Academic Education Publishing House

Teaching Reform and Educational Practice for the Automatic Control Principles Course Empowered by Diversified Assessment Approaches

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Abstract: Under the new engineering disciplines construction's background, the process-based examination's reform has become a important approach and it can improve engineering courses' study quality. In automatic control, the traditional assessment method's shortcomings are evident, that it emphasis on the final exam and neglect learning process; it focuses on the memorization and neglects practical skills; it focuses on the score level and ignores constructive feedback. Regarding the issues, the education team carries out a diversified assessment reform for the course and focus on three things: the examination structure is not reasonable, no effective means for evaluating engineering capabilities, the process feedback mechanism is not complete. Relying on superstar learning platform, team establishes an assessment model, which is supported by continuous tracking, multi evaluation and data-driven feedback. No using the regular assignments and end term closed book exam's old pattern, and designs a three stage progressive structure, knowledge acquisition, ability transformation and comprehensive application. For the arrangement, it can evaluate students' learning engagement, theoretical mastery and engineering practical ability. This thing can provide some practical references for new engineering disciplines' process based assessment reform similar courses.

Keywords: Diversified Assessment; Process Evaluation; Automatic Control Principles; Teaching Reform; Educational Practice

1. Introduction

In order to compliant the macro strategic deployment for the upgrading and evaluation of new engineering disciplines reform, reforming the assessment methods for core theoretical courses in engineering disciplines has become an urgent task. Engineering core theoretical courses are the student knowledge system and professional competence's foundation. Optimizing the assessment model is an inevitable requirement for implementing the outcome-oriented education concept and meeting the engineering education accreditation's standard [1]. Looking at the domestic universities' current assessment situation, the final summative examinations still hold a dominant position. This traditional model has obvious shortcomings: the evaluation dimensions are limited, process feedback is insufficient, making it difficult to accurately measure the student comprehensive abilities' actual growth. The current assessment methods still have a considerable gap for the goal of cultivating innovative and comprehensive engineering talents. So it is urgent to shift to a diversified and process-oriented assessment model to lay a solid foundation for engineering talent cultivation.

Automatic control principles is a compulsory core course for the automation major and serve as a crucial link that connects the preceding and subsequent courses. This course is challenging: it involves numerous complex concepts, abstraction level is high and mathematical calculations are large. Students should not merely rely on applying formulas, they also need to apply theoretical models to actual control systems. This requires them to possess both solid analytical skills and engineering practice thinking at the same time [2].

However, under the traditional model, this course was almost solely evaluated through a single closed-book final exam. Such exams had a narrow scope and focused on theoretical calculations: deriving formulas, solving transfer functions and determining system stability. This one-dimensional assessment method has inadvertently encouraged the trend of cramming for exams. Many students slack off in their studies throughout the semester and only memorize problem-solving templates and mechanically apply fixed formulas on the eve of the exam. Although their final grades are acceptable, they often lack the ability to transfer and apply knowledge. When faced with actual industrial equipment such as motors and heating furnaces, they often struggle to conduct problem analysis and basic debugging. In response to this mismatch between teaching and application, the current reform of new engineering education is pushing universities to re-examine the assessment methods. More and more universities advocate integrating information-based teaching technologies and implementing a process-based assessment model, so as to better cultivate students' ability to solve engineering practical problems [3].

The education ministry states that undergraduate teach should strengthen learning process' monitoring, evaluation and feedback. It requires engineering majors to change their assessment approach, abandon the evaluation model that only focuses on the final results and establish a comprehensive assessment system that combines process evaluation and result evaluation. Currently, many universities in China have carried out pilot work on the automatic control principles course's process assessment, gradually incorporating online teaching video learning, in-class quizzes, and after-class assignments into the assessment indicators [4]. However, from the actual effect of the reform implementation, several problems still exist. The design of the process assessment tasks for some courses is rather arbitrary, and the interrelationships among the various assessment modules are weak. The the scores lacks scientific basis' weight distribution results in a relatively subjective overall evaluation. At the same time, online learning often involves superficial compliance or even task completion for the sake of it, and even cheating and fraud. This reduces the authenticity and credibility of the assessment data and fails to truly reflect the students' progress and ability growth at this stage. In response to the above situation, this paper takes the automatic control principle course as the research object and redesigns a diversified process based evaluation system, aiming to solve single assessment dimension and insufficient feedback during the learning process' problems. Ultimately, it can aim to significantly improve the applied talents' quality. This paper text is highly professional. The task mode can help you deeply review the entire evaluation plan. Do you want to use it?

