Education Reform and Development, 2025, Volume 7, Issue 4
https://ojs.bbwpublisher.com/index.php/ERD
Online ISSN: 2652-5372
Print ISSN: 2652-5364

Educational Applications of Collaborative Innovation under Engineering Accreditation: A Case Study of "Digital Signal Processing"

Wei Dai*, Changpeng Ji, Ying Liu, Wenxin Ji

Liaoning Technical University, Huludao125105, China

***Corresponding author:** *Wei Dai, daiwei@lntu.edu.cn*

Abstract: This paper takes the case study of "Digital Signal Processing" to explore the educational applications of collaborative innovation under engineering accreditation. Digital signal processing is an emerging discipline that involves multiple disciplines and is widely applied in many fields. This course is the core foundational course of communication engineering, but it is highly theoretical, difficult to understand, and hard to master. To solve these issues, this paper explores teaching reform solutions from collaborative ability, creativity, classroom teaching methods, and educational philosophy to help students firmly grasp the fundamentals of science, mathematics, and engineering, meeting the demand for talent in the future engineering industry. The digital signal processing course group of Liaoning Technical University has carried out reforms and practices in several aspects, such as classroom teaching models, experimental teaching, and performance evaluation mechanisms. After three semesters of practice, the qualitative achievement of the course has increased by an average of 14.04%, and the quantitative achievement by 5.55%, indicating that the students' interest in the course, their ability to apply the knowledge of the course, their ability to practice engineering, and their ability to work in a team have all improved greatly.

Keywords: Digital signal processing; Communication engineering; Teaching reform; Collaboration; Innovation

Online publication: April 28, 2025

1. Introduction

The digital signal processing course is the fundamental theory for the development of information science and information technology. The course primarily studies the basic principles and methods of digital signal acquisition, transformation, analysis, and filtering. The course is in a key position in the curriculum system of information talent training programs, which plays an important role in consolidating the basic theories of signal processing and cultivating students' scientific thinking ability, engineering practice ability, and innovative research spirit [1].

Due to the theoretical complexity, difficulty, and challenging mastery associated with the "Digital Signal

Processing” course, it is hard for students with weak mathematical foundations, poor abstraction skills, and a lack of hands-on capabilities to comprehend and grasp, resulting in relatively poor teaching outcomes [2]. The primary issues with the “Digital Signal Processing” course are as follows:

(1) The teaching positioning is inaccurate

Teaching is teacher-centered, and students only passively accept learning arrangements in the teaching process, which is a typical input-oriented learning with single teaching methods and little student participation [3]. The traditional teaching model emphasizes the explanation of theoretical knowledge and abstract formulas, but ignores students’ needs, disregards the differences in students’ understanding ability, and only “imparts” unilaterally [4]. At the same time, classroom teaching mainly focuses on explaining complex and difficult formula transformations, students blindly pursue memory formulas to pass exams, and know what they know but do not know why, let alone use theoretical knowledge to solve practical problems.

(2) Teaching lacks extensibility in terms of content, time, and space, limiting how students can achieve learning outcomes

Reviewing the current teaching format, most of the teaching activities are limited to the classroom “teaching” and “learning,” with monotonous outputs that make it difficult for students to generate interest, and active participation in the learning process, therefore, students are not able to grasp the content of this course well and comprehensively.

(3) It emphasizes theory over practice

The common issues in current teaching activities are that the practical process is single, the analysis of the problem is not thorough enough, and teachers blindly “impart” knowledge without allowing students to practice, ignoring the subjective initiative of students in learning [5]. This classroom-bound teaching approach fails to train students to meet societal needs adequately. The course experiments involve using MATLAB programming for system analysis, signal analysis, system design, and signal filtering. This method is now widely adopted by most schools [6].

Comparing the teaching process of relevant courses at schools such as MIT, it is found that teachers in foreign schools explain relatively less content than in domestic universities, employing richer classroom teaching methods and playing more of a guiding role. However, foreign schools assign a larger homework load, requiring students to spend three times the classroom teaching duration to complete it, thereby significantly enhancing their self-learning and problem-solving abilities.

