

# THE BLENDED TEACHING REFORM OF “SIGNALS AND SYSTEMS” COURSE EMPOWERED BY ARTIFICIAL INTELLIGENCE

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**Abstract:** Aiming at the prominent pain points in the traditional teaching of Signals and Systems, such as compressed class hours, fragmented resources, weak practical links, and time and space constraints on teacher-student interaction, combined with the strategic requirements of the Ministry of Education for the development of “Artificial Intelligence+Higher Education”, this research carries out an exploration of AI-empowered blended teaching reform of the course. A “Four-in-One” blended curriculum system integrating classroom learning, AI teaching assistant accompanied learning, resource expansion and practical teaching is constructed. By deeply integrating generative AI large models, the three maps of knowledge, ability and quality with the BOPPPS teaching model, a smart teaching community with the ternary interaction of “Teachers-Students-Machines” is created. Taking the Sampling Theorem as an example, a 100-minute teaching implementation process is designed, with AI technology embedded in all links of teaching and learning from the pre-class BOP, in-class P to post-class PS. The research results show that this teaching reform model effectively solves the problems of traditional teaching, improves students’ engineering practical ability, autonomous learning ability and team cooperation ability, and at the same time enhances teachers’ teaching efficiency. The formed teaching plan has good popularizability and transplantability, providing a reference paradigm for the smart teaching reform of basic courses for electronic information majors.

**Keywords:** AI empowerment; Signals and systems; Blended teaching; BOPPPS teaching model; “Four-in-One” curriculum system

## 1 INTRODUCTION

Under the guiding spirit of the National Education Congress of “focusing on using artificial intelligence to boost educational reform”, the Department of Higher Education of the Ministry of Education has continuously deepened the exploration and practice of “Artificial Intelligence (AI) and Higher Education”. Smart courses have become an important direction of higher education teaching reform, providing a new path to solve the pain points of college course teaching [1,2].

As a core professional basic course for electronic information majors, Signals and Systems plays a key connecting role in the professional curriculum system. The 64-class-hour arrangement puts forward higher requirements for teaching efficiency and quality. Traditional teaching has such problems as compressed class hours, fragmented resources, weak practical teaching and limited interaction, which cannot adapt to the training needs of high-quality talents [3,4].

Against this background, this paper takes AI technology as an enabling means to explore the path of blended teaching reform of the Signals and Systems course [5], construct a “Four-in-One” blended curriculum system, integrate the BOPPPS teaching model to establish a full-process AI-empowered teaching model, and promote the transformation of the traditional binary teaching structure of “Teachers-Students” to the ternary smart teaching structure of “Teachers-Students-Machines” [6-11]. The research selects core knowledge points in the course to design specific teaching cases and apply AI empowerment methods to the teaching process, aiming to effectively solve the pain points of traditional teaching, improve teaching quality, cultivate students’ ability to use AI tools, engineering practical ability and innovative thinking ability, and at the same time provide practical reference and experience for the smart teaching reform of similar courses in colleges and universities [12,13].

## 2 OVERALL DESIGN OF AI-EMPOWERED BLENDED TEACHING REFORM

### 2.1 Reform Objectives

This teaching reform is carried out around the three-dimensional objectives of knowledge, ability and quality.

**Knowledge Objective:** Enable students to understand the basic concepts of Signals and Systems, and master the time-domain and transform-domain analysis methods of signals and systems proficiently.

**Ability Objective:** Build a new teaching model with the help of AI large models and knowledge graphs to improve students’ ability of simulation verification by using software, and cultivate students’ communication and expression ability and team cooperation ability through group cooperative inquiry.

Quality Objective: Make students master the application methods of AI tools in professional learning skillfully and cultivate autonomous learning ability and innovative thinking ability.

## 2.2 Construction of the “Four-in-One” Blended Curriculum System

In view of the core problems of traditional teaching, this research puts forward the design idea of “refining classroom teaching, empowering teaching with AI, enriching online learning resources and strengthening practical teaching”, and constructs a “Four-in-One” blended curriculum system including classroom learning, AI teaching assistant accompanied learning, practical teaching and resource expansion [14-16], see Figure 1.