2. Problems with the Current Assessment Methods

2.1 The Proportion of Final Exam Scores is Too High, Leading to a Prominent Phenomenon of Exam-Oriented Learning

In the automatic control principles course's traditional assessment model, the final closed book exam score usually accounts for the total score's 60% to 70%. Due to the excessive weight given to the final assessment, daily learning is often neglected. Daily coursework is difficult to provide long-term incentives for students to study diligently. As a result, most students do not invest sufficient effort in their regular classroom learning and their knowledge acquisition is rather scattered. They skip the gradually mastering the core theoretical concepts' process in a progressive manner. This exam oriented model may enable students to achieve good scores in the final exam, but what they learn is mostly just the solution methods for conventional problem types. They rarely deeply reflect on the overall design logic, operation mechanism and control systems' practical application, and it is difficult for them to truly internalize the core theoretical foundation of this discipline.

2.2 The Scope of Assessment Content is Narrow, and the Evaluation of Engineering Capabilities is Lacking

At the current stage, the course assessment is primarily based on traditional examinations, focusing mainly on basic theoretical content such as deriving transfer functions, determining system stability, and calculating time-domain and frequency-domain indicators. These assessments emphasize testing students' mathematical and computational skills. However, core engineering application abilities that are critical for the cultivation of emerging engineering talents—such as system modeling, controller parameter design, engineering case analysis, and control system debugging and optimization—are hardly addressed in the existing examinations. The entire assessment system is overly biased toward theoretical calculations, weakening the evaluation orientation toward engineering practice ability and innovative thinking. This significantly deviates from the goal of cultivating high-quality applied and engineering-oriented talents in the automation major under the context of emerging engineering education [5].

2.3 Process Data is Fragmented and Scattered, Rendering the Evaluation and Feedback Function Ineffective

The current formative assessment content of the course mainly consists of routine teaching activities such as classroom roll-calling, after-class homework grading, and sporadic in-class questioning [6]. These various types of assessment data are independent of each other and scattered in distribution, lacking systematic integration and correlation analysis, and thus failing to form a complete learning data chain throughout the semester. Teachers can only judge students' usual learning performance based on subjective impressions or fragmented data, making it impossible to precisely identify students' knowledge weaknesses, differences in mastery levels, or poor learning habits. Consequently, it is difficult for teachers to make objective, quantitative, and accurate evaluations of individual students' learning status.

In summary, the core drawback of the traditional assessment model lies in the structural imbalance of the assessment system [7]. Final summative assessment occupies an absolutely dominant position, while formative assessment is merely a formality, carries low weight, and has a loose structure [8], resulting in the undesirable situation of “no supervision during the learning process, and a final exam determining everything". Students lack effective assessment constraints in their daily learning, and the examination evaluation is disconnected from the actual learning process. At the same time, the assessment content fails to provide a comprehensive examination of students' engineering thinking, system design capabilities, problem-analysis abilities, and professional expression skills. As a result, it cannot fully and objectively reflect students' overall learning outcomes, nor can it adequately meet the actual demands of emerging engineering course teaching and talent cultivation.

3. Design Scheme for a Diversified Assessment System

The research team, relying on the Chaoxing Xuexitong online teaching platform [9], has developed online teaching resources for the Automatic Control Principles course. A course knowledge graph comprising over 240 interrelated knowledge nodes has been constructed, supplemented by more than 30 pre-class teaching video task points and over 400 in-class online test questions. In parallel, an AI-powered intelligent tool has been integrated to provide 7*24 after-class online tutoring support.

In response to the problems existing in the traditional assessment model-such as lack of process supervision, single-dimensional assessment, insufficient evaluation of engineering capabilities, and delayed learning feedback [10] and in consideration of the actual course teaching context, the teaching team has constructed a layered and diversified assessment system centered on “whole-process tracking multi-dimensional evaluation and data-driven feedback”, as specifically shown in Figure 1. This system, targeting all enrolled students, divides the assessment into three progressive and mutually supportive levels from low to high: knowledge acquisition, capability transformation and comprehensive application, thereby forming a complete teaching evaluation closed loop. Among these, the knowledge acquisition level corresponds to students' basic learning engagement, addressing the question of “whether students participate in learning”; the capability transformation level corresponds to the effectiveness of knowledge internalization and transfer, addressing the question of “whether students truly understand and master what they have learned”; and the comprehensive application level corresponds to engineering practice and comprehensive innovation ability, addressing the question of "whether students can apply what they have learned to practice." The three-tier structure fully covers the main line of talent cultivation—knowledge input, internalization and absorption, and capability output—achieving dynamic evaluation throughout the entire learning process and across all dimensions of ability.

