Teaching Reform of "DSP Technology and Its Applications" Based on the OBE-SRT Synergy Mechanism

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Abstract: This study deeply integrates the concept of Outcome-Based Education (OBE) with Student Research Training (SRT) projects, systematically reconstructs the teaching system of "DSP (Digital Signal Processor) Technology and Its Applications", which is a core course for electronic information majors. While OBE and Project-based Learning (PBL) have been widely explored, a deep synergy mechanism that systematically maps SRT project tasks directly onto hierarchical OBE learning outcomes, supported by a data-driven intelligent evaluation feedback loop, was notably lacking in previous reforms. Guided by industrial demands and engineering education accreditation standards, the research reversely designs and refines three-level OBE learning objectives, decomposes SRT tasks, and organically integrates them into the course's theoretical teaching and practical links, and implements an intelligent multi-source evaluation system. The results show that after the reform, the average course score increased significantly by 10.37 points, and the excellent rate rose by 19 percentage points. Three innovative mechanisms were developed: a dynamic content adaptation mechanism, a trinity collaborative teaching model, and a learning analytics-driven evaluation system. To address challenges such as project integration depth and teacher workload, optimization strategies, including a hierarchical project library and a refined innovation evaluation model, are proposed. This study provides a replicable practical paradigm and theoretical reference for in-depth reform of core courses in electronic information majors in the background of engineering education accreditation.

Keywords: Outcome-Based Education (OBE), Student Research Training (SRT), DSP (Digital Signal Processor) technology, Curriculum reform, Engineering education accreditation, Project-driven teaching.

1. INTRODUCTION

Driven by the new round of technological revolution, such as artificial intelligence (AI) and the Internet of Things (IoT), Digital Signal Processor (DSP) technology has become a core enabling technology in many cutting-edge fields. As a course for electronic information majors, "DSP Technology and Its Applications" undertakes the mission of cultivating students' systematic mastery of DSP theoretical essentials and excellent engineering practice capabilities. However, in-depth investigations and analyses reveal that the traditional teaching model faces structural dilemmas, restricting the alignment between talent training quality and industrial demands. The following main problems exist.

(1) Teaching objectives are significantly disconnected from industrial needs. Research by Wang *et al*. (2023) revealed that employer satisfaction with engineering graduates' capabilities in problem discovery and analysis and in solving practical problems is below 70%. The traditional curriculum system overemphasizes knowledge indoctrination and fails to effectively align with the industry's core demands for system design, problem analysis, and innovative problem-solving capabilities, leading to a prominent phenomenon of separation between learning and application among graduates (Trevelyan, 2019; Garousi *et al*., 2020).

(2) The update of teaching content lags behind the speed of technological iteration (Voas *et al*., 2018; Shen *et al*., 2020). DSP technology is rapidly evolving towards integration with deep learning and heterogeneous computing, while current textbooks and teaching content are still dominated by classical algorithms, failing to timely absorb cutting-edge technologies and engineering cases. This lag leaves a technological gap of several years between students' knowledge and industrial applications (Fleming *et al*., 2024).

(3) The evaluation system is simplistic, making it difficult to scientifically measure comprehensive capabilities. The traditional assessment system, predominantly based on final written exams (Gratchev *et al*., 2024), fails to effectively evaluate multidimensional competencies such as practical operation, innovation, and teamwork, leading to the common discrepancy between high scores and low real-world abilities.

This study aims to address these gaps by proposing and implementing a novel Outcome-Based Education-Student Research Training (OBE-SRT) synergy mechanism for course reform. The primary contribution lies in the systematic construction of a three-dimensional teaching model that deeply integrates hierarchical OBE objectives with decomposed SRT project tasks, supported by an

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intelligent, data-driven evaluation system, moving beyond traditional Project-based Learning (PBL) implementations, which often lack such tight coupling and analytical feedback.

The OBE concept, systematically proposed by Spady (Spady, 1994), is student-centered and prioritizes demonstrable ability outcomes over content coverage. Through backward design, curricula derive course objectives, content, pedagogy, and assessment from graduate attributes, and implement a continuous-quality-improvement (CQI) feedback loop that uses evaluation data to iteratively refine instruction (Syeed *et al.*, 2022). While OBE provides a robust framework, its implementation often remains generic. Consistent with this OBE-oriented, evidence-based improvement logic, big-data analytics in MOOC-supported flipped courses have been used to predict performance for targeted intervention (Qian *et al.*, 2022; Li *et al.*, 2023). In the field of engineering education, the IEA's Graduate Attributes and Professional Competencies benchmark (IEA, 2021) affirms that Washington Accord signatories use outcomes-based program criteria and competence-based registration standards. *China's Engineering Education Accreditation Standards* (2024 edition) also clearly stipulate that course teaching must strictly follow the OBE principle to ensure effective support for graduation requirements and measurable achievement.

SRT projects are important platforms for undergraduates to engage in research at an early stage. By participating in the full cycle of real or simulated research projects, students can deeply hone core engineering capabilities such as problem scoping and analysis, solution design and implementation, and iterative testing and refinement. (Picard *et al.*, 2022). Similar benefits are reported in PBL frameworks. However, SRT, as implemented here, emphasizes authentic, often frontier, research tasks, providing a richer context for innovation capability development compared to typical PBL cases. In participating in scientific research projects, students effectively develop the ability to discover, analyze, and solve problems, as well as innovative consciousness and creative thinking (Huang *et al.*, 2019). Moreover, through immersive experience in the research process, they shape a rigorous academic norm awareness, teamwork spirit, communication skills, and project management capabilities (Kimpton *et al.*, 2024), laying a foundation for further study or career development.

