5 minutes): Real time evaluation

Post a layered application question in Rain Classroom:

Basic layer: Given a simple circuit, find its Thevenin

equivalent circuit.

Enhancement layer: On the base layer, calculate the maximum power when calculating the load value. Students complete the submission in class, and the system generates real-time statistical results. Teachers provide real-time feedback and consolidation on areas with high error rates.

Purpose: To test the achievement of the core objectives of this lesson and achieve a closed-loop teaching.

3.6. Summary (5 minutes): Sublimation and Expansion

Teacher's summary: Reiterate the core idea of the Davidian theorem and its enormous value in circuit simplification, system analysis, and maximum power transmission (such as antenna impedance matching and sound system design).

Extension: Propose a thought-provoking question: "What is the relationship between Norton's theorem and Thevenin's theorem? Under what circumstances is Norton's theorem more convenient to use?" This lays the groundwork for the next lesson.

Purpose: To organize the knowledge structure, elevate the knowledge points from engineering applications to methodological level, and establish connections with subsequent course content.

4. Teaching Innovation and Characteristics

4.1. Mode innovation

The organic integration of the "BOPPPS" framework and the "PBL" concept: The rigorous structure of BOPPPS ensures the effectiveness and closed loop of classroom teaching, and the real problems of PBL are used as the main thread throughout, inspiring students to actively explore and achieving the unity of "teacher led" and "student led".

4.2. Content innovation:

"Experimental exploration" is used to reverse "theoretical generation": changing the order of "theorems first, questions later", allowing students to first observe phenomena and draw conclusions through simulation experiments before learning theories, effectively reducing the cognitive load of students in private universities and resolving the boredom of abstract theories.

4.3. Evaluation innovation:

"Instant and procedural" data-driven teaching: using information technology tools (Rain Classroom) for pre-test and post test, realizing teaching decisions based on real-time data, evaluation is more timely and accurate, and runs through the entire learning process.

5. Teaching Effectiveness and Reflection

Effect: This model has achieved significant results in teaching. Student classroom participation and attendance rate have significantly increased; Showing a strong desire for knowledge and collaborative spirit in project exploration; After class feedback indicates that students have a much better understanding and application ability of theorems than previous students.

Reflection: This model places higher demands on teachers' teaching design and classroom control abilities. In the future, it is necessary to further enrich the PBL project case library and explore how to use generative AI technology to provide more differentiated project tasks and guidance for different groups, in order to achieve personalized teaching to the extreme.

Summary: The "BOPPPS+PBL" teaching model effectively transforms the classroom from a "knowledge imparting field" to a "ability generating field", which is very suitable for promotion and application in engineering basic courses in various universities. It is an effective path to cultivate high-quality applied talents.

6. Conclusion

This teaching model takes "project as the soul, student as the foundation, and AI as the wing", and has comprehensively and fully reshaped the course of "Fundamentals of Circuit Analysis". It effectively solves the pain points of traditional teaching, significantly enhances the high-level, innovative,

and challenging nature of the curriculum, and provides an effective solution for cultivating new engineering talents with solid theoretical foundations, excellent engineering practical abilities, and innovative thinking.

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