

# Research on the Teaching Reform of Experimental Courses under the Background of Digitization—Taking the Communication Engineering Major as an Example

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**Abstract:** A digital laboratory course of instruction designed to provide comprehensive digital instruction based on the concepts of engineering education accreditation. Combining experiment and theory teaching closely, taking complete teaching process as the main line, modern information technology as a means, through the teaching content of the common research and construction, to provide a wealth of hardware and software course resources. Equipped with flexible and rich offline hybrid teaching modes, supplemented by convenient resource sharing channels, it realizes digital experimental teaching, online theoretical teaching, electronic report compilation, paperless examination and assessment, auxiliary intelligent assessment and multi-dimensional intelligent analysis, which helps collaborative teaching and research exploration and realizes the co-construction and sharing of teaching resources. Meanwhile, through intelligent analysis, the continuous improvement cycle will be carried out to achieve continuous improvement of course content, optimization of teaching process differences and efficient achievement of teaching goals, so as to realize the comprehensive improvement of teaching quality.

**Keywords:** Teaching digital lab courses; Teaching informationization; Outcome based education; Mixed online and offline teaching

## 1. Introduction

Digital laboratory course teaching is evolving and gaining popularity, which utilizes modern information technology tools, such as virtual simulation software, digital tools and platforms, to provide students with a more intuitive and interactive learning experience. In 2023, the General Office of China's Ministry of Education issued the "Action Plan for Deepening the Reform of Basic Education Curriculum and Teaching"<sup>[1]</sup>, which puts forward the action of digitally empowered teaching and learning quality enhancement, emphasizing the construction of a new mode of teaching and learning in the context of digitization, in order to improve the efficiency and quality of teaching and learning.

With the advancement of the strategic action of education digitization, a variety of normalized application modes have emerged, such as assisted teaching based on integrated media resources and interactive teaching based on tools, software and platforms<sup>[2-4]</sup>. Among them, assisted teaching based on integrated media resources is a teaching method centered on students, supported by multimedia resources, and aiming at improving learning effects. Teachers choose appropriate multimedia resources, such as pictures, videos, and audios, to enrich the teaching content according to the needs of the teaching content, so that students can understand and master knowledge from multiple perspectives. Interactive media, such as online discussions, can also be utilized to increase students' participation and enhance their motivation to learn. At the same time, mobile media, such as cell phones and tablets, are fully utilized to enable learning anytime and anywhere, breaking the limitations of time and space. Teachers can also utilize virtual/augmented reality technology to provide an immersive learning experience so that students can understand and master knowledge more deeply, and interactive teaching based on tools, software, and platforms is characterized by the use of various technological means to enhance the interactivity of the teaching process. With the development of network technology, a variety of online teaching platforms and interactive tools continue to emerge, and teachers can use these tools to design teaching as a series of continuous activities, such as creating content, initiating topics, participating in the evaluation of

others' views and opinions, voting, and instant visualization of classroom exercises, thus activating teacher-student interactions, interactions between teachers and students, and learning resources. Teachers can also make use of lightweight intelligent teaching tools such as MOOclassroom, which is composed of a small program on the WeChat side and a teaching background on the computer side, to help teachers land high-quality online open courses in the classroom teaching, and to assist in the efficient development of classroom teaching. These models improve students' independent inquiry ability and learning interest through rich resources and interactivity.

Through the digitization of experiment content, the gradient system from knowledge experiment verification to knowledge engineering case design to knowledge innovation development is realized. For each experiment, students are first allowed to learn basic verification, and then expand the experimental knowledge to the engineering case design, so that students solve the actual engineering tasks, and finally combined with the knowledge of experimental innovation development, so that students can learn each knowledge when doing Engineering tasks and innovative development, not only can enhance students' interest, but also cultivate students' creative ability and innovative consciousness; after the automatic generation of the experimental report, the teacher can receive the student's experimental report in the background, the intelligent review function can assist the teacher to review, reduce the burden of teaching and learning at the same time can be followed up as a background analysis of the big data students' easy to error points, difficulties, and guide teachers to carry out targeted teaching.

This paper takes the communication engineering major as an example, to improve students' ability to solve complex engineering problems and innovation and creativity as the main goal, students participate in intra-specialty, inter-specialty and interdisciplinary comprehensive experiments through diversified experimental means, and gradually realize the different points of knowledge in the same course throughout, synthesis, different courses in the same specialty through, synthesis, different majors and disciplines of different courses throughout, synthesize, explore the effective way to cultivate students' innovation ability.