This study's novelty lies in its deep integration mechanism, contrasting with existing approaches. Unlike traditional PBL, which might use simplified cases, the OBE-SRT synergy specifically leverages authentic and ongoing research projects, meticulously decomposes them to align with granular OBE outcomes, and employs a pervasive intelligent evaluation system for feedback, creating a tighter loop between research activity and defined learning outcomes.

This study proposes an OBE-SRT deep synergy mechanism (Figure **1**) that maps project tasks to hierarchical outcomes and embeds them throughout the course, supported by an intelligent evaluation loop, distinguishing it from generic PBL approaches.

2. RESEARCH DESIGN AND METHODS

2.1. Construction of the Curriculum Reform System

2.1.1. Refined Design of OBE-Oriented Three-Level Learning Objectives

Strictly in accordance with the engineering education accreditation standards of the Washington

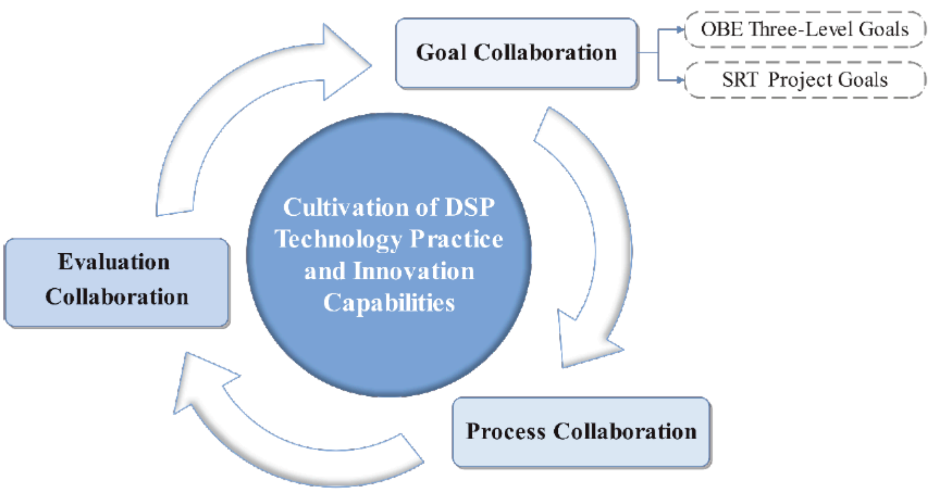

Figure 1: Conceptual framework illustrating the research problem of traditional teaching gaps and the proposed OBE–SRT synergy solution mechanism.

Table 1: Design of OBE Three-Level Learning Objectives System

Objective Level	Capability Dimension	Specific Indicators and Requirements
Basic Level	Knowledge Understanding and Mastery	Deeply understand the basic principles of DSP systems, proficiently master core algorithms, and the architectural characteristics and programming models.
Advanced Level	Ability to Solve Complex Engineering Problems	Be able to comprehensively apply DSP theoretical knowledge and technical means to effectively solve problems in typical signal acquisition, real-time processing, and reliable transmission in fields.
Innovation Level	Research and Innovation Ability	Possess initial ability to propose new DSP application schemes or improve existing technologies; actively participate in SRT and other research projects, and achieve measurable phased innovative results.

Accord and based on in-depth research and analysis of core competency requirements for DSP-related positions, the objectives of "DSP Technology and Its Applications" were decomposed into three capability levels. The details were shown in Table **1**.

2.1.2. Decomposition of SRT Project Tasks and In-Depth Course Integration

Focusing on core application scenarios of DSP in real-time signal processing, multi-source data fusion, and intelligent control, 5 categories of typical and cutting-edge SRT projects were selected and integrated:

(1) Signal Monitoring: *e.g.*, "System for Identifying Vocal Characteristics of Chicken Ammonia Stress and Determining Health Levels", targeting specific processing of poultry vocalization, behavior, and other data.

(2) Multi-Source Fusion: *e.g.*, "Early Warning System for Postpartum Stress Behavior and Body Temperature Data Fusion in Dairy Cows", focusing on collaborative processing of multi-modal signals, different from single-signal analysis.

(3) Intelligent Picking: *e.g.*, "Module for Rapid Extraction of Visual Features of Blueberry Ripeness and Picking Path Planning", focusing on visual signal parsing and action planning in picking scenarios.

(4) Field Inspection: *e.g.*, "Module for Real-Time Denoising of Tea Garden Disease Images and Rapid Localization of Lesion Areas", emphasizing image signal enhancement and target detection in field environments.

(5) Precision Control: *e.g.*, "System for Real-Time Calculation of Pig Body Size Measurement Data and Generation of Robotic Arm Servo Control Commands", highlighting the precise and real-time generation of control commands.

Taking the project "Real-Time Denoising of Tea Garden Disease Images and Rapid Localization of Lesion Areas" as an example, how its tasks were systematically decomposed and seamlessly integrated into various course links is shown in Figure **2**.