3.1 Knowledge Acquisition Level: Quantitatively Record Students’ Daily Learning Engagement

The Knowledge Acquisition Level serves as the foundational tier of the entire assessment system. Its core objective is to quantitatively document students’ basic learning behaviors before and during class, authentically record their learning engagement and ensure solid mastery of foundational course knowledge. This level relies on the Chaoxing Learning Platform for automated data collection and statistical analysis and achieves process monitoring through the coordinated functioning of three modules: Knowledge Graph-Guided Learning, Anti-Skipping Video Learning, and Chapter Instant Testing.

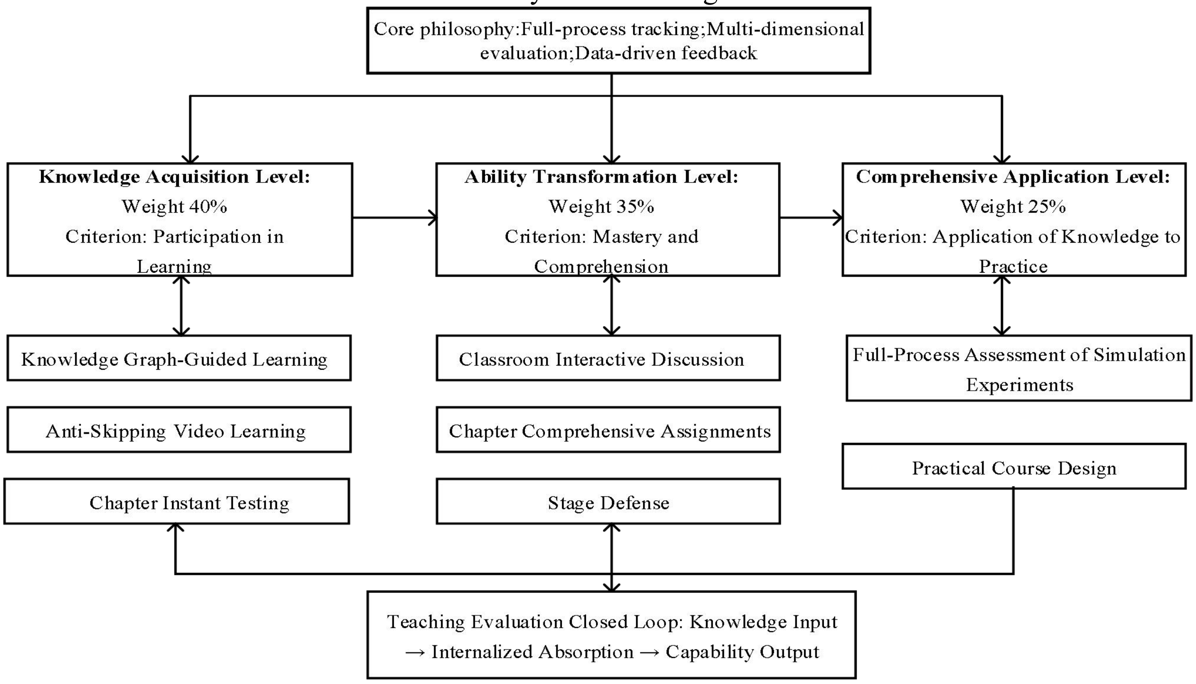

Figure 1. Structure Diagram of the Diversified Process Assessment System

To help students understand the course structure better, we created a knowledge graph for each chapter on the Chaoxing platform, following the syllabus. Instead of having scattered points, we organized the main ideas into modules and nodes. We also added some extra materials to these nodes, such as videos showing real engineering cases, modeling examples, and practice exercises. This way, students can just follow the graph to learn step by step and find the resources they need for specific parts. The system also tracks everything in the background, like how far they've gotten, how often they open the materials, how much time they spend on a page, and the path they take while learning. Through multi-dimensional data, the system comprehensively determines students' level of learning engagement, thereby circumventing the issue of passive or perfunctory learning.