Digital signal processing courses are highly theoretical, tightly entwined with applications, and heavily focused on technology, which faces significant challenges in the context of traditional teaching methods: (1) The content of textbooks is out of date, it is difficult to reflect theoretical support for industry development; (2) The course’s numerous mathematical formulas and intricate deductions make it challenging for students to comprehend physical meaning, and feeling fearful of difficulties; (3) There is a disconnect between theory and practice, lacking typical engineering application cases, making it hard for students to apply what they have learned; (4) The experimental components are mainly verification-based, lacking comprehensive and extensible experimental content, and students lack innovation ability [7].

Various teaching teams from domestic universities have actively explored related teaching reforms in digital signal processing courses [8], for instance, the literature [9] proposes a gradual hybrid teaching model, constructing a “theoretical T + practical G + collaborative C” capability enhancement hybrid teaching system, significantly boosting students’ confidence and professional responsibility. The literature [10] designed a hierarchical approach for theoretical courses, experimental courses, and course design in digital signal processing, forming an integrated learning and research teaching model. The literature [11] explains the importance of ideological and political education and how to integrate and implement ideological and political education in the entire teaching process. The literature [12] applied the hybrid flipped classroom teaching mode in the teaching of digital signal processing courses in the context of new engineering disciplines, reorganized the content of the digital signal processing course, used flipped classroom teaching to cultivate students' innovation ability, strengthened students' independent learning, and demonstrate good teaching effectiveness. The literature [13] integrates ideological and political education into the curriculum and designs a blended online and offline first-class curriculum for teaching on the outcomes-based education concept. Based on the education theories of outcomes-based education and conceive-design-implement-operate. The literature [14] is student-centered, "specialization and integration" oriented, through the project-driven and inquiry-based teaching method, to stimulate students' enthusiasm for learning, and explore students' learning potential; virtual simulation, simplifies the complexity, the abstract theory visualization, reduces the difficulty of theoretical learning, and the use of a diversified course evaluation to provide teaching and learning support. The literature [15] takes "strengthening the foundation, emphasizing abilities, and inspiring innovation" as the concept, benchmarking the "golden course" standard, and carrying out curriculum assessment reform from three aspects: optimizing assessment content, highlighting process evaluation, and innovating assessment methods. To give full play to students' main role, a new curriculum assessment mode combining process assessment and practical assessment is formed, to realize the curriculum's high-level, innovative, and challenging nature.

2. Key aspects of course teaching reform

2.1. Classroom teaching guided by students' needs

Reflecting on the current teaching format, students are often exposed to long lectures and blackboard-filled notes during classes, which can easily lead to fatigue, disinterest, or even aversion. Classroom teaching reform encompasses a student-centered preparatory mode before class and a teacher-guided knowledge exposition mode during class. Implement a novel, student-centered theoretical teaching reform by integrating the flipped classroom model into the educational process. Post-reform teaching focuses more on constructing students' knowledge of digital signal processing, developing their capabilities, and enhancing their qualities.

In practice, tasks are designed for pre-class, in-class, and post-class stages, and extension activities. Before class, relying on textbook reference books, fine course websites, MOOCs, and other resources, arrange pre-course study and guide students to identify problems. In-class sessions use inquiry-based teaching methods to facilitate discussion, and predetermine exploratory questions to achieve the goal of guiding students' thinking about knowledge points; Key and difficult points are discussed in seminar classes through teacher-student and student-student interactions to complete student-centered, creativity and teamwork-driven activities, effectively engaging students in learning and allowing teachers to monitor students' learning status in real-time. Post-class assignments are given to consolidate knowledge learned. By expanding the design of comprehensive project assignments, students are required to work in small groups to develop students' independent thinking, access to information, use of modern tools, communication, and expression abilities.

2.2. Integrating classroom teaching with extracurricular practice

Classroom teaching based on colleges and universities can help students establish the theoretical system of knowledge, but cultivating the talents needed by society with practical ability needs to strengthening the practice of exercise. Therefore, it is necessary to combine theory with practice to enable students to integrate and use the knowledge they have learned.