(1) Integration into theoretical teaching. In teaching image enhancement, the tea-garden project’s noise-reduction task was used to demonstrate spatial filtering methods under realistic field conditions, simultaneously connecting these approaches to frequency-domain analysis via Fourier transform principles.

(2) Alignment with experimental links. An experimental project was designed in which students used a DSP-based camera system to acquire tea-garden images, implement adaptive noise

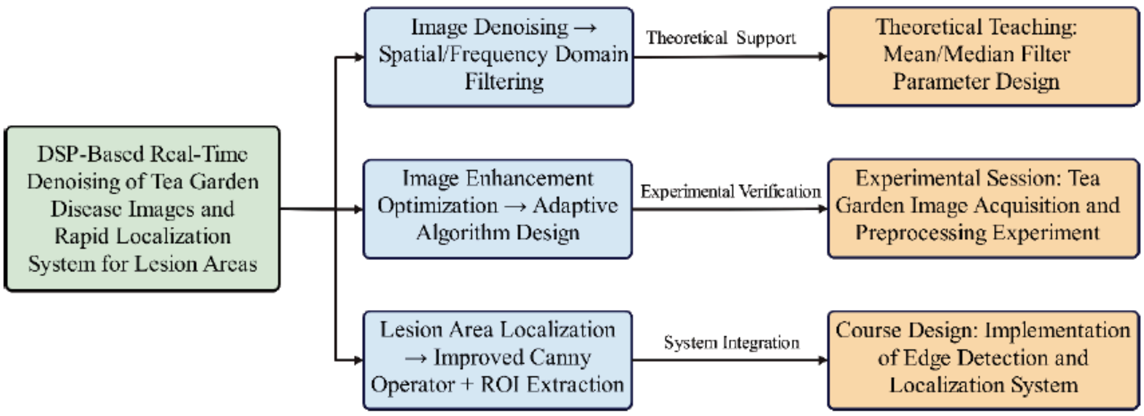

Figure 2: SRT project example (tea garden disease image processing): task decomposition and course integration.

reduction, and compare algorithm performance, thereby strengthening real-time image acquisition and preprocessing skills.

(3) Deepening through course design. Students completed a project implementing a lesion-detection system on a DSP platform, applying image segmentation and optimization knowledge to achieve real-time localization, thereby building a field-ready image-processing system.

2.1.3. Construction and Application of Evaluation System

A course evaluation system based on learning analytics technology was independently developed, establishing a multi-dimensional, process-oriented evaluation model as shown in Table **2**. The model includes 4 core dimensions and 12 quantifiable secondary indicators.

2.2. Empirical Research Design

2.2.1. Research Objects

The 2021 cohort (traditional teaching model, N=110) of the Electronic Information Engineering major at Nanjing Agricultural University was selected as the control group, and the 2022 cohort (OBE-SRT reform model, N=102) as the experimental group. Through analysis of data such as admission scores, prerequisite course scores, and basic ability tests, it was confirmed that there were no significant differences between the two groups in academic foundation, cognitive ability, and professional background, meeting the basic conditions for comparative research. No specific inclusion/exclusion criteria were applied beyond cohort membership. The study was conducted with approval from the university's academic administration department, and informed consent was obtained from all participating students, including those involved in interviews.

2.2.2. Multi-Source Data Collection Methods

To ensure the comprehensiveness and objectivity of the evaluation, multiple methods were used to collect data as follows:

(1) Academic performance data. Systematically collect and analyze final written exam scores, scores of each experimental link, course design scores, and comprehensive course scores.

(2) Engineering ability assessment. Adopt a standardized Engineering Proficiency Test (EPT) to conduct standardized evaluations of students' abilities in analyzing, designing, and making decisions to solve complex engineering problems before and after the course.

(3) Questionnaire survey and interviews. Design a 5-point scale questionnaire with 28 core items, focusing on investigating students' satisfaction, participation, and perceived ability improvement with the reform model; supplemented by in-depth interviews to obtain qualitative feedback.

2.2.3. Data Analysis Methods

Multiple statistical analysis methods were used to process the data:

(1) Quantitative comparative analysis. An Independent samples t-test was used to rigorously analyze the differences and significance of key indicators, such as students' course scores, experimental scores, and EPT scores, before and after the reform. Specific t-values and p-values were reported in Section 3.2.

Table 2: Evaluation Index System

Evaluation Dimension	Secondary Indicators	Evaluation Methods and Technologies
Knowledge Mastery	1. Depth of theoretical understanding	Dynamically adjusting difficulty and content based on answer performance
	2. Knowledge system construction	Evaluating the relevance and completeness of knowledge points
Practical Ability	3. Standardization of experimental operations	Recording operation steps, result accuracy, and the debugging process
	4. Quality of project task completion	Coverage, accuracy, efficiency, robustness
Innovative Thinking	5. Novelty of scheme design	Comparison of innovation points and potential prediction based on the historical project library
	6. Advanced nature of technical implementation	Quantitative comparison with baseline methods or literature-reported results
Team Collaboration	7. Rationality and execution of the division of labor	Task allocation, completion degree, dependency relationships
	8. Effectiveness of communication and coordination	Topic relevance, participation, conflict resolution efficiency

(2) Qualitative content analysis. Systematic content analysis was conducted of technical reports, design schemes, and code documents submitted by students in projects to evaluate their technical depth, standardization, and innovation.

