

Research on Teaching Reform of the “Digital Signal Processing” Course

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Abstract:

As a core course in electronics and information engineering, the Digital Signal Processing curriculum has long faced four major challenges in traditional classroom teaching: abstract and difficult-to-grasp theoretical concepts, monotonous teaching methods, inadequate experimental training, and an incomplete assessment mechanism. To effectively address these issues, this paper proposes a systematic teaching reform plan based on a comprehensive analysis of existing research on pedagogical innovation. Reforms are analyzed across multiple dimensions-content, methodology, experimentation, and evaluation-by integrating blended online-to-offline instruction, knowledge mapping, flipped classrooms, diversified assessment, and peer support mechanisms into actual teaching practice via the Xuexitong online platform. These initiatives not only enhance teaching quality but also significantly improve students' learning initiative, engineering practical skills, innovative thinking, and teamwork capabilities.

Keywords:

Digital Signal Processing, Teaching Reform, Mind Mapping, Experiment System, Diversified Assessment

1. Introduction

With the advancement of science and technology, Digital Signal Processing technology has become deeply integrated into various aspects of daily life. It is widely applied in fields such as smartphone communication, noise-canceling headphones, image enhancement, medical imaging, radar signal processing, and aerospace. This course is a core compulsory subject for electronics and information-related majors, with prerequisites including foundational courses like Advanced Mathematics and Signals and Systems. Its follow-up courses include Modern Signal Processing, Digital Image Processing, Speech Signal Processing, and DSP System Design. It is also one of the key subjects tested in postgraduate entrance examinations for electronics and information-related disciplines at many universities. The course requires students to possess strong mathematical logic and deduction skills, the ability to think abstractly and summarize concepts effectively, and the competence to flexibly apply theoretical knowledge to practical situations.

However, against the backdrop of increasing demands for applied talent cultivation and the advancement of New Engineering Initiatives, traditional teaching models have gradually revealed numerous shortcomings. A comprehensive analysis of the current teaching landscape [1,2,3], identifies four major pain points: First, the teaching content is fragmented, making it difficult to construct a systematic knowledge framework. The course theories are abstract with complex and scattered knowledge points, characterized by strong theoretical emphasis, conceptual abstraction, and numerous formulas. Students tend to develop apprehension toward the subject, showing significant difficulties in understanding fundamental principles and transform domain analysis [1], and struggle to independently establish connections between knowledge points. The teaching content is disconnected from engineering applications. Theoretical instruction often remains confined to formula derivation, failing to effectively integrate with practical application scenarios such as speech processing and signal processing [1,4,5]. Second, teaching methods and models are outdated. The traditional approach remains teacher-centered, characterized by one-way knowledge transmission. This results in low student engagement and hinders the shift from passive acceptance to active inquiry. [1,5] Third, the experimental component overemphasizes verification at the expense of innovation. Experimental tasks predominantly consist of simple software simulations and verification exercises, lacking comprehensive and innovative projects that guide students through parameter design, system debugging, and solving authentic engineering problems [4,6]. Fourth, assessment methods are one-dimensional. Evaluation relies heavily on final written examinations, overlooking students' performance in learning processes, practical abilities, teamwork, and innovative thinking [7].

In response to the aforementioned challenges, numerous universities and colleges have conducted extensive explorations in teaching reform. In terms of teaching content and methodology, knowledge graphs have been constructed to systematically organize the intrinsic relationships between knowledge points, guiding students to shift from passive knowledge acquisition to mastering engineering learning thinking methods, thereby cultivating their holistic perspective and practical problem-solving capabilities [5,9]. By integrating heuristic, discussion-based, and case-based teaching approaches, supplemented with informational tools such as Rain Classroom and virtual simulation experiment systems, classroom interaction can be effectively enhanced, boosting students' learning interest and participation [8,9]. At the level of teaching implementation and evaluation, Rain Classroom has been utilized to achieve precision teaching and process-oriented learning assessment [9]. Additionally, combining online education platforms with hardware DSP experiments and computer simulation experiments can increase the flexibility of practical work, enabling the organic integration of in-class and extracurricular learning [10], thereby strengthening the cultivation of engineering practical abilities [4,6].

Against this background, this paper fully draws on advanced experiences and combines them with practical teaching experience to systematically elaborate on the teaching reform plan for the Digital Signal Processing course from four dimensions: knowledge system reconstruction, teaching method innovation, experimental system optimization, and assessment mechanism reform, aiming to provide references for the development of similar courses.