To better facilitate students' extracurricular practice, colleges have established a multi-tiered practical teaching system, including basic practical instruction, advanced practical teaching, and project capability cultivation, and have also set up experimental classes with distinctive features to provide students with comprehensive professional practice training. An example is the acquisition of frequency conversion signals in modern communication power supplies. Pre-class tasks involve releasing the topics in advance for students to research the basic characteristics of the signals they will handle, possible filter types, parameters, and their pros and cons, and propose preliminary solutions; during class, group representatives explain the principles, content, and pros and cons of the adopted solutions, then the students and the teacher together discuss and compare all the proposed solutions and the core parameters; post-class, groups refine their approach based on in-class discussions, enhance detail handling, and summarize the knowledge points and critical issues or parameters considered in the solutions. Students can understand the actual engineering problems and develop their ability to find problems, analyse problems, and solve problems.

2.3. Using information technology to aid course teaching reform

Traditional teaching methods involve a top-down "monologue" style of teacher-student face-to-face communication. While unobjectionable from a knowledge transmission standpoint, this approach lacks interaction between students and teachers during the learning process.

With the advancement of information networks, the network, as a teaching tool, is increasingly valued by educators for its superior openness and interactivity. Teachers can create teaching videos through live streaming or recorded formats to present content more vividly and visually, facilitating students' anytime, anywhere learning. When encountering key or difficult points or knowledge points that need to be updated, teachers can offer targeted answers through live-streamed teaching, enabling students to study without the constraints of time and location, as long as they are in a place where they have access to the Internet. Additionally, an online classroom environment can be developed, including online classrooms, online homework, and online interactions, allowing students to communicate and interact with teachers outside of physical classrooms, enhancing their enthusiasm for learning.

2.4. Reform of the grading mechanism

According to the teaching needs of the digital signal processing course and referring to the teaching syllabus, a test question library including theoretical knowledge points, relevant knowledge points MATLAB implementation, and comprehensive design questions will be constructed as an effective teaching auxiliary system, forming a score evaluation mechanism that combines paper exams, classroom discussions, and project assignments.

The effectiveness of teaching reforms is generally measured by the degree to which objectives. The evaluation method for the achievement degree of course objectives includes both quantitative and qualitative evaluations. The quantitative evaluation primarily uses a weighted calculation method based on the achievement degree of course objectives, while the qualitative evaluation primarily uses a questionnaire survey method. Both types of evaluation are converted to normalized values, with both values greater than 0.65 indicating achievement of the goal and either value less than 0.65 indicating non-achievement. The total achievement value is taken as the smaller of the two.

3. Construction of a three-dimensional hybrid teaching model

The three-dimensional fusion hybrid teaching mode is shown in **Figure 1**, which is oriented by immersive learning experiences, fully leveraging information technology tools, and utilizing the hybrid teaching of "online learning and offline teaching cycles" and "traditional teaching and digital technology complementarity" to construct a hybrid teaching paradigm that emphasizes both ideological and political elements and professional knowledge, complements theoretical learning with practical training, and combines case-guided learning with progressive cutting-edge theories.

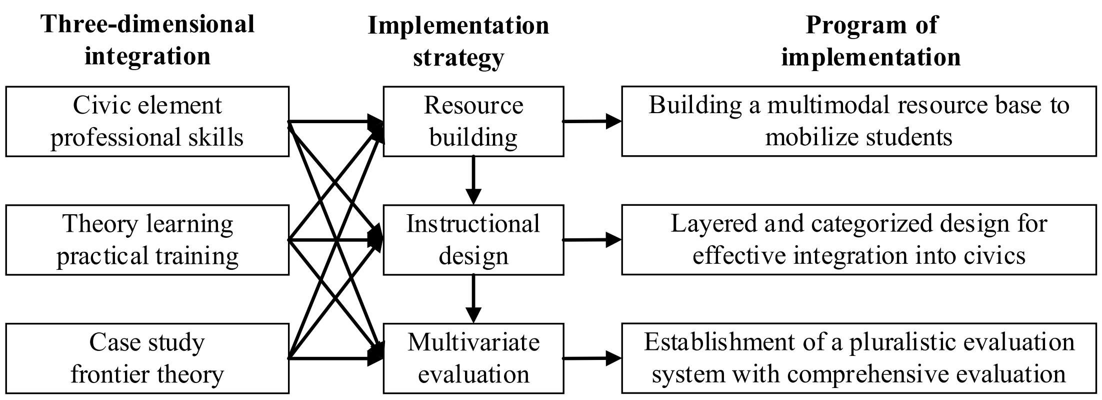

Figure 1. Three-dimensional fusion blended teaching model.