(3) Relationship and path verification. A Structural Equation Model (SEM) was constructed to verify the influence paths and strength of the OBE-SRT synergy mechanism on various levels of learning outcomes.

3. REFORM IMPLEMENTATION AND EFFECTIVENESS ANALYSIS

3.1. Practice of Systematic Teaching Process Reconstruction

A comparative summary of key teaching changes before and after the reform is provided in Table **3**.

3.1.1. Innovation in Theoretical Teaching Model

The cramming-style teaching was completely abandoned, and a three-stage teaching method of case introduction, principle elaboration, and project migration application was fully implemented. First, real-world engineering problems drawn from SRT projects were used to anchor the introduction of core theoretical concepts, highlighting their practical relevance and necessity. Second, key algorithmic principles were elucidated through simulation and visualization tools, with an emphasis on clarifying their fundamental mechanisms and design considerations. Finally, students were tasked with applying these concepts in project-related assignments, enabling them to explore parameter influences and system behaviors within a practical implementation context, thereby reinforcing theoretical understanding through hands-on application.

3.1.2. Upgrade of Practical Teaching System

A stepped, project-based, three-level practical teaching system of "foundational experiments, comprehensive experiments, and project design" was constructed.

The three-level practical teaching system, including foundational experiments, comprehensive experiments, and a capstone project, for DSP Technology and Its Applications is shown in Figure **3**.

Table 3: Comparison of Teaching Approaches Before and After Reform

Aspect	Traditional Approach (Before Reform)	OBE-SRT Approach (After Reform)
Objective Setting	Based primarily on syllabus knowledge coverage.	Reverse-designed from industry needs and OBE 3-level objectives.
Content Source	Textbook-driven, classical algorithms.	Dynamic integration of decomposed SRT project tasks.
Teaching Method	Teacher-centered, lecture-based.	Student-centered, project-driven, case-based.
Practice Focus	Verification experiments are dominant.	Foundational project, comprehensive project, capstone project.
Evaluation	Heavy reliance on the final written exam.	Multi-source, process-oriented, and outcome evaluation.
Teaching Team	Primarily course instructor.	Course instructor, research mentor, and industry engineer.

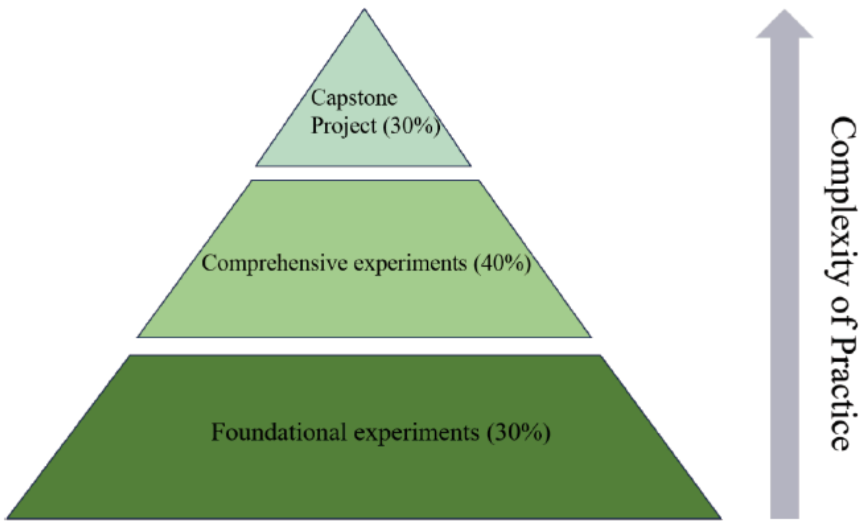

Figure 3: Three-level practical teaching system for DSP technology and its applications.

3.1.3. Remodeling Reform of Evaluation Methods

Breaking the "one-exam determines everything" model, a comprehensive evaluation model emphasizing both process evaluation and outcome evaluation with a weight of 6:4 was implemented as follows:

(1) Process evaluation (60%)

① Experimental reports and reflections (20%). Focus on the depth of problem analysis, scheme design, result discussion, and debugging summary.

②Project progress and quality (25%). Based on milestone completion, code and document quality, and technical difficulty resolution, recorded and reviewed through the platform.

③ Team collaboration contribution (15%). Comprehensive evaluation based on peer review, mentor observation, and platform collaboration records.

(2) Outcome evaluation (40%)

① Course design works and defense (25%). Evaluate system integrity, function realization, performance indicators, innovation points, and defense performance.

② Additional points for innovative achievements (15%). Direct rewards for substantial innovative outputs in projects, such as patents, papers, and competition awards.

3.2. Empirical Analysis of Multi-Dimensional Reform Effectiveness

3.2.1. Significant and Balanced Improvement in Academic Performance

The distribution of students' scores after the reform became more reasonably normalized. Comparison of key indicators shows: The average course score increased significantly from 71.78 ± 6.32 to 82.15 ± 5.87. An independent samples t-test confirmed this improvement was statistically significant with $t(210) = 12.74$ and $p < 0.001$. Student score distribution showing a more reasonable normalization after the reform is presented in Figure **4**.