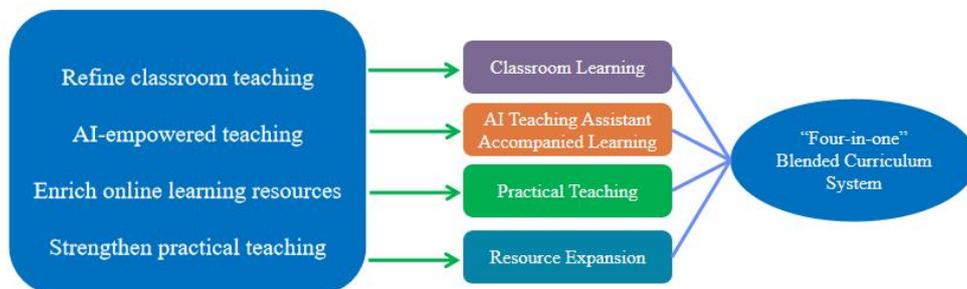


Figure 1 “Four-in-One” Blended Curriculum System

**Classroom Learning:** Teachers focus on theoretical explanation and AI technology, while students display self-learning achievements, interact and communicate in groups to improve teaching effects.

**AI Teaching Assistant Accompanied Learning:** Introduce large models such as Deepseek and Doubao to assist teachers and students in consulting materials before and after class. Rely on the three maps of knowledge, ability and quality to sort out the internal correlation between knowledge points and help students establish a holistic view of knowledge.

**Practical Teaching:** Realize visual simulation of the core knowledge points of the course with the help of MATLAB to clarify the differences and connections between theory and practice. Improve students’ programming and practical operation abilities, laying a practical foundation for the study of professional courses.

**Resource Expansion:** Integrate resources from MOOC platforms to meet students’ basic learning needs. Build self-developed agents to link with high-quality resources such as Bilibili and official WeChat accounts.

## 2.3 “Teachers-Students-Machines” Ternary Interactive Teaching Community

This research constructs a smart teaching community with the ternary interaction of “Teachers-Students-Machines”, which takes AI large models and agents as the link to realize the two-way empowerment of teaching and learning [7], see Figure 2.



Figure 2 “Teachers-Students-Machines” Ternary Model

Teachers are the designers and guides of teaching. According to the teaching objectives and students’ learning situation, they put forward requirements for lesson plan design and teaching link optimization to AI tools, and carry out blended teaching design based on the BOPPPS model. AI tools are used to complete test proposition, intelligent marking and other work. Students are the main body and explorers of learning. According to the pre-class preview objectives, students preview through platforms such as MOOC and Learning Pass. Use large models for intelligent Q&A to expand the knowledge boundary. Complete practical simulation and post-class inquiry with the help of software. Machines (large models/agents) are the assistants and collaborators of teaching and learning. Machines provide teaching and learning materials according to the needs of teachers and students. Complete test marking, learning situation statistics and other work, becoming an important assistant for teachers and students.

## 3 INTEGRATION AND IMPLEMENTATION OF AI EMPOWERMENT AND BOPPPS TEACHING MODEL

To implement the “Four-in-One” curriculum system and the “Teachers-Students-Machines” ternary interaction model, this paper deeply integrates AI technology with the BOPPPS teaching model, and decomposes the six links of the BOPPPS model (Bridge-in, Objective, Pre-assessment, Participatory learning, Post-assessment, Summary) into a three-stage teaching process of pre-class BOP, in-class P and post-class PS [10].

Taking the Sampling Theorem as a teaching case, a 100-minute teaching process is designed to expound the AI-empowered teaching methods and steps, so as to realize the implementation and verification of the teaching model. The Sampling Theorem is a knowledge point connecting continuous signals and discrete signals in Signals and Systems, which combines theoretical and engineering characteristics and is the basis for understanding digital signal processing, making it suitable for carrying out AI-empowered blended teaching model, see Figure 3.