2. Pain Points and Current Status in the Teaching of Digital Signal Processing Courses

2.1. The course theory is abstract, making it difficult for students to understand

The formula derivations in this course require the comprehensive and flexible application of knowledge from advanced mathematics and linear algebra, demanding high logical thinking and abstraction skills from students. The traditional teaching model primarily uses blackboard writing for formula derivation. On one hand, this consumes significant class time, squeezing out time for classroom interaction and practical segments. On the other hand, during complex formula derivations, students tend to passively follow the teacher's thought process, lacking independent thinking. They can also easily get bogged down in the details of the derivation, struggling to see the bigger picture beyond the immediate logic, and fail to connect concepts from different parts of the course in a timely manner. This leads to a shift in the learning focus, causing students to neglect grasping and understanding the overall knowledge framework.

2.2. Single teaching method, teacher-centered approach, resulting in low student participation

The traditional theoretical teaching mainly relies on PPT, blackboard derivations, and example problem lectures. The teaching model is predominantly one-way knowledge transmission from the teacher. Classroom interaction is mostly limited to "in-class questions," which often focus on basic concept recall, lacking heuristic questions that guide students towards deep thinking. There is seldom discussion segments centered around engineering application scenarios. Consequently, students often remain passive recipients of knowledge, making it difficult to effectively foster students' self-directed learning and higher-order thinking skills. Students end up merely understanding theoretical formulas mechanically without deeply mastering the principles and application logic behind the knowledge.

2.3. Weak practical/lab component, lacking comprehensiveness and innovation

Traditional lab projects are mostly theoretical verification. From signal parameter setting, and Matlab code/function calls, to data result saving, clear descriptions are provided. Students only need to follow the standard steps to verify the correctness of theories and formulas. This approach leaves little room for independent thinking and autonomous exploration by students. Furthermore, the lab content lacks experimental designs that integrate multiple knowledge points or skills. Each lab often focuses on a single knowledge point (e.g., convolution operation of signals, FFT spectrum analysis, filter design), without involving the collaborative application of knowledge from different modules. Students cannot appreciate the systematic nature and interconnectedness of the knowledge, making it difficult for them to form a complete engineering thinking framework. Additionally, the lab design lacks alignment with cutting-edge technology, failing to cultivate innovation capabilities for tackling complex engineering problems within the lab environment.

2.4. Assessment system is not comprehensive, neglecting dynamic evaluation of the learning process and comprehensive consideration of student abilities

The assessment method in traditional teaching primarily consists of formative assessment and a final exam. Formative assessment mainly includes usual attendance,

in-class questions, and lab reports, with the closed-book final exam carrying the highest weight. Furthermore, the assessment content overemphasizes the memorization of theoretical knowledge and formula derivation, lacking systematic evaluation dimensions for students' practical operation skills, innovative thinking, and comprehensive literacy. This situation leads students to neglect their usual performance, resulting in a learning state characterized by last-minute cramming before exams and quick forgetting afterwards. This hinders the improvement of students' comprehensive abilities and impedes the achievement of talent training objectives.

The four major teaching pain points in the Digital Signal Processing course mentioned above essentially reflect a disconnect between the traditional teaching model and the trinity talent development requirements "theoretical depth, practical ability, and value literacy" in the context of emerging engineering education. Specific manifestations include: abstract and complex theories leading to learning difficulties; monotonous teaching methods failing to stimulate students' autonomy and motivation; weak experimental components resulting in a lack of engineering application skills; and theory-biased assessments causing students to study merely for exams and forget shortly after. These issues not only hinder the improvement of teaching quality but also impede students' deep understanding and flexible application of course knowledge, making it difficult to achieve the trinity educational goal of "knowledge imparting, ability cultivation, and value shaping." Therefore, it is essential to center on the core philosophy of "student-centered, competency-oriented, and education as the foundation," transform pain points into leverage points, and carry out a systematic and integrated reconstruction across multiple dimensions, including teaching content, methods, experiments, and assessment. This will drive the transformation of course teaching from "knowledge imparting" to "holistic education", thereby genuinely enhancing the quality of teaching.

3. Innovative Methods and Pathways in Teaching Reform

3.1. Pre-class Preview + In-class Intensive Teaching + Post-class Consolidation

To address the abstract nature of the course theory and students' difficulties in comprehension, online learning resources were developed on the Xuexitong platform. A demonstration teaching package from the platform was imported to build the course, and video content was adjusted in accordance with the textbook.

Before Class: Students are required to independently study video lessons and complete online pre-class quiz questions. For content involving abstract formulas and complex derivations, the teacher provides key point hints on the Xuexitong platform, guiding students to attempt derivations offline, organize their questions, and submit them online. The teacher must analyze students' answers and feedback in detail before class to identify common problems.