As shown in Figure **4**, the score distribution exhibits a notable improvement. The excellent rate for scores of 90 or above increased substantially from 15% to 34%, a rise of 19 percentage points. The good rate for scores between 80 and 89 points increased from 32% to 41%, up 9 percentage points. The pass rate for scores of 60 to 79 points decreased significantly from 53% to 25%, a drop of 28 percentage points. The failure rate for scores below 60 points decreased sharply from 10% to 2%, down 8 percentage points. The data indicate that the reform significantly improved the overall academic level and effectively reduced polarization. A summary of key statistical comparisons is provided in Table **4**.

3.2.2. Significant Improvement in Learning Experience and Satisfaction

Questionnaire results showed students' high recognition of the reform. 91% of students agreed that "project-driven teaching based on projects has greatly improved my learning interest and initiative". 87% of students believed that "diversified process and outcome evaluation methods can more comprehensively and truly reflect my knowledge mastery and ability level than a single written exam". 82% of students stated that "through in-depth participation in projects, I have systematically mastered basic research methods such as literature research, scheme design, experimental verification, and result analysis". 78% of students recognized that "the

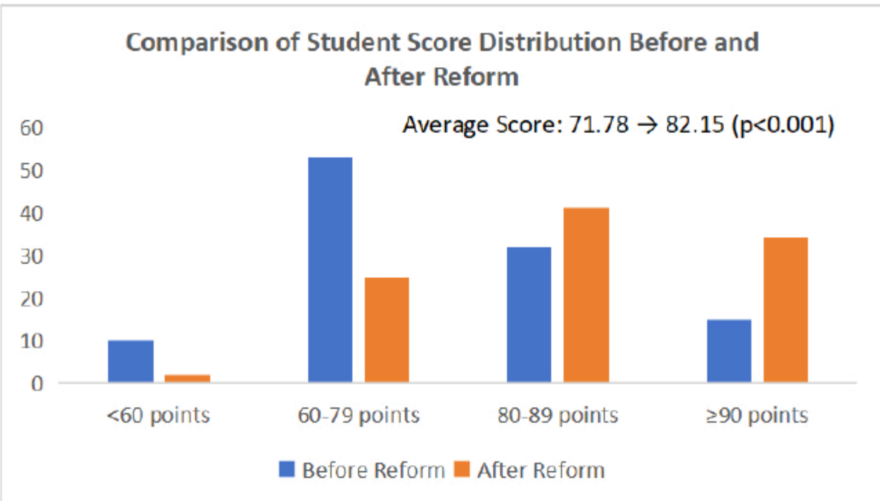

Figure 4: The comparison of student score distribution before and after reform.

Table 4: Statistical Comparison of Key Performance Indicators

Indicator	Control Group	Experimental Group	Statistical Test	p-value
Average Course Score	71.78 ± 6.32	82.15 ± 5.87	t(210) = 12.74	< .001
Excellent Rate (≥90)	15%	34%	-	-
Failure Rate (<60)	10%	2%	-	-
EPT Score (Post-Course)	68.45 ± 7.11	80.12 ± 6.58	t(210) = 9.56	< .001

reformed course content is closely integrated with current industrial technical needs and cutting-edge development trends, making learning applicable". The specific results were shown in Figure **5**.

4. DISCUSSION

4.1. Analysis of Core Innovation Mechanisms

4.1.1. Dynamic Content Adaptation Mechanism

A sensitive "industry demand, research frontier, course content" tripartite linkage update mechanism was established.

(1) Demand Sensing. At the beginning of each semester, systematically sort out the latest capability requirements and technical hotspots of the industry for DSP technical talents through enterprise visits, engineer interviews, recruitment information analysis, industry report research, and patent database mining.

(2) Content Curation & Transformation. A joint working group composed of course leaders, enterprise technical experts, and research project mentors jointly evaluates and selects projects or project modules that are highly compatible with current course objectives, technologically novel, and suitable for teaching transformation.

(3) Continuous Update. Update no less than 20% of teaching cases, experimental content, and project design topics every academic year to ensure that teaching content keeps pace with technological development and industrial actual needs, effectively solving the problem of textbook lag.

The specific implementation process of this tripartite linkage update mechanism is detailed in Figure **6**.

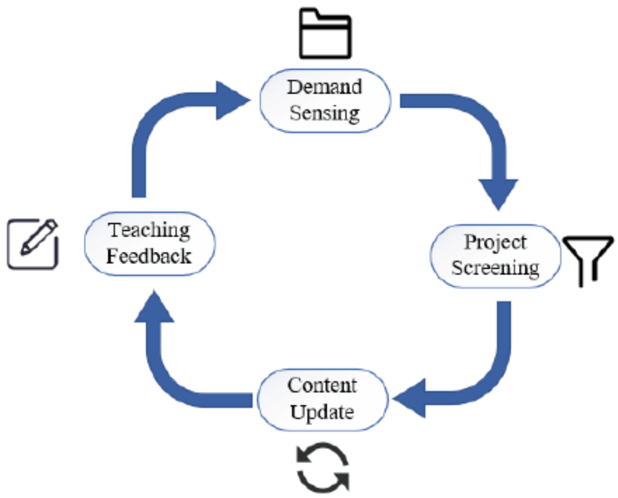

Figure 6: Tripartite linkage dynamic content adaptation mechanism.