Rooted in the characteristics of the curriculum, deeply exploring ideological and political elements, finding the right fit, and achieving equal emphasis on ideological and political elements and professional knowledge. From the perspective of "cultivating virtue and nurturing talents," grasping the requirements of professional training objectives for the curriculum, following the knowledge system of the course, and combining elements of science and technology philosophy to extract ideological components from national sentiments, scientific literacy, and humanities knowledge. These are then refined into each chapter and section, forming a knowledge map that integrates professional knowledge with ideological elements.

Design "engineering cases" around core knowledge points to learn by doing and do with learning, reflecting the complementary effect of theoretical learning and practical training. Based on the common content of "basic concepts, basic theories, and basic methods," with the content of "practical sessions" as a bridge and the content of "typical applications" as traction, it combines the classical theories and software simulation organically; and carefully designs experimental and practical projects. The experimental and practical projects that expand on the theory are horizontally related, emphasizing the intrinsic connection between the knowledge modules, and vertically implemented, highlighting the comprehensive application of theory to realization.

Precise teaching to grasp the foundation in class, and after class, using case studies to guide knowledge expansion and understand cutting-edge theories, to realize the progression of basic content to the cutting-edge theories. The course teaching focuses on the fundamentals but also keeps up with the frontier of the development of the discipline. Based on consolidating basic theories, adding cutting-edge knowledge related to the profession, so that students can understand the latest development achievements and related application industries of the profession. Online teaching provides students with cutting-edge resource links, videos, and case studies, while also accompanied by corresponding tasks to keep up with the times in learning professional knowledge.

4. Practice of three-dimensional fusion hybrid teaching reform

4.1. Multidimensional resource construction

Using information technology such as images, animations, audio, and video to reshape course content, providing three-dimensional and multi-dimensional output, and constructing immersive learning resources.

By focusing on teaching key points and difficult aspects, addressing students' interests, and incorporating current social hot events, constructing multi-dimensional and three-dimensional resources that integrate professional knowledge and ideological and political elements from multiple aspects such as multimedia courseware, online courses, virtual simulation, mind maps, and WeChat public platforms.

Introduce three-dimensional demonstration animations for formulas and theorems that students find difficult to understand, and combine them with independently produced interactive animations to break them down, transforming stillness into motion and simplifying complexity. Core knowledge points are exemplified through typical engineering cases, closely combining abstract algorithms with real-life scenarios, facilitating theory-to-practice transitions, and enabling students to perceive that digital technology is pervasive in modern life and to apply their learning effectively.

Utilizing the Rain Classroom platform to establish online courses, corresponding online resources are established based on the learning situation, including micro course analysis, online discussions, unit tests, practice and expansion, and multiple modules.

Introducing principle demonstration and algorithm simulations to enhance student interest while reducing learning difficulty. The principle demonstration dynamically presents the signal operation process, emphasizing the physical meaning behind the formula and laying the foundation for engineering applications. Algorithm application is divided into three parts: foundation, design, and expansion. Students can process real signals through simulation to meet the personalized learning needs of students at different levels.

Learn and build together with students, and create the course's official account "Xiao Dai Signal Processing", featuring modules for program practice, engineering cases, and experience sharing. The experience-sharing module includes excellent practical examples and competition experiences from students in the major, which are reviewed and published by teachers. This aims to foster sharing and mutual assistance among students through online interaction, establishing a sustainable platform for learning and communication.

4.2. Tiered and categorized teaching design

The design of hybrid teaching directly affects the synergy among teaching elements, thereby influencing the effectiveness and quality of teaching. At the micro level of learning design, the process starts by reinforcing goal setting, guided by three sub-questions to determine core objectives: What is the most crucial content of this lesson? What do students most hope to achieve? Where are the key difficulties in student learning? Next, how to stimulate students' interest in learning and enhance their subjective initiative is considered. For this purpose, course resources are sorted, and teaching is designed in layers and categories according to the needs of online and offline teaching objectives. Online activities focus on autonomous learning by students, integrating brainstorming and quick-response segments to create a real-time interactive atmosphere that engages learning interests. Offline activities leverage the Rain Classroom, focusing on teacher analysis of key points and student-teacher interaction to clarify doubts and guide thinking. In terms of content, application cases lead the teaching, managing the theoretical-cognitive-practical-collaborative progression, layered teaching deepens understanding, guiding students into immersive learning, and weaving the intangible ideological soul into tangible professional knowledge, transforming the classroom not only into a stage for imparting knowledge but also a venue for value-led education. Innovation and application of teaching tools. With the rapid development of Internet technology, people's lifestyles and production methods have undergone significant changes. In this context, traditional classroom teaching methods and approaches struggle to meet the diverse educational needs. Therefore, multimedia resources can be integrated into classroom teaching, and online classroom models used for extracurricular teaching, aiming to help students effectively master the course.