To address common pseudo-learning behaviors in online educatio-such as automated course scrolling, idle session retention, and fast-forwarding-all instructional videos for each section of this course have enabled the anti-skipping and anti-dragging functions on the Chaoxing Learning Platform. Students are required to watch the entire video content in full and complete the learning progress before their performance can be recorded as valid. This technically prevents undesirable learning behaviors such as idle course scrolling, multi-window idle time accumulation, and other forms of superficial engagement. The platform simultaneously collects detailed data including single-viewing duration, overall completion rate, repeated viewing counts, and pause/rewind nodal points. If multiple students repeatedly revisit a particular knowledge-point video, it can be identified as a common difficulty area for the class. Instructors can then adjust the focus of classroom teaching accordingly, reinforcing weak links in a timely manner. All video learning data are quantitatively incorporated into the process-based assessment scores.

At the end of each instructional video, a companion in-class quiz bank is provided, covering three question types: conceptual differentiation, basic calculations, and simple case analyses. The system imposes prerequisite learning restrictions, requiring students to complete the video before participating in the quiz. Upon completion of the test, the system automatically grades the responses, generates scores instantly, and accumulates them toward the chapter learning points. For incorrectly answered questions, the system automatically pushes the correct answers along with knowledge point explanations, helping students correct errors and fill gaps in real time, thereby preventing the cumulative build-up of knowledge deficiencies. This ensures a closed-loop learning process at each stage and lays a solid foundation for subsequent capability development.

3.2 Capability Transformation Level: Multi-Dimensional Assessment of Knowledge Internalization and Transfer

Fundamental knowledge acquisition serves as the foundation of course learning; however, achieving knowledge internalization and completing the transformation from theory to capability constitute the core instructional objectives of the Automatic Control Principles course. While the Knowledge Acquisition Level focuses primarily on assessing whether students “have completed learning tasks” the Capability Transformation Level emphasizes evaluating whether students “truly understand the knowledge and can apply it flexibly”. This level transcends the limitations of traditional standardized written examinations by employing three assessment methods-Classroom Interactive Discussion, Chapter Comprehensive Assignments and Stage Defense-to multi-dimensionally examine students' depth of knowledge mastery, logical analytical skills and knowledge transfer capabilities.

During classroom instruction, the instructor sets up inspirational and open-ended questions centered on key and difficult points as well as easily confusable knowledge areas in each chapter—such as the causes of steady-state error in proportional control and the influence of open-loop zeros on root locus characteristics. These questions have no fixed standard answers and require students to engage in comprehensive analysis, reasoning, and argumentation based on theoretical knowledge. Relying on the Chaoxing platform’s functions-including random quick-response, online student selection, and thematic discussions-the system fully records students’ classroom participation frequency and contribution performance. Classroom evaluation no longer solely judges whether answers are correct or incorrect, but places emphasis on assessing students' analytical logic, reasoning processes, and degree of engineering integration. Based on the quality of student contributions, depth of discussion, and novelty of their insights, graded assessments are assigned and incorporated into the overall assessment scores. This approach drives students to actively think and participate deeply in knowledge construction during class.

Upon the completion of each chapter, comprehensive and open-ended homework assignments are assigned, moving beyond single, mechanical calculation problems. The focus is placed on comprehensive question types such as engineering case analyses, simple control system design and cross-chapter knowledge argumentation. The scoring rubric no longer focuses solely on final computational results but emphasizes comprehensive evaluation across four dimensions: problem-solving approach, method selection, depth of analysis, and engineering standards. This holistically assesses students’ engineering logical thinking, theoretical application ability, engineering cognition level, and professional written communication skills, thereby remedying the exam-oriented shortcoming wherein students can only apply formulas mechanically without engaging in genuine critical thinking.

This course has two defense sessions: one is a mid-term defense and the other is an end-term defense. The mid-term defense mainly examines whether students have truly mastered the basic theories and whether they can apply the theories to new scenarios. The end-term defense is linked to the course design project. Students are required to explain the reasons for the scheme selection, introduce the system modeling process, describe the PID parameter tuning method, and interpret the simulation results. The entire defense process is used to assess students' presentation and expression skills, logical thinking level and project planning ability. To ensure fairness in scoring, the defense is evaluated by two teachers: the main instructor and another professional instructor. The final score is the two teachers' scores' average, which reduces the individual subjective scoring bias.