## **2. Exploring the Digitalization of Experimental Teaching in Communication Engineering**

### ***2.1. Analysis of the Necessity of Digital Laboratory Teaching Reform***

There are some shortcomings in the effect of traditional experimental teaching, such as limited by the traditional laboratory management mode and experimental teaching resources, it is difficult to meet the individualized needs of talent training. At present, the rapid development of digital China, the use of digital technology to optimize the way of experimental teaching, to carry out the reform of practical teaching under the new situation is very necessary<sup>[5]</sup>. The display of experimental principles and phenomena can be carried out through digital technology, open experimental resources, and create a fully open laboratory; the laboratory can also be made into a fully open comprehensive innovation base, and students can use odd hours to conduct experiments outside the laboratory, which is conducive to students' independent learning and effective arrangement of their own learning time; and accelerate the transformation from the queuing into the laboratory mode to the all-weather learning mode, make full use of the laboratory resources to meet the requirements of students' independent learning and personalized training<sup>[6-8]</sup>.

Combining digital technology to realize the engineering case of experimental content, digitalization of the experimental process, diversification of experimental methods, intelligent evaluation and analysis, together with the digital display system, it can constantly monitor the operation status of the laboratory, the learning process results, and continuously enhance the quality of talent cultivation through the continuous improvement of the concept of education.

### ***2.2. Digital Experimental Teaching Management Platform***

The communication engineering program of our college starts from the concept of engineering education to cultivate professionals who meet the needs of the society and the development trend of technology. At present, there are professional basic course experiment platform, simulation platform and software radio platform to meet the needs of comprehensive and innovative teaching, which will greatly improve the experimental conditions of core courses and comprehensive ability training of the communication engineering program on campus, and play an important role in promoting the cultivation of professional talents.

**2.2.1. Ensuring the demand for experimental teaching in specialized courses**

We have built a digital unified management platform for basic experiments in communication engineering, and its architecture is shown in Figure 1 below.

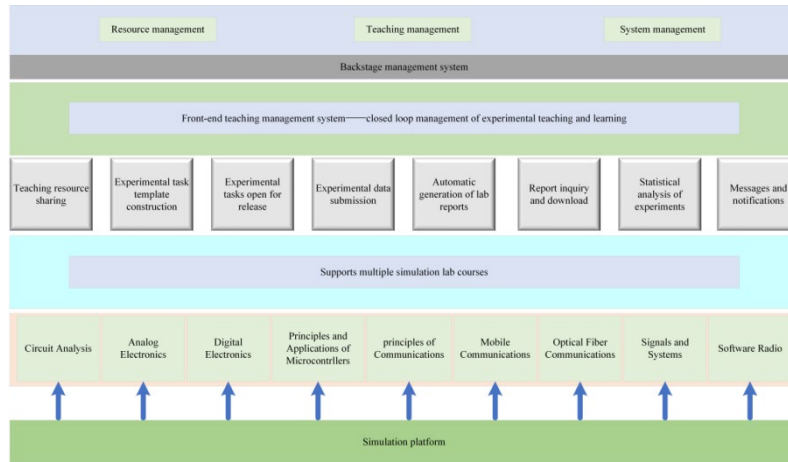


Figure 1: Digital experiment management platform

The digital experimental platform shown in Figure 1 can support the experimental teaching of relevant professional basic courses and core courses, such as “Circuit Analysis”, “Fundamentals of Analog Electronics”, “Fundamentals of Digital Electronics”, “Principles and Applications of Microcontroller”, “Principles of Communication”, “Mobile Communication”, “Optical Fiber Communication”, “Signals and Systems”, “Software Radio” and other courses of the experimental teaching links, you can make the principles of the course through practice, students can better understand the corresponding knowledge points, complete the comprehensive education and training that emphasizes both theory and practice, and consolidate students' professional foundation. At the same time, the experimental courses supported by the above experimental platform are equipped with virtual simulation resources, which can effectively solve the problems of students' experiments being constrained by factors such as time and space, and better meet students' personalized learning needs.

**2.2.2. Support students' ability to innovate and develop**

Engineering education personnel training requires universities to establish innovative, integrated, full-cycle engineering education “new concept”, so it is necessary to carry out a number of integrated innovative design experiments, and combined with actual engineering cases to train students to solve complex engineering problems. We have built a comprehensive experiment platform for digital software radio, as shown in Figure 2 below.

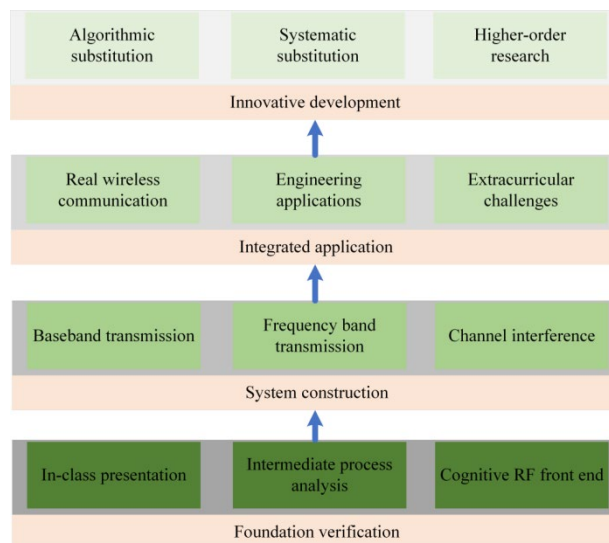


Figure 2: Software radio experiment platform

The platform is based on modern communication theory, supported by open broadband RF front-end,