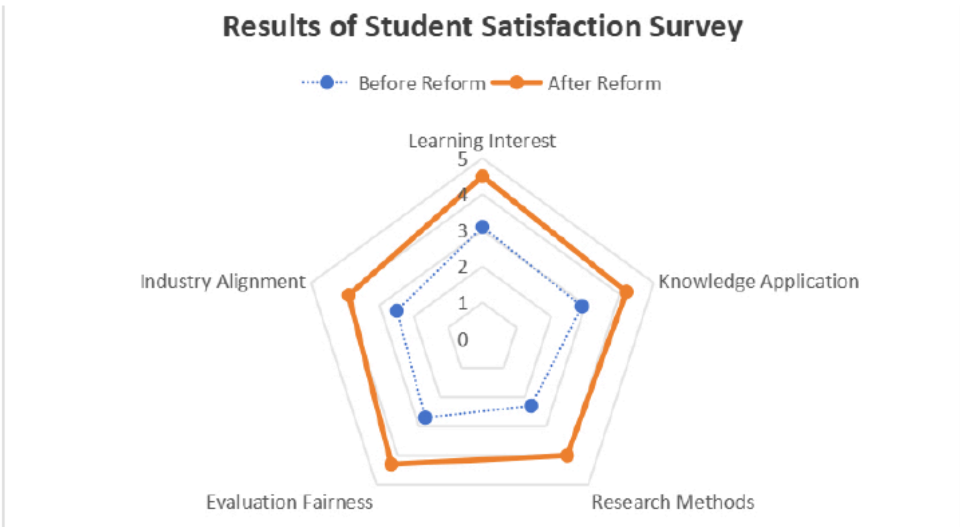

Figure 5: The student satisfaction survey results on multiple dimensions before and after reform.

4.1.2. Cross-Domain Collaborative Teaching Model

An innovative trinity teaching team was constructed, breaking the traditional model of teachers working alone. The core responsibilities of Course Instructors are to construct the logical structure of knowledge systems, conduct solid training in basic theories and core skills, and organize and manage teaching processes. Research Mentors, usually composed of graduate supervisors or senior researchers undertaking related projects, provide in-depth guidance on key technical breakthroughs, innovative algorithm design, research scheme formulation, and academic norms in SRT projects. Industry Engineers: Senior engineers from cooperative Jiangsu Jinheng Information Technology Co., Ltd., provide real project scenarios, industry technical standards, engineering practice experience, and performance testing resources to ensure that teaching is aligned with the industrial frontline. The tripartite synergy model for cultivating interdisciplinary talents is shown in Figure **7**.

The three parties jointly formulate teaching syllabi, design project tasks, and develop evaluation standards through regular joint lesson preparation meetings, joint reviews, and online collaboration platforms, forming a strong educational synergy.

4.1.3. Assessment & Feedback System

An evaluation system based on big data learning analytics technology realizes data capture of the entire process, seamlessly integrating development environments, code repositories, simulation platforms, and tracking process data such as students' code submission frequency and quality, experimental data records, debugging logs, online discussion content, and project document updates. The platform performs competency profiling by using machine learning algorithms to analyze massive process and result data, generating intuitive ability radar charts for each student, as shown in Figure **8**, which clearly display their relative strengths and weaknesses in dimensions such as Algorithm Design, Hardware Debugging, Innovative Solutions, and Team Collaboration. Based on these profiles and knowledge graphs, the system then provides personalized feedback and guidance by identifying students' weak links and pushing relevant supplementary learning materials, typical teaching cases, online tutoring resources, or recommended micro-projects for participation, thereby achieving personalized learning intervention and support.

4.2. In-Depth Analysis of Existing Problems and Challenges

4.2.1. Insufficient Depth of Integration Between Project Tasks and Knowledge Points

Approximately 15% of students reported that the correlation among some subtasks of projects and specific course knowledge points is not close enough or the connection is not natural. The main reasons include insufficient demonstration of the accurate mapping relationship between project tasks and OBE three-level objectives during the initial project library construction, with some projects overemphasizing high-level applications while weakening basic support. When decomposing complex projects into tasks integrable into teaching links, there are knowledge gaps or jumps, failing to form a smooth progressive chain from knowledge to ability, making it difficult for some students to apply knowledge in migration.

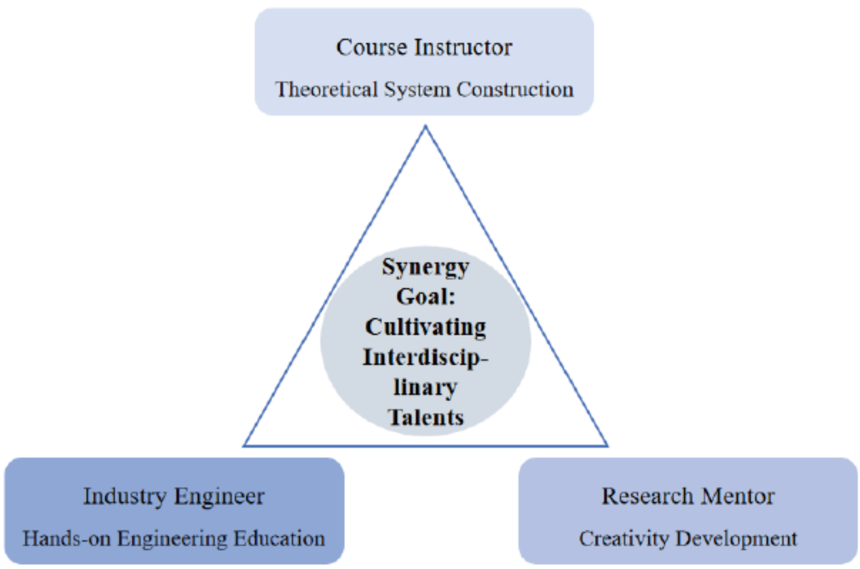

Figure 7: Tripartite synergy model for cultivating interdisciplinary talents: course instructor, industry engineer, and research mentor collaboration.