4.3. Dynamic multifaceted teaching evaluation

Relying on the platform of "Teaching Online," the "N+1" assessment is implemented to form a comprehensive and precise evaluation system to promote learning through evaluation. A multi-dimensional, comprehensive and dynamic evaluation system is an indispensable part of teaching, and it is also a powerful tool to guide and motivate students to actively learn and participate in the teaching process. The course adopts the "N+1" assessment format, where N is process evaluation, and 1 is summative evaluation, both of which are weighted according to 60% and 40% to get the final grade. Process evaluation is the usual diversified assessment, including homework, classroom performance, online practice, major assignments, and stage assessment. It comprehensively assesses students' learning attitude, learning engagement, learning effectiveness, practical ability, and collaborative awareness. Online and offline teaching each account for 50%, with online classrooms mainly referring to students' online video learning duration, learning frequency, participation in discussions, etc. Considering the differences in students' foundations, especially for students with relatively weak foundations, this method can improve their learning enthusiasm and participation.

In the case of communication engineering students, according to the distribution of objective achievement degrees, there is a significant improvement in students' academic performance from 2019 to 2023. From qualitative indicators: The achievement degree of Goal 1 in the 2020–2021 academic year has increased by 12.75% compared to the 2019–2020 academic year; The achievement degree of Goal 1 in the 2021–2022 academic year has increased by 18.55% compared to the 2019–2020 academic year; The achievement degree of Goal 2 in the 2020-2021 academic year has increased by 10.64% compared to the 2019-2020 academic year; The achievement degree of Goal 2 in the 2021–2022 academic year has increased by 20.42% compared to t the 2019–2020 academic year. Compared to the 2019–2020 academic year, the achievement rate of Goal 3 in the 2020–2021 academic year has increased by 9.68%; The achievement of Goal 3 in the 2021–2022 academic year has increased by 14.28% compared to the 2019–2020 academic year. The proportion of each goal achievement degree to the total achievement degree is 0.35, 0.45, and 0.20, respectively. Based on this, it is calculated that the total achievement degree of the 2020-2021 academic year has increased by 14.04% compared to the 2019–2020 academic year, and there is a significant improvement in qualitative indicators. From quantitative indicators, the total achievement degree of the 2020–2021 academic year has increased by 5.55% compared to the 2019–2020 academic year. This indicates that through curriculum reform, students have achieved a certain degree of improvement in their mastery of course knowledge. Convert both evaluations into normalized values, and take the smaller value of the two to form the overall achievement degree. As shown in **Figure 2**, it can be seen that the student's course achievement degree is increasing year by year.

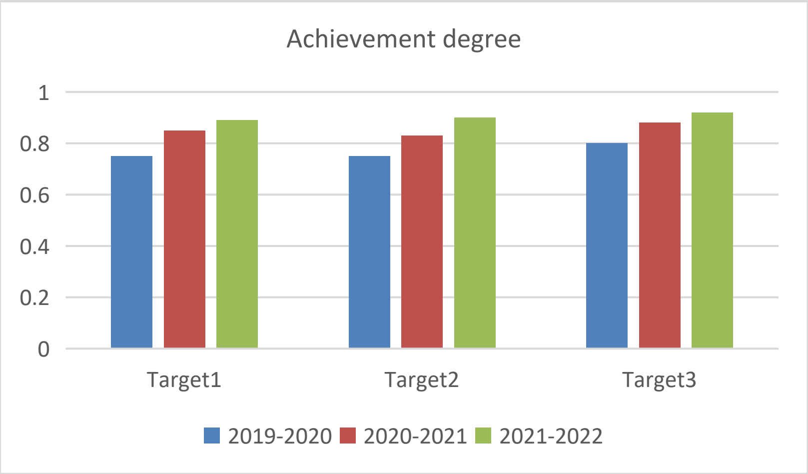

Figure 2. Achievement degree.