3.3 Comprehensive Application Level: Focus on Practical Assessment of Complex Engineering Capabilities

The Comprehensive Application Level constitutes the highest tier of the entire assessment system and serves as the core anchor point for the talent cultivation objectives of emerging engineering education (New Engineering). It is primarily designed to evaluate whether students can flexibly apply theoretical knowledge from the course to actual control systems and solve real-world engineering problems. This level relies on two major modules-Full-Process Assessment of Simulation Experiments and Practical Course Design with emphasis placed on process-oriented evaluation and hands-on capability verification, while deemphasizing singular outcome-based assessment.

Simulation experiment teaching relies on physical platforms including four-wheeled smart cars, three-tank water systems, and robotic arms to establish an experimental system covering all course knowledge points, encompassing core content such as control system time-domain response analysis, PID parameter tuning, root locus and frequency-domain characteristic analysis, and nonlinear system control. The experimental assessment breaks away from the traditional evaluation model of "only looking at final simulation results" and adopts a full-process traceability assessment approach. Students are required to submit their modeling processes, simulation steps, debugging records, and problem-troubleshooting procedures in stages via the Chaoxing platform, thereby preserving complete process data of trial, modification, and optimization. The instructor provides targeted feedback and guidance for each operational step, employing students' problem-troubleshooting ability, debugging and optimization mindset, and engineering practical competency as the core evaluation metrics, thereby authentically reflecting students' engineering practice capabilities.

In the final project, we adopted practical engineering topics based on real automated tasks, such as controlling the attitude of a drone or adjusting the speed of a DC motor. Students were required to complete the entire process independently, including system modeling, designing control schemes, debugging simulations, and analyzing results. Finally, they were required to submit a complete course design report.

Our evaluation criteria do not merely focus on technical skills. We also assess their engineering thinking, whether they followed the standard procedures, and the level of writing professional documents. Such requirements are in line with the actual expectations of engineers in the industry and can effectively help them connect what they have learned in class with future workplace needs.

4. Analysis of Innovative Reform Points in Assessment

As shown in Table 1, the tiered diversified assessment system constructed in this paper differs from the superficial reform model of simply adding ordinary score components to traditional courses, and has formed distinctive features in terms of assessment authenticity, evaluation systematization, and educational adaptability.

4.1 Knowledge Graph Support Enabling Rigid Constraints on the Learning Process

In most higher education institutions, process-oriented assessment merely adds online video-watching components in a superficial manner, commonly suffering from issues such as students engaging in idle course scrolling to accumulate time, learning becoming mere formality, and distorted process data-rendering process evaluation practically ineffective. Our teaching team, relying on a structured knowledge graph, systematically decomposes scattered knowledge points, associates them with corresponding engineering learning resources, and incorporates rigid mechanisms including anti-skipping video playback and non-skippable progress advancement, thereby constructing a closed-loop learning pathway of "complete learning → node activation → test unlockin → graph progression". This technically eliminates pseudo-learning behaviors, ensures that all learning data are authentic and valid, and fundamentally resolves the pain points of low data credibility and inability to truly reflect learning status in traditional process assessment, thus endowing process evaluation with genuine practical reference value.

Table 1. Multi-Rubric Scoring and Weight Allocation Table for Course Assessment Modules

Assessment Modules	Specific Assessment Content	Scoring Rubrics	Individual Weightings
Knowledge Graph-Guided Learning	Learning progress of knowledge nodes, resource access frequency, page dwell time and learning path	Quantitatively scored based on platform backend data. Full credit is awarded for complete completion of stepwise learning without perfunctory behaviors. Proportional deductions are	10%