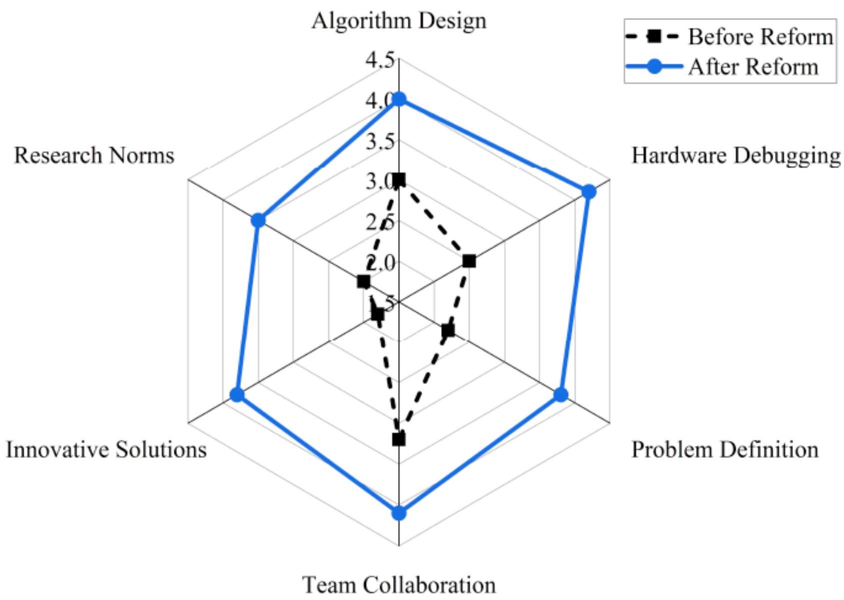

Figure 8: Student competency radar chart generated by big data learning analytics.

4.2.2. Challenges in Teachers' Cross-Domain Guidance Capability and Load

More than 60% of participating teachers reported that undertaking both regular teaching tasks and in-depth guidance of high-demand projects has caused severe pressure on time and energy. The underlying reasons include limitations in teachers' own knowledge structures and experience; some full-time teachers have long been separated from engineering frontlines or cutting-edge research, lacking cross-domain knowledge and practical experience required to guide SRT projects in specific fields. Insufficient incentive mechanisms and recognition: Universities generally have a tendency to "value research over teaching, and papers over practice". Although SRT project guidance requires significant investment, it is not fully reflected or reasonably compensated in professional title evaluation, performance assessment, or workload calculation, seriously dampening teachers' enthusiasm.

4.2.3. Persistent Subjectivity in Evaluation Standards for High-Level Innovation Capabilities

In evaluating "Innovation Level" outcomes, although expert review and machine learning assistance are introduced, the inter-rater reliability of the core indicator "Novelty" is still low. The main problems include the need to further refine and operationalize evaluation dimensions; existing descriptions are relatively general, lacking specific, observable behavioral or outcome standards that can clearly define different levels of innovation. Insufficient objective quantitative tools and data support: The evaluation of innovativeness overly relies on experts' subjective experience judgment, lacking more objective and quantifiable auxiliary tools and evidence support based on patent database analysis, literature novelty comparison, and algorithm performance benchmark testing.

4.3. Interpretation of Results and Comparative Analysis

The significant improvements in academic performance and student satisfaction align with findings from other studies integrating OBE with active learning strategies and project-based approaches. However, the magnitude of improvement observed here, particularly the 19-percentage-point increase in the excellent rate and the balanced score distribution, underscores the effectiveness of the deep OBE-SRT synergy. These gains were attributed to several factors, including the clear goal orientation provided by the three-level OBE objectives, which directed student efforts; the authentic motivation derived from engaging in real SRT projects, enhancing interest and initiative; and the comprehensive feedback from the intelligent evaluation system, enabling targeted improvement.

The challenges encountered, such as misalignment between project knowledge points and teacher workload, are not unique to this reform but are common in implementing complex pedagogical innovations. Similar issues are reported in PBL implementations, highlighting the need for careful resource planning and faculty development.

4.4. Considerations on Transferability, Sustainability, and Equity

The transferability of this model to other universities and engineering courses appears feasible, provided key elements are adapted: 1) Establishing industry-academia partnerships for authentic projects,

2) Fostering a collaborative teaching culture among faculty, researchers, and engineers, and 3) Investing in or accessing learning analytics platforms for evaluation. Scalability depends on managing the teacher workload through effective team structures and institutional support.