The final assessment, or end-of-term test, consists of comprehensive subjective questions that assess students' ability to analyse, solve, and design for discrete-time signals and systems, focusing on students' ability to integrate, actively learn, and analyse and solve problems.

To precisely assess students' specific mastery during learning and to facilitate continuous improvement, under the guidance of professional accreditation, process, and final evaluations are aligned with four graduate requirement indicators supported by the course. These are processed and analysed by the "Dai Math Easy" big data evaluation system developed by the team, allowing for precise tracking of each student's achievement of various indicators, thus achieving precise, multifaceted, and dynamic evaluations that provide direction and ideas for continuous improvement in resource construction, teaching design, and teaching implementation. **Table 1** shows the evaluation methods and value ratios corresponding to professional accreditation indicators.

Table 1. Professional accreditation indicators corresponding to evaluation methods

Course Objective	Support Requirement	Classroom Performance	Online Homework	Computer Lab	Network Evaluation	Practical Report	Homework After Class	Value Ratio
1	1.4	10	0	0	5	0	10	25
2	2.1	0	10	0	5	0	10	25
3	3.2	0	0	20	0	0	10	30
4	4.1	0	0	0	0	10	10	20
Total		10	10	20	10	10	40	100

5. Collaborative and innovative

Teachers must find long-term solutions in an engineering context when disseminating knowledge, and students must react to the teaching process, integrating personal development with actual professional growth.

For example, when conducting the "EEG signal acquisition" project in the lab, students can be organized to practice collection methods, display original noisy ECG signals, summarize problems, and execute experimental plans to cultivate their learning ability, help them integrate professional knowledge, develop new methods continuously, and maintain an open attitude towards new ideas and the unknown.

This training is expected to enable students to gradually master the skills and knowledge of discovering problems, thinking about them, seeking methods, and drawing conclusions through questioning and guidance etc. In the process of observation, discovery, thinking, debating, experiencing, and comprehending. In addition, the use of inquiry-based teaching enables students to actively participate and play a leading role in teaching activities, helping them taste the joy of their discoveries and a strong desire for knowledge and creativity.

In specific implementation, students may be asked once or more to practice arousing questions that the instructor may ask individually or in groups during class, lasting from 30 seconds to 3 minutes, questions that may include: (1) Outlining problem-solving strategies; (2) Drawing a flowchart for the just-described process; (3) Beginning to solve the problem, seeing how many questions can be resolved in two minutes; (4) Proving or verifying results; (5) What concerns or questions you have.

Engineering fundamentally involves cooperation among individuals with diverse backgrounds, capabilities, and responsibilities. Understanding others' needs and considering multiple perspectives in decision-making epitomizes the essence of teamwork. University students are notably deficient in this recognition; thus, helping students become independent learners is not the endpoint of educational training.

In the cooperative learning teaching model, students expand their knowledge acquisition channels by exchanging ideas and experiences with each other, which stimulates inspiration and active thinking. Through cooperative discussions and learning, students inspire each other within the group, deepening their understanding of knowledge and enhancing their summarization and expression abilities. At the same time, turning individual competition into group competition, using the overall performance of the group as the basis for assessment, forming a new pattern of "members within-group cooperation, members between groups competition". This enables students to communicate with each other, respect each other, and share the joy of success together, promoting their comprehensive development.

At present, group learning has not been implemented in the "Digital Signal Processing" course, but it is anticipated that students will be arranged to complete some projects in groups while the experimental course reform mentioned above is underway. The collaborative and cooperative reform plan proposed in this paper will specify more detailed requirements for grouping methods: (1) Ideal team size is 2–3 people to reduce the likelihood of domination by one person in two-person teams and to prevent exclusion in larger groups. (2) Teams should be determined by teachers, who are generally more apt at forming teams than students themselves. When students form their teams, top students often choose each other, leaving others to arrange themselves, which is unfair. Ideal teams consist of members with different capabilities, common interests, and available times. (3) Assign and rotate team member roles, essential roles include the team leader (for breaking down structures), the recorder (for documentation), and the inspector (for implementing solutions).