with digital baseband processing as the core, and fully combines the theoretical and practical teaching needs, which can meet the principle verification experiments of communication theoretical knowledge points, and also meet the professional comprehensive design and innovative development, introduces the software radio concepts and entities, and continuously penetrates the engineering concepts and engineering design methods, so that the students can be able to innovate from the basic innovation. It constantly extends and integrates to the actual engineering innovation; through the case function level verification and analysis, it helps students to further consolidate their understanding of the theoretical contents and summarize the engineering cases and solution methods in combination with the theory; through the code level modification and design, it gradually guides the students to further familiarize themselves with the general process of mastering the development and design, and cultivates the students' innovative consciousness of active practice.

### **3. Effectiveness of communication engineering laboratory management platform construction**

The digital experimental teaching reform of communication engineering majors adheres to the nurturing concepts of student-centeredness, result-orientation, and continuous improvement, cultivates students' ability to solve complex engineering problems in communication and realize communication systems or modules according to specific needs, and in the process enhances students' innovative consciousness and innovative entrepreneurship. Construct a whole-process management system mainly based on course objective setting, course content arrangement, teaching process organization, teaching data collection, teaching effect evaluation and continuous improvement to realize the effective support of course objectives to the cultivation objectives and to provide a complete closed loop of continuous improvement of course teaching to the support of human training system. The digital laboratory teaching reform will continuously improve professional teaching in the following aspects.

#### **(1) Enriching the form of course content**

Firstly, the course content covers courseware, videos, homework, exercises and experiments, which meets the needs of most daily teaching scenarios. Secondly, provide fully digitalized online learning, online experiments, online review, export and archiving functions, providing users with a more flexible teaching experience. Finally, Provide complete paperless examination management services, including flexible grouping methods, disorderly order of test questions, anti-cheating mechanisms, etc., and at the same time, meet the needs of make-up examination scenarios.

#### **(2) Flexible course content organization**

On the one hand, it supports customized chapter outlines and hierarchical organization of teaching content. On the other hand, it dynamically updates the teaching content, realizes improvement while teaching, and synchronizes teaching and improvement.

#### **(3) Complete organization of teaching activities**

In terms of class teaching, it supports the creation of multiple teaching classes for the same course at the same time. In terms of open course teaching, support open course teaching to realize resource sharing and quality course construction. In terms of teacher co-management, it supports the co-management or class management of multiple teachers in the same course. In terms of differentiated teaching, different classes are supported to set different teaching content permissions, course scoring and statistical analysis rules to meet the needs of standardization and professional differentiation. In terms of grade management and statistics, we support grade management and statistics by class.

#### **(4) Complete teaching process**

Pre-learning: Various pre-study tasks are organized through a rich content format. In the middle of learning: complete monitoring tools and intelligent supervision of the learning process to help achieve learning goals efficiently. Post-learning: Provide efficient review assistance and rich data analysis tools, which not only greatly reduce the workload of teachers, but also provide multi-dimensional analysis of the effect of the intelligent analysis means to promote the continuous improvement of the teaching process.

#### **(5) Templating and sharing of curriculum resources**

Support teaching through open classes; support the generation and sharing of course resource templates, and realize the sharing of teaching resources and the exploration of virtual teaching and research activities for courses.

#### (6) Flexible and efficient management of laboratory resources

Firstly, provide the creation and management functions of Digital Intelligence Labs, mapping physical labs or creating virtual labs. Secondly, provide publishing and management of laboratory courses, supporting the realization of complete industrial education concept teaching. Finally, supporting the management of assets such as lab boxes, lab software, gateways and meters, and the analysis of teaching operation data.

#### 4. Conclusion

Information and communication infrastructure is an important part of modernized infrastructure system, and communication network infrastructure represented by 5G technology, internet of things, industrial Internet and satellite Internet is among the strategic construction plans of China's "new infrastructure". In the future, the communication engineering profession ushers in a new historic development opportunity, and the society urgently needs a large number of communication talents with the ability to solve complex engineering problems. The cultivation of engineering education requires universities to set up innovative, comprehensive, full-cycle engineering education "new concept", which requires us to urgently improve the quality of engineering education in communication engineering. With the comprehensive promotion of the digital China strategy, it is especially important to create a fully open laboratory to support students and the community to learn "everywhere, all the time, everyone", and to analyze the learning effect, the learning process, and to monitor the operation of the laboratory at all times, incorporating digital technology. This paper discusses the construction of digital experimental teaching platform for communication engineering majors as an example, which provides an effective reference for the further comprehensive implementation of digital practice teaching.

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