Sustainability is closely tied to institutional commitment. The cost involves potential investment in the analytics platform and releasing faculty time for collaboration and project guidance. To address teacher workload and ensure equity, the proposed structured project library and collaborative support system are crucial. They help distribute guidance efforts and provide differentiated project options, potentially mitigating cognitive load and catering to diverse student ability levels, though this requires further study. Student motivation was high, likely due to project authenticity, but monitoring the cognitive load associated with complex projects remains important.

4.5. Limitations

This study has several limitations. It was conducted within a single institution and focused on one core course, which may limit the generalizability of the findings. The study duration covered one reform cycle; long-term impacts on student career development are unknown. Furthermore, the evaluation of higher-order thinking skills, despite improvements, still contains subjective elements.

4.6. Systematic Optimization Strategies

4.6.1. Constructing a Structured Hierarchical Project Resource Library

A three-level project library system from basic to advanced to innovative was established, realizing accurate matching between project difficulty, complexity, and students' ability development. The Foundation Tier includes verification and small-scale design projects strongly associated with core course knowledge points and basic experiments. Goal: Consolidate basics, proficiency in platforms, and mastery of basic development processes. Intermediate Tier: Comprehensive projects requiring the integration of multiple knowledge points of the course or even cross-course knowledge. Goal: Cultivate system integration capabilities, complex problem decomposition capabilities, and multi-technology integration capabilities. Advanced/Innovation Tier: Projects oriented to industrial frontiers or research hotspots, with a certain exploratory and challenging nature. Goal: Stimulate innovative thinking, cultivate the ability to explore cutting-edge technologies, and nurture high-level outcomes.

An intelligent matching algorithm was developed to recommend the most suitable project tiers and specific topics for students based on their previous performance, interest tags, and ability profiles.

4.6.2. Building a Teacher Capability Development and Collaborative Support System

(1) Regularly select teachers to participate in project cooperation with cooperative enterprises to gain an in-depth understanding of industrial technical needs and engineering practices. Encourage and support teachers to participate in high-level research projects in related fields or form joint teams with research mentors to guide SRT, facilitating their own knowledge updates. Organize special training on cutting-edge DSP technologies, engineering education methods, project guidance skills, and innovation evaluation methods.

(2) Institutionalize the collaboration processes and responsibility division among course teachers, research mentors, and enterprise engineers in SRT project guidance. Course teachers are responsible for project management and basic support, research mentors for technical depth and innovation, and enterprise engineers for engineering and practicality. Establish efficient online and offline collaboration platforms.

Table 5: Optimization Scheme of Innovation Evaluation Index System

Evaluation Dimension	Core Elements	Evaluation Methods and Data Sources
Technical Innovation	1. Novelty of Scheme	Patent database retrieval and comparison analysis, academic literature research review, and expert blind review.
	2. Technical Advancement	Comparative testing of key performance indicators of algorithms and systems.
Application Value	3. Demand Fit	Quality of user demand analysis reports, validity verification data of prototype systems in simulated or real scenarios, and feedback from potential users/experts.
	4. Market Potential/Social Impact	Preliminary business plans/application prospect analysis, social benefit evaluation.
Teamwork & Execution	5. Task Allocation & Execution Efficiency	Project management tool records, milestone achievement rate, data analysis of team self-evaluation, and mutual evaluation.

4.6.3. Improving the "Three-Dimensional and Five-Element" Innovation Evaluation Model

To address the subjectivity of innovation evaluation, a more refined and objective evaluation framework is proposed in Table **5**.

This model emphasizes evidence orientation, requiring evaluations to be based on quantifiable data or verifiable objective materials, significantly reducing subjective arbitrariness.

5. CONCLUSIONS AND PROSPECTS

This study successfully demonstrated the efficacy of a systematically constructed OBE-SRT collaborative teaching system in reforming the "DSP Technology and Its Applications" course. The main contributions and conclusions are as follows.

(1) A deep integration framework was proposed and validated for OBE and SRT, moving beyond traditional PBL by directly mapping authentic research tasks onto granular OBE outcomes and employing pervasive data-driven evaluation.

(2) The reform effectively tackled the disconnection from industry needs, outdated content, and simplistic evaluation inherent in the traditional model.

(3) Significant improvements were documented in academic performance, *e.g.*, average score increase of 10.37 points, $t(210)=12.74$, and $p<.001$, practical and innovative abilities, and student learning experience.

(4) The study provides a replicable paradigm, including a tripartite collaborative teaching model, a dynamic content update mechanism, and strategies for overcoming implementation challenges like project integration and teacher workload.

Implications for stakeholders are as follows.

(1) Deeply integrate frontier research and industrial projects into the curriculum through structured mechanisms.

(2) Prioritize faculty development in pedagogical innovation and cross-domain collaboration, and revise incentive structures to reward teaching and project guidance efforts.

(3) Actively engage in co-designing projects and teaching activities to ensure graduate competencies align with evolving industry needs.

Institutional-level recommendations are as follows.

(1) Establish formal policies and resource support for industry-academia-research collaboration in teaching.

(2) Invest in university-wide learning analytics infrastructure to support data-informed teaching and evaluation.

(3) Implement faculty development programs focused on modern pedagogical methods and project supervision skills.

By strategically synergizing outcome-based education with student research training within a data-informed feedback loop, engineering education can effectively bridge the theory-practice gap, enhancing both student competency and alignment with industrial innovation. This approach provides a sustainable path for cultivating high-quality, future-ready engineering talent.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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