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Exploration of Hybrid Teaching Mode in the Course of "Fundamentals of Circuit Analysis"

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Abstract: Circuit analysis fundamentals are fundamental courses in electronic-related majors, aiming to cultivate students' basic electrical knowledge and problem-solving abilities. The course covers a wide range of content and has both theoretical and practical aspects. In the teaching process, we have consistently adhered to a student-centered approach and continuously explored and improved our teaching methods. We have developed a blended teaching model that integrates online self-study, offline guided learning, in-class theoretical knowledge, extracurricular hands-on practice, virtual simulation operations, and practical project training.

Circuit analysis fundamentals is a crucial foundational course for majors such as electronic information science and technology, electronic information engineering, and communication engineering. It serves as the first step in cultivating students' electrical literacy. The course mainly focuses on studying and researching the basic principles, basic components, fundamental analysis methods, and applications of circuits. Prerequisite courses include college physics, advanced mathematics, and the following courses in the curriculum are analog electronic circuits, digital electronic circuits, high-frequency electronic circuits, etc. In the entire curriculum system, this course plays a pivotal role in bridging the gap between earlier and later courses.

In recent years, with the advancement of the "Internet+ education," higher education has been continuously reformed and developed. The blended teaching model based on MOOCs (Massive Open Online Courses) has gradually become the norm in education. The key focus of this model is to put "students at the center," utilizing information technology as a medium and combining online and offline methods to prioritize students' learning experiences.

This paper, considering the rigorous theoretical nature, strong logicality, practicality, and the rich engineering knowledge content of the circuit analysis course, as well as the specific characteristics of the students, explores a blended teaching approach that integrates online and offline components, theoretical and virtual simulations, as well as experiments and activities both inside and outside the classroom.

1. Teaching pain points

First, this course on circuit analysis is highly theoretical and demands a strong foundation in mathematics and physics. As a result, students often find it challenging to grasp the content. Many students develop a sense of difficulty halfway through the course, and some may even consider giving up. This is detrimental to their subsequent learning in related courses. If the first step isn't firmly established, they are likely to struggle in later stages. Additionally, the course covers a wide range of content, but there are only 54 teaching hours, which makes it challenging to effectively convey the vast amount of knowledge within the limited class time.

Faced with the issues of extensive content, limited teaching hours, and students with weaker foundations, it is essential to help students build a clear knowledge framework. Therefore, it is necessary to clarify the connections between course materials, construct a comprehensive knowledge structure, optimize teaching content, and enhance teaching methods. Strengthening the interconnection of key concepts and developing a robust knowledge system is crucial.[1]

Second, traditional classroom teaching often follows a one-sided approach, with the teacher delivering lectures and limited interaction in the classroom. This leads to poor listening efficiency among students, and there is limited effective communication between teachers and students. Students become passive learners. Therefore, it is imperative to improve teaching resources, establish effective channels for communication between "teaching" and "learning," and stimulate students' enthusiasm for learning.

Third, practical teaching in this course primarily focuses on verification experiments, with fewer opportunities for comprehensive and creative projects. Moreover, students often use packaged laboratory equipment, limiting their exposure to innovative thinking and leading to a tendency to replicate knowledge without deeper understanding.

Fourth, the students we are dealing with are natives of the post-2000 generation, deeply immersed in the mobile internet era. They tend to acquire knowledge and information in a fragmented manner. Addressing how to adapt teaching methods to facilitate students' fragmented knowledge acquisition and make their learning styles more flexible is a pressing issue.

Fifth, the teaching team has room for improvement, as many times, teachers work in isolation. Individual capacity and insights are limited, making it challenging to comprehensively explain complex topics in a way that aligns with the unique characteristics of the field, balances depth and simplicity, and incorporates the latest developments.

2. Exploration of mixed teaching mode

2.1. Optimize the classroom teaching content, establish the knowledge MAP, and establish the system through the context

To strengthen the construction of the teaching team, the team members have studied and discussed for many times, and optimized the teaching content of the course according to the training program of the three majors in our college.[2] The teaching content of circuit analysis revolves around the basic components, basic analysis method and basic theorem in the circuit, including three modules of DC circuit, dynamic circuit and sinusoidal steady state circuit. The specific content is shown in Figure 1.