During Class: Targeted explanations are provided based on student questions, guiding them to master the derivation process of formulas and helping them organize and summarize the knowledge framework. During instruction, for abstract theoretical principles (such as filter design), the introduction phase can involve playing a noisy song followed by the clear audio signal after filtering. This before-and-after comparison allows students to intuitively perceive the filter's effect on the signal spectrum, transforming abstract theoretical knowledge into tangible sensory

experience. Encouraging students to attend lectures with questions in mind can significantly enhance classroom effectiveness.

After class: Teaching PPTs, full-length formula derivation videos, and extended case studies (such as practical applications of signal processing in engineering) are uploaded to the Xuexitong platform. Structured mind maps and knowledge graphs are also provided to clearly illustrate the logical relationships between key concepts, facilitating student review and consolidation. Meanwhile, online post-class assignments are published on Xuexitong, encouraging students to engage in peer review and collaborative learning support. This approach establishes a closed-loop learning chain of “pre-class preview, in-class intensive instruction, and post-class consolidation.”

3.2. Enriching Teaching Methods to Enhance Student Classroom Engagement

To address the issues of monotonous teaching methods, teacher-centered instruction, and low student participation, the following measures are implemented: On one hand, based on common difficulties identified in pre-class assessments, “group discussions + live demonstrations” sessions are designed. For example, the teacher selects moderately challenging knowledge points or controversial aspects of complex formula derivations, allowing students to conduct mini-lectures in groups. Students can create their own PPTs, short videos, or physical demonstrations. The teacher then selects representative presentations to annotate and explain simultaneously on the blackboard or screen, helping students supplement details and correct misunderstandings. This approach not only trains students’ expression skills but also enables them to understand knowledge from multiple perspectives, thereby enhancing their engagement interest. Additionally, a rotating team leader system is implemented, where different group members take turns serving as the discussion leader for each activity, preventing the limitation of only a fixed few participants. On the other hand, a real-time points reward system for classroom activities is established. For instance, students participating in activities like quick Q&A, polls, or thematic discussions on Xuexitong can earn 0-10 points per activity. This enlivens the classroom atmosphere and allows students to deepen their understanding through reasoning and feedback. Through positive reinforcement, students experience the value of participation and the recognition of their contributions, gradually developing the habit of active involvement.

3.3. Hierarchical Restructuring and Design of Lab Content

For foundational verification experiments such as signal operations and signal representation, the traditional classroom teaching model is reformed. The instructor provides complete code with detailed comments, along with basic software manuals, to guide students in self-directed learning and simulation debugging after class. By modifying parameters and observing waveform changes, students gain an understanding of the algorithmic principles. They are required to submit videos demonstrating their results and explaining their process to the instructor. This approach cultivates students’ proficiency in using software tools and fosters habits of active inquiry. For core experiments like spectrum analysis and filter design, the instructor refrains from providing precise parameters and instead offers a constrained range. Students are guided through an iterative cycle of “adjusting parameters → observing results → analyzing causes → optimizing” to independently identify the optimal solution. The experiment report is enhanced to include sections on parameter

design rationale and debugging logs, allowing the instructor to assess the logic behind students' parameter design and their problem-solving abilities, rather than merely evaluating whether the final experimental results meet the standards. DSP experiment kits are deployed to strengthen engineering practice through hardware platforms. After completing simulation verification, students port their algorithms to run on the hardware platform. By engaging in practices such as processing real-time signals and analyzing computational resource consumption, students gain firsthand experience of how algorithms perform differently in real hardware environments, thereby developing their ability to solve practical engineering problems.

Building on this foundation and aligning with current industry trends, open-ended comprehensive projects are established. Students are encouraged to form teams of 3-5 members, independently choose a project direction, and complete the entire process from requirements analysis and solution design to simulation implementation. A final project defense session is held at the end of the semester. Evaluation is conducted across multiple dimensions, including the innovativeness of the solution, effectiveness of the results, teamwork, and report quality. Emphasis is placed on assessing students' problem analysis, solution justification, and collaborative performance during the experimental process. This approach aims to cultivate students' abilities in comprehensive application, hands-on practice, teamwork, communication, and innovation, rather than solely grading them based on the final experiment report.