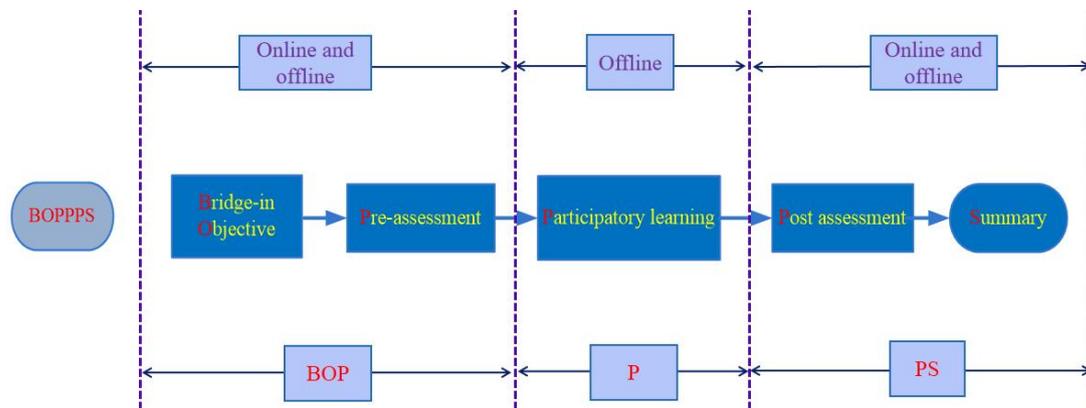


Figure 3 BOPPPS Teaching Model

### 3.1 Pre-class BOP Session (25 minutes): AI-empowered Preview and Teaching Preparation

**Bridge-in (17 minutes):** Teachers complete lesson plan design by means of AI in three ways. First, build self-developed agents, improve exclusive knowledge bases and carry out targeted training. Second, use large models such as Deepseek and Doubao in combination to integrate various ideas and obtain application cases of the Sampling Theorem in communication engineering. Third, optimize prompts through in-depth interaction. With questions such as “Why should the sampling frequency be greater than twice the maximum frequency?” and “What is the cause of aliasing phenomenon?”, students carry out basic preview through MOOC videos and PPT on Learning Pass, and use AI large models for intelligent Q&A to form a preliminary understanding of the Sampling Theorem. Large models search for materials according to the needs of teachers and students, and teachers form teaching plans combined with students’ understanding ability.

**Objective (3 minutes):** Clarify the three-dimensional learning objectives of this lesson. First, understand the concept and principle of the Sampling Theorem, realize the sampling and recovery of continuous signals by using MATLAB, and have the ability to solve engineering problems. Second, learn to use AI tools to assist in understanding the core connotation of the Sampling Theorem and conduct simple audio signal sampling analysis. Third, clarify the correlation between this knowledge point and courses such as Digital Signal Processing and Communication Principles.

**Pre-assessment (5 minutes):** Organize students to watch the video of “Digital China” to understand the connection between A/D conversion and the Sampling Theorem. Release pre-assessment questions through Rain Classroom, and realize automatic marking and learning situation statistics. According to the statistical results, teachers find that more than 30% of students have an inaccurate understanding of aliasing phenomenon, which is taken as the key and difficult point of classroom teaching.

### 3.2 In-class P Session (60 minutes): AI-empowered Participatory Learning

In-class participatory learning achieves students’ in-depth learning of the Sampling Theorem through three steps. Smart teaching and theoretical explanation, AI-assisted group inquiry and MATLAB simulation display, and teacher-student interaction and teacher comments.

**Smart teaching and theoretical explanation (15 minutes, teacher-led).** Introduce AI technology and mainstream large models, extract the audio of “Digital China” with different sampling frequencies to let students feel the influence of sampling frequency on sampling results, introduce the time-domain model of the Sampling Theorem, and deduce the core conclusion through time-frequency analysis.

**AI-assisted group inquiry and MATLAB simulation display (30 minutes, student-led).** Teachers divide students into 3 groups, with the following tasks for each group. The first group explores oversampling, the second group explores critical sampling, and the third group explores undersampling. Each group sets parameters and writes codes with the help of large models, and realizes simulation analysis by using software. Each group selects a representative to give a classroom report, showing the simulation process, experimental results and conclusions.

**Teacher-student interaction and teacher comments (15 minutes, teacher-student interaction).** Teachers conduct targeted guidance and questioning during the group reports, such as “Why can oversampling improve the quality of signal recovery?”, make professional comments on students’ experimental results and analysis conclusions, answer students’ doubts in the process of inquiry and simulation in a timely manner, sort out the knowledge context, and strengthen students’ understanding and application of the Sampling Theorem.

### 3.3 Post-class PS Session (15 minutes): AI-empowered Evaluation and Summary Reflection

Post-assessment (10 minutes, student-led): Teachers compile and release online tests through Learning Pass, and complete automatic marking with the help of AI functions. For the common problems exposed in the test, teachers conduct key explanations.

Summary (5 minutes, teacher-led): Teachers and students sort out the principle, simulation implementation method and engineering application scenarios of the Sampling Theorem, assign post-class inquiry tasks, requiring students to explore the application of the Sampling Theorem in communication systems by using AI tools and write research reports, so as to cultivate students’ autonomous inquiry and engineering thinking.

## 4 MAIN CHARACTERISTICS OF THE TEACHING REFORM

With AI as the enabling means, this teaching reform integrates the BOPPPS model with the “Four-in-One” system, implements teaching cases and achieves all-round innovation with four core characteristics, see Figure 4.

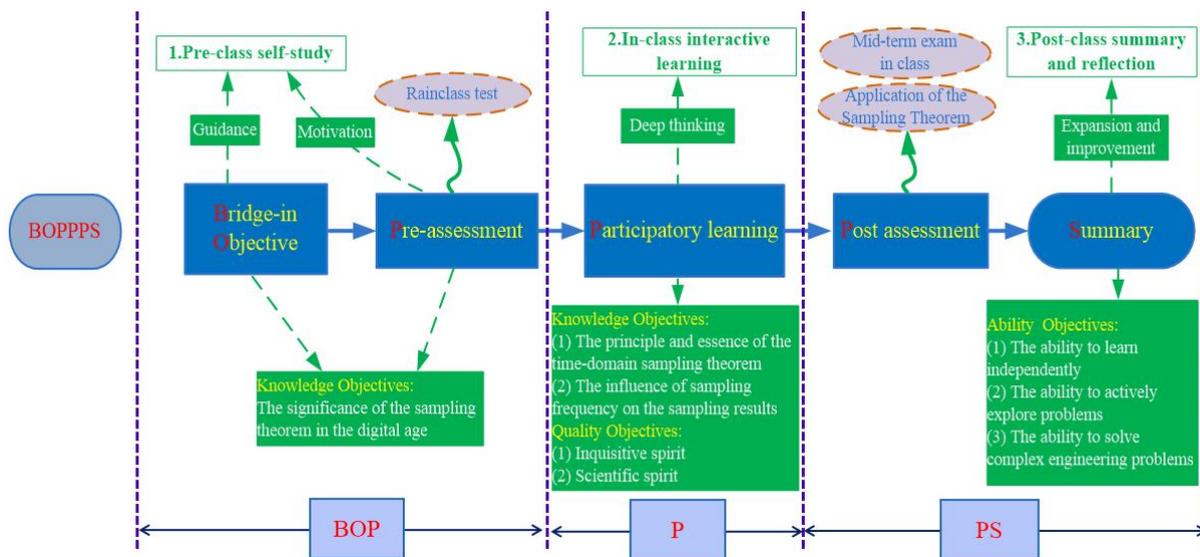


Figure 4 BOPPPS Blended Teaching System Integrating AI-Empowered Teaching

In-depth Integration of AI and BOPPPS Model to Realize the Intellectualization of Teaching Process AI technology is embedded in all pre-class, in-class and post-class links of the BOPPPS model, breaking the technical barriers of traditional blended teaching. AI is used to complete lesson plan design and pre-assessment of learning situation before class. AI is applied to assist group inquiry and simulation practice in class. AI is relied on to realize intelligent evaluation and resource expansion after class, forming a smart teaching model of “full-process AI empowerment” and improving the pertinence and effectiveness of teaching.

Collaborative Application of Self-developed Agents and Three Maps to Solve the Problem of Resource Fragmentation On the basis of existing professional knowledge, teachers build self-developed agents and complete targeted training to realize efficient connection between self-owned resources and high-quality network resources. The three maps of knowledge, ability and quality help sort out the knowledge context and establish a holistic view of knowledge, solving the pain point of fragmented network resources.

Personalized Teaching to Meet Students’ Differentiated Learning Needs According to students’ learning progress, answer situation and other data, large models can provide customized learning content and test questions for students. Intelligent agents realize real-time testing and intelligent marking, enabling students to consolidate weak links in a timely manner and improve learning effects.

Sustainable and Popularizable Teaching Model the AI-empowered blended teaching plan formed by this reform is not only applicable to the Signals and Systems course, but also its design ideas and implementation methods can be transplanted to other courses of electronic information majors. Technical means such as the collaborative application of multiple large models, self-developed agents and three maps are adapted to the development trend of digital and intelligent education in colleges and universities, with sustainability, and provide a replicable practical paradigm for the teaching reform of similar courses.

## 5 CONCLUSION

Under the background of the development of “AI and Higher Education”, the AI-empowered blended teaching reform of the Signals and Systems course provides an effective path to solve the pain points of traditional teaching, improve teaching quality and cultivate high-quality electronic information talents. The “Four-in-one” blended curriculum system constructed in this research realizes the deep integration of AI technology and the BOPPPS teaching model, creates a

“Teachers-Students-Machines” ternary community, and selects the Sampling Theorem as a teaching case to design an AI-empowered teaching implementation plan, which solves the problems of class hours, resources, practice and interaction in traditional teaching and realizes the organic implementation of the three-dimensional training objectives of knowledge, ability and quality.

Teaching practice shows that this reform model not only improves students’ mastery of professional knowledge and engineering practical ability, but also cultivates their AI application ability and innovative thinking, and at the same time enhances teachers’ digital and intelligent teaching ability and teaching work efficiency. The teaching plan formed by this reform has good sustainability and popularizability, and can provide a practical paradigm for the smart teaching reform of similar courses in colleges and universities. In the future, this research will optimize the application strategies of large models and agents, improve the three maps, continue to explore the deep integration of AI technology and course teaching, and boost the digital and intelligent education in colleges and universities.

## COMPETING INTERESTS

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