	completeness	applied for lagging learning progress or insufficient resource access.	
Anti-Skipping Video Learning	Completeness of instructional video viewing, learning completion rate, frequency of repeated viewing, and learning status of key and difficult points.	Full credit is awarded for complete viewing of all videos and meeting progress requirements. Proportional deductions are applied for instances of fast-forwarding, idle session retention, or failure to meet progress standards. Full credit recognition is granted for qualified review of key and difficult points.	10%
Chapter Instant Testing	Accuracy rate of in-class quiz responses covering conceptual differentiation, basic calculations, and simple case analyses.	Automatically graded by the system, scored based on the average test score. Moderate supplementary points may be granted for independent review and correction of incorrect answers. Tests not completed will receive no score.	20%
Classroom Interactive Discussion	Participation and response quality in classroom quick-response, thematic discussions, and question answering.	Comprehensively graded based on participation frequency, analytical logic, reasoning process, degree of engineering integration, and innovative thinking, without solely judging answers as right or wrong.	10%
Chapter Comprehensive Assignments	Comprehensive assignments such as engineering case analysis, control system design, and cross-chapter knowledge argumentation.	Scored comprehensively across four dimensions: problem-solving approach, method selection, depth of analysis, and engineering standards. Emphasis is placed on the application of knowledge to practice rather than solely on the correctness of final results.	10%
Stage Defense	Mid-term theoretical application defense and final-term course design project defense.	Dual-teacher joint evaluation. Scored based on solidity of theoretical mastery, logical presentation, clarity of scheme articulation, and question-response ability. The final score is the average of the two evaluators' scores.	15%
Full-Process Assessment of Simulation Experiments	Control system simulation modeling, parameter tuning, debugging and troubleshooting, and full-process experimental documentation.	Full-process traceability assessment. Scored based on operational standardization, problem-troubleshooting capability, debugging and optimization approach, and experimental completeness, without solely judging the final simulation results.	10%
Practical Course Design	Control system design for engineering scenarios, modeling and simulation, result analysis, and course design report writing.	Assesses engineering scheme design, technical implementation, process standardization, document writing, and innovative application capabilities, with scoring aligned with the requirements of engineering positions.	15%

4.2 Integration of Subjective and Objective Evaluation, Establishing a Bidirectional Complementary Evaluation Mechanism

At present, many course assessment reforms merely add a large number of daily tasks. Such assessments usually rely on limited data and have a single evaluation perspective, making it difficult to balance objectivity and professional rigor simultaneously. To address this issue, this paper proposes a two-layer evaluation framework, combining data-driven quantitative assessment with qualitative assessment based on human judgment. At the quantitative assessment level, the platform automatically collects objective indicators such as study duration, test accuracy, and experiment completion rate, thereby constructing a quantifiable, reliable, and fair evaluation benchmark. At the qualitative assessment level, the evaluation includes teachers' classroom observations, defense evaluations, as well as subjective scoring of assignments and projects. This part is crucial as it can capture abilities that machines cannot measure, such as students' logical reasoning skills, engineering thinking, and the ability to solve problems creatively. Subsequently, the two types of evaluation information are integrated according to reasonable weights to make up for the shortcomings of each evaluation method. This integrated evaluation model can avoid the drawbacks of evaluation based on a single data source and ensure that the final assessment results are both fair and professionally reliable.

5. Conclusion and Outlook

The diversified assessment reform implemented in this study does not simply superimpose assessment components onto traditional teaching models, but rather represents a systematic restructuring of the course evaluation system, achieving deep integration of the teaching process and the assessment framework. The traditional model of "one final examination determines the grade" fragments course learning into two distinct phases: casual daily learning and intensive exam cramming at the end of the term. Students focus primarily on short-term memorization and problem-solving techniques as their main learning objectives, resulting in a high likelihood of knowledge decay and disconnection between theory and practice shortly after course completion.

This instructional reform attempts to integrate assessment throughout the entire teaching process, covering all instructional stages including pre-class online learning, in-class interactive discussions, post-class homework training, stage defenses, simulation experiment hands-on practice, and final course design projects, thereby achieving full-process traceability and comprehensive evaluation of learning. Following the implementation of the reform, students' daily learning engagement can be accurately recorded and recognized, reversing the exam-oriented culture of last-minute cramming. Meanwhile, instructors can leverage platform data to promptly identify common class-wide knowledge difficulties and individual students' learning deficiencies, dynamically adjusting the focus of classroom teaching and instructional pacing to achieve precision teaching and individualized instruction. As the assessment orientation shifts from "scoring on problem-solving" to "applying knowledge to practice", students are no longer confined to mechanical question-solving but instead actively explore the operational mechanisms of control systems, patterns of parameter variation, and engineering application value, thereby honing both their critical thinking abilities and engineering competencies.

At the same time, this practice also has certain room for improvement. The full-process, multi-dimensional process assessment has significantly increased instructors' workload in terms of homework grading, defense evaluation, and data organization. How to optimize the assessment process, streamline redundant tasks, and