3.4. Diversified Assessment and Mutual Growth

A diversified assessment approach is implemented, with a restructured weighting scheme that shifts the focus away from relying solely on final exam scores and teacher evaluation. Instead, a formative assessment system encompassing the entire learning process and multiple evaluation dimensions is established. First, the assessment weightings are reconfigured to reduce the proportion allocated to the final exam. For online participation, evaluation metrics are set across multiple dimensions. These metrics include, but are not limited to, activities issued via the Xuexitong platform, such as in-class questions, individual tasks, chapter tests, stage tests, thematic discussions, quick Q&As, surveys, interactions, and note submissions. Furthermore, the single-teacher evaluation approach is no longer used. In group task practice sessions, a peer evaluation mechanism is introduced, allowing students to enhance their critical thinking and collaborative communication skills while evaluating others' solution designs, result presentations, and team contributions. Additionally, a "learning assistance" incentive mechanism is established to encourage students to form learning communities. Students who actively help their peers and achieve significant results in group discussions and project collaborations are awarded extra assessment points, encouraging mutual assistance and sharing among students, stimulating learning motivation, and promoting common growth. Through diversified assessment methods, the aim is to make evaluation truly serve learning improvement, focusing not only on students' knowledge mastery but also placing greater emphasis on the enhancement of multidimensional abilities such as learning skills, collaborative spirit, and innovative thinking.

4. Conclusions

This paper systematically examines the key challenges in teaching the Digital Signal Processing course and proposes a series of corresponding reform initiatives. The core of the reform lies in transforming the traditional teaching philosophy—

shifting from a teacher-centered knowledge transmission approach to a student-centered model that fosters the integrated development of competencies and qualities. The reform measures are implemented in the following aspects: First, in terms of knowledge structure development, mind mapping is introduced to address the issue of fragmented knowledge points, helping students establish interconnections and form a systematic knowledge framework. Second, in teaching models and methods, an online-offline hybrid teaching cycle consisting of “pre-class self-study, in-class intensive instruction, and post-class consolidation” is adopted to enhance learning continuity and interactivity. Third, in experimental practice, a tiered experimental system—comprising basic verification, design-based experiments, DSP kit applications, and comprehensive projects—is implemented to holistically strengthen students’ engineering practical skills and innovative capabilities. Finally, a diversified assessment mechanism is established to comprehensively evaluate students’ learning processes and overall competencies. These methods have proven effective in improving the classroom environment and elevating teaching quality. In the future, we will further explore the application of artificial intelligence in teaching, continuously enrich teaching resources, and deepen the integration of ideological and political education to better meet the demands of cultivating high-quality engineering talent in the new era.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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References

- [1] Dong, M.; Ma, L.; Zhu, Z.Y. et al. Student-Centered Blended Teaching Mode Exploration for Digital Signal Processing. *Journal of Electrical and Electronic Education*, 2023, 45(5), 144-146.
- [2] Zhu, J.; Pan, X.L.; Jiang, F. “Digital Signal Processing” Teaching Exploration and Practice. *Education and Teaching Forum*, 2024, 17, 145-148.
- [3] Wei, H. Exploration on Teaching Reform of “Digital Signal Processing” Course. *Wireless Internet Science and Technology*, 2024, 21(3), 84-87.
- [4] Jia, H.J.; Xu, T.Y. Exploration on Teaching Reform of “Digital Signal Processing” Course under the Background of Informatization. *Vocational Technology*, 2024, 23(9), 90-95.
- [5] Long, J.L.; Li, Y.; Zhang, J.M. et al. Fishing Instead of Fish in the Teaching Course of “Digital Signal Processing”. *Education and Teaching Forum*, 2024, 21, 129-132.
- [6] Jiang, E.H.; Zhou, J.F.; Dou, D.Z. et al. Research on the Experimental Teaching Platform for digital signal processing course. *Journal of Hubei Normal University (Natural Science)*, 2024, 44(4), 39-44.

- [7] Shao, C.L.; Huang, Z.X.; Geng, L. et al. Exploration of Digital Signal Processing Course Reform Based on Professional Certification of Engineering Education under the Background of New Engineering Construction. *Journal of Jilin Engineering Normal University*, 2023, 39(11), 69-73.
- [8] Yan, H.; Chen, Z.Y.; Hu, G.B. Practice of Innovative Teaching Mode for Digital Signal Processing Course. *Electronic Technology*, 2024, 53(03), 402-405.
- [9] Wang, Y.; Zhang, L.L.; Teng, J.Y. et al. Research and Practice of Precise Digital Signal Processing Teaching Based on Rain Classroom. *China Modern Educational Equipment*, 2025, 453, 84-86.
- [10] Li, Z.Y. Construction and Effect of Digital Signal Processing Online Course. *Education Teaching Forum*, 2020, 21, 207-208.



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