We have streamlined the knowledge structure of the course, creating a clear framework for understanding the subject matter. We established an overall "knowledge tree" for the course and "knowledge maps (MAPs)" for each chapter. This approach assists students in navigating the course material systematically, ensuring a solid grasp of the subject matter and avoiding scattered knowledge. With a clear internal structure, we facilitate the connections with related courses.

In the classroom, we adopt a strategy of "addition and subtraction." We minimize the theoretical content delivered during lectures, focusing on the core knowledge while reducing derivations and extended topics. However, we encourage active student engagement and innovation by posing questions and stimulating discussions during class. This approach aims to enhance students' critical thinking and creativity.[3]

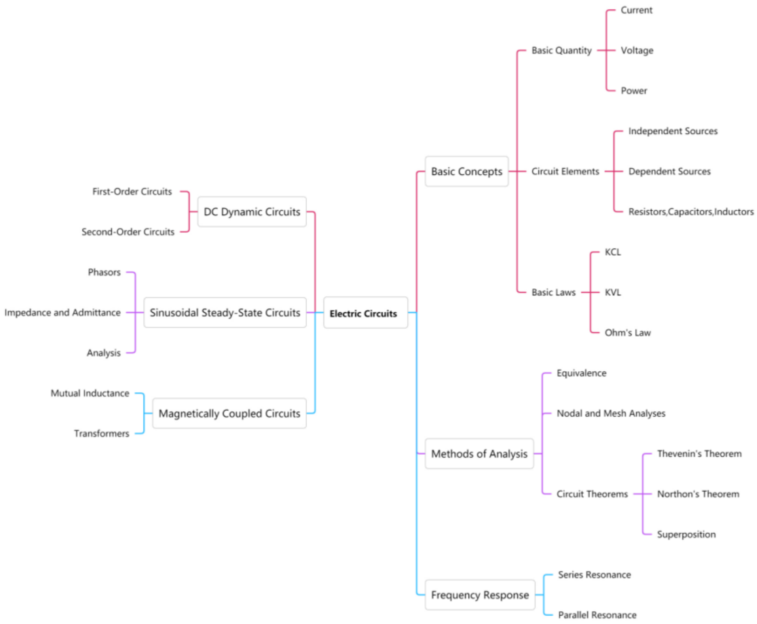


Figure 1: Main contents of the course

2.2. We employ a seamless blend of online and offline resources to cater to students' diverse learning preferences

This approach allows students to acquire knowledge in a flexible and multifaceted manner, maximizing their autonomy in the learning process. We utilize the Rain Classroom platform to provide selected online instructional videos and exercises, offer real-time QQ support for student inquiries, and share recorded videos on platforms like Bilibili. These resources enable students to engage with course content through pre-study, consolidation, supplementation, and exploration during their free time, thus increasing the flexibility of their learning while improving its quality.[4]

2.3. We promote a strong connection between in-class and out-of-class activities

In-class activities focus on students' comprehension of fundamental circuit theories and analytical methods through hands-on exercises and experiments. This solidifies their theoretical foundations and strengthens their analytical skills. Outside of class, students are encouraged to engage in research-based learning. They form study groups and online discussion groups to collaboratively explore relevant issues, topics, and projects. This approach ignites students' enthusiasm and motivation for learning. Additionally, we design specific projects related to different teaching content, assigning technical specifications for students to work on in teams of three. These extracurricular projects require students to complete designs and testing reports, helping them apply and consolidate the knowledge acquired in class. Furthermore, we encourage students to participate in electronics design competitions to enhance their comprehensive skills in problem-solving, analysis, and practical circuit implementation.

2.4. We integrate theoretical knowledge, virtual simulation, and practical project training

First, we emphasize the consolidation of knowledge through theory. In class, we explain the theoretical aspects and continually reinforce and consolidate students' understanding. We assess students' grasp of the knowledge dynamically through the Rain Classroom platform, allowing us to adjust the teaching content accordingly. We use brainstorming sessions, case studies, presentations, and discussions to further reinforce and consolidate their knowledge. Then, we delve into the virtual simulation ("Void") aspect, enhancing their comprehension. Students use the Multisim simulation software for online learning. They perform simulations and verifications based on tasks assigned by the teacher, leading to discussions that deepen their understanding of the subject matter. Finally, we transform theoretical knowledge into practical applications ("Solid"). Circuit analysis places strong emphasis on the practical application of theory. After acquiring a certain level of theoretical knowledge, students develop practical skills and problem-solving abilities through hands-on experiments. Simple verification experiments can be conducted individually, while complex experiments require group collaboration, fostering teamwork and innovation skills among students. Refer to Figure 2 for illustration.