During the course, roles should be rotated so each student experiences different roles. Role-playing can help stimulate students' interest in learning and participation enthusiasm.

6. Conclusion

Based on long-term frontline teaching experience, to discuss the reform plan for the core course "Digital Signal Processing", starting from improving teaching effectiveness and cultivating talents needed by society. Considering the needs of the communication engineering discipline and industry development in our country, taking industrial development needs as the starting point, the reform emphasizes the combination of practical and application, setting new goals and requirements for teamwork abilities.

Based on the existing teaching situation of this course, several important factors in the reform process are discussed, and a general reform framework and a defined reform plan are proposed to provide a reference for the actual teaching reform. Theory combined with practice, through reform and development, put forward a kind of education and teaching mode that can stimulate students' interest in learning and cultivate them to become engineering talents who meet the development needs of the industry. Some of the reform ideas in this paper have been applied to current teaching and learning activities, including focusing on inspiring students' interest in learning and critical thinking, which have already yielded positive teaching outcomes and favourable feedback ratings from students. However, collaboration and creativity are difficult to quantify because these concepts are not singular or defined within science, but are not easy concepts to understand. The series of reform measures for the "Digital Signal Processing" course will be implemented in the following years, and their effectiveness needs to be further improved.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Jiang H, Xu Y, Cheng Y, 2022, Reform and Exploration on Teaching Objectives of Digital Signal Processing. Education and Teaching Forum, 8(35): 69–72.

[2] Chen X, Yao Z, Song H, 2024, Design and Practice of Progressive and Innovative Experimental Programs for Digital Signal Processing Course. Heilongjiang Education (Research and Evaluation of Higher Education), 2024(5): 64–66.

[3] Zhao Y, Zhao P, Lu J, 2023, Research and Practice of Mixed Teaching Models for Digital Signal Processing. China Education Society of Electronics, 2023(2): 77–78.

[4] Dong M, Ma L, Zhu Z, et al., 2023, Student-Centered Blended Teaching Mode Exploration for Digital Signal Processing. Journal of Electrical and Electronic Education, 45(5): 144–146.

[5] Dong T, 2022, The Current Situation of Blended Learning in Colleges and Universities and Suggestions for Improvement. Western China Quality Education, 8(22): 138–141.

[6] Yan N, Dai C, 2023, Design of Simulation Experiment Platform for Digital Signal Processing Course Based on MATLAB. Information and Computer, 35(2): 221–223.

[7] Huang Q, Lu G, Yang H, 2023, The Exploration and Practice of First-Class Course Construction in Digital Signal Processing. Journal of Electrical and Electronic Education, 45(1): 46–49.

[8] Tian Z, Gao S, Chan X, 2025, Construction of Engineering Creativity and Craftsmanship Training Model for Applied Undergraduate Engineering Talents. Education Reform and Development, 7(1): 100–106.

[9] Wang Y, Zhang X, Zhang L, 2020, Exploration and Practice of Implementation of Gradual Blended Teaching Mode by Taking "Digital Signal Processing" Course as Example. Experimental Technology and Management, 37(12): 244–249.

[10] Ma L, Shi Y, Yuan H, 2023, Research on Hierarchical Course Teaching Design of Digital Signal Processing. Education and Teaching Forum, 25(6): 67–70.

[11] Yu Y, Li L, Ou Y, 2023, Exploration of the Ideological and Political Elements in the Course of Digital Signal Processing. Journal of Electrical and Electronic Education, 45(5): 86–89.

[12] Zhang T, Chen H, Liao Q, 2024, Practical Exploration of Blended Flipped Classroom—Taking the Course of "Digital Signal Processing" as an Example. The Guide of Science & Education, 2024(3): 104–106.

[13] He F, Jiang D, Chen H, 2024, Research on the Teaching Design of Blended First-Class Courses Based on the OBE Concept—Taking Digital Signal Processing Course as an Example. University Education, 2024(6): 39–41.

[14] Ji P, 2024, Teaching Research of Digital Signal Processing Course Based on "The Integration of Innovation and Profession." Journal of Jilin Agricultural Science and Technology University, 33(1): 110–115.

[15] Jiang H, Xu Y, Cheng Y, 2023, Exploring the Assessment Reform of Digital Signal Processing Courses Against the Standard of "Gold Class." Journal of Higher Education, 9(16): 130–133.