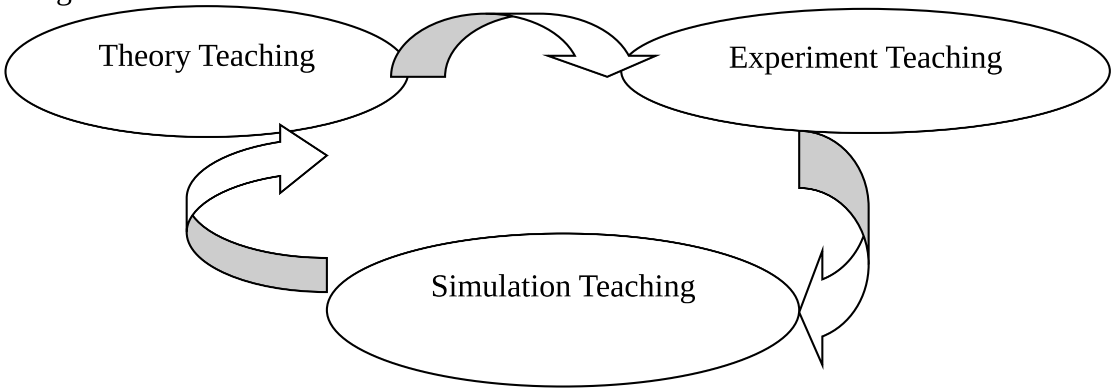
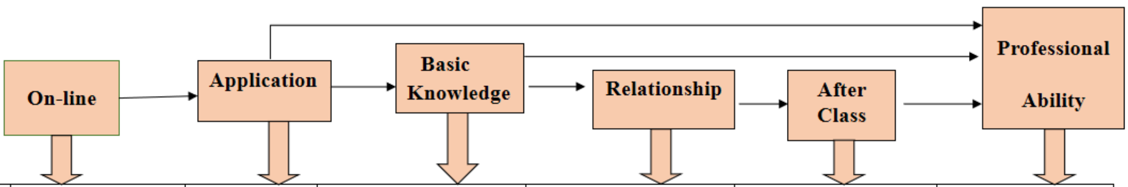


Figure 2: Combination of "Reason virtual and real"



Basic Concepts	Systems KVL KCL	TV Picture Tube /Electricity Bills	Basic Quantity Reference Diretion Basic Laws	Basic Major Courses in Electricity	Simulation with Multisim	Ability to understand basic quantities and electronic component recognition ability
Analysis and calculation of DC circuits.	Series and Parallel Resistors	The Lighting Circuit	Analytical Methods for Linear Circuits	The DC Bias Circuit of the Amplifier	Complete online work	Use of basic instrumentation. Application of simulation software.
DC Dynamic Circuits	Characteristics of capacitors and inductors	Delay Circuits/ Relay Circuits	Routing Rules / Three Elements Method.	Trigger Circuit	Complete online work	The application and analysis ability of first-order circuits
Sinusoidal Steady-State Analysis	Introduction of Sinusoids	AC Bridges	Phasors/ Analysis	Basic Amplifier Circuit	Design a phase shifter	The ability to analyze AC circuits
Magnetically Coupled Circuits	Mutual Inductance Transformers	Transformer as a Matching Device	Dotted Terminals/ Mutual inductance voltage	Interstage Coupling	PSpice analysis of magnetically coupled circuits	The ability to analyze magnetically coupled circuits
Frequency Response	Basic Concepts of Frequency Response	Radio Receiver	Series Resonance Parallel Resonance	Resonant Amplifier	Computation using Multisim	The application and analysis ability of resonant circuits

Figure 3: Organization and implementation of teaching content

In mixed teaching mode of specific organization teaching implementation process in life, the actual case of engineering import content, on knowledge, emphasis and the cohesion between the subsequent course, cooperate with the corresponding simulation project, at the same time into the course education, through the content of class and under class, realize the value shaping, ability training and education process of knowledge students osmosis, form the correct values and learning concept. As shown in Figure 3.

At the same time, the educational institution implements a diversified assessment system to further enhance the teaching effectiveness, as illustrated in Figure 4. The comprehensive result is calculated as follows: 40% of the grade is based on usual assessments, and 60% is determined by the final exam scores. Usual assessments comprise offline homework (10%), adherence to learning discipline (5%), completion of online video viewing and homework assignments (10%), participation in experiments (10%), and performance on stage tests (5%). These assessments also encompass classroom performance, attendance, unity and cooperation evaluations, as well as self-assessment by students, peer evaluation, and teacher assessments.

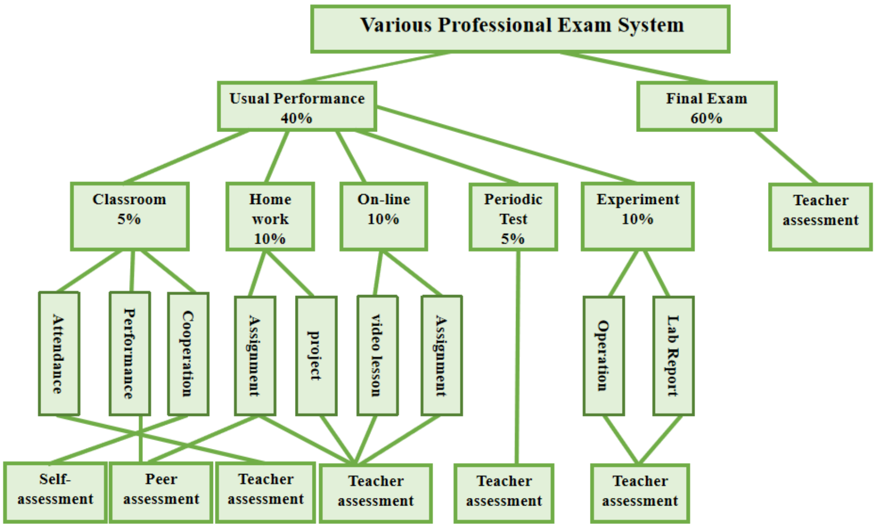


Figure 4: Assessment system

3. Teaching Reform Achievements

3.1. Students have shown a strong interest in learning, and their academic performance has significantly improved.

The adoption of a blended learning approach, combining both online and offline elements, has enabled students to engage in flexible self-directed online learning beyond the classroom. The "Reason virtual and real" (theory, virtual, and practical) combined teaching approach allows students to not only understand the "what" but also the "why" of the subject matter. Moreover, it empowers them to independently develop simple electronic systems, effectively igniting their interest in the subject. Teachers are available for flexible online consultations outside of class, ensuring that students' questions are promptly addressed, strengthening communication between teachers and students, and bridging the gap between them. This approach allows teachers to gain deeper insights into students' real-time situations and make timely adjustments. In recent years, many students have demonstrated significant interest and enthusiasm for the course, leading to preliminary improvements in their academic performance. Figure 5 illustrates the final exam scores for the 19th and 20th cohorts, indicating an overall improvement in performance, with an increased proportion of students scoring 80 points or above. Some outstanding students have participated in competitions related to electronics design, robotics, and other subjects, achieving awards and demonstrating the notable effectiveness of the teaching reform. The foundational Circuit Analysis course has also received positive feedback from students, with course evaluations consistently scoring above 95 for the past two years.

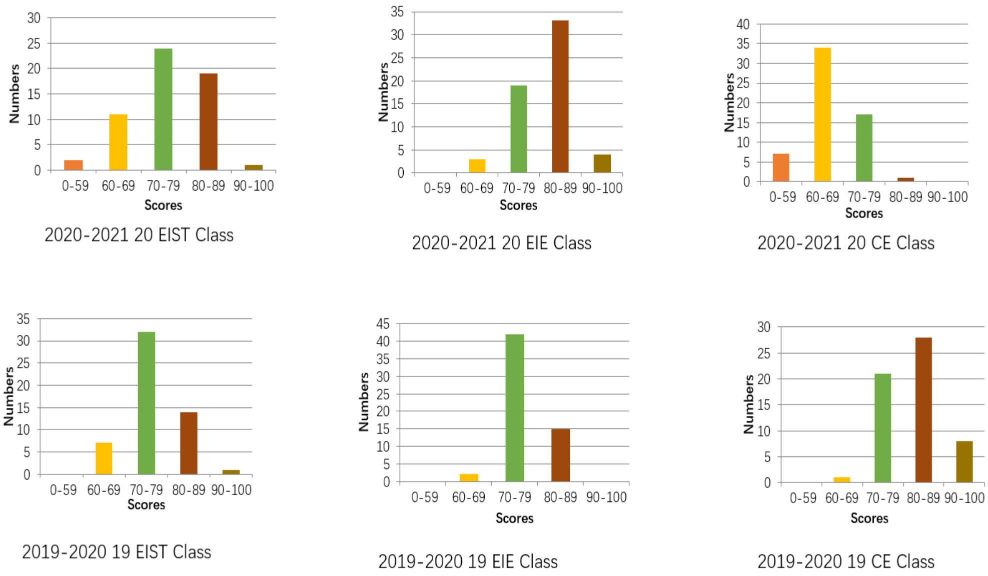


Figure 5: Distribution of student grades

3.2. Improvement in Teaching Team Competence

The teaching team continuously participates in subject seminars, engages in ongoing communication, exchanges ideas, and collaborates to optimize and organize teaching content based on students' specific needs and professional requirements. They have developed rich educational resources, including the "knowledge tree," "knowledge maps," English and Chinese course materials, chapter exercise solutions, question banks, micro-videos, and have authored three textbooks. This concerted effort has significantly elevated the overall teaching competence of the team.

3.3. Optimization of the Teaching Evaluation System with Emphasis on Process Assessment

A scientifically designed evaluation system for the blended learning model has been implemented, emphasizing process-based assessments. Evaluation is conducted at various stages, including online learning, offline performance, and practical projects. This approach enables students to have a clear understanding of their progress by assessing their performance in online videos, exercises, in-class lectures, and group discussions. The introduction of practical projects ensures that students promptly apply theoretical knowledge in practice, fostering their critical thinking, innovation, and hands-on skills.

4. Teaching Reflection

4.1. Existing Problems

Compared to traditional teaching methods, the blended learning model offers significant advantages but also presents some challenges during implementation. Firstly, concerning students, ensuring their self-awareness and self-discipline remains a challenge. Particularly, for students with poor self-discipline, many learning tasks are completed merely to meet requirements, resulting in lower quality work. In group projects, some students exhibit low levels of engagement and overly rely on their group members. For these students, learning gradually becomes a mere formality. Additionally, blended learning, while initially novel with dynamic classroom lectures, flexible learning methods, and lively interactive discussions, may see student enthusiasm and engagement wane as the course progresses.

Secondly, from a teacher's perspective, there is sometimes insufficient consideration of students' practical situations and psychological characteristics when designing teaching activities and projects. Factors such as whether students have adequate free time or the capacity to complete tasks are not always taken into account. This can lead to students feeling overwhelmed, losing interest, and becoming fatigued over time.

4.2. Improvement Methods

4.2.1. Enhancing the Effectiveness of Online Learning and Increasing Student Initiative

Teachers should not only be knowledge disseminators but also guides for students. Strengthening discipline and rules for online learning, guiding students to utilize existing resources, helping them acquire effective learning methods, and increasing their initiative in learning are essential. Moreover, maintaining communication and dialogue with students to promptly understand their condition and adjust teaching methods accordingly is crucial.

4.2.2. Enhancing Teachers' Teaching Abilities

Teachers must continually enhance their teaching skills to meet the evolving needs of students. Firstly, by leveraging the advantages of the existing curriculum development team and combining high-quality online teaching resources with new instructional materials, we can enrich physical classroom teaching for the Fundamentals of Circuit Analysis course. Secondly, teachers should actively participate in teacher training programs to improve their ability to integrate information technology and classroom teaching effectively. Lastly, the educational institution should continually optimize teaching designs, emphasizing practical skill development in students and striving to improve overall teaching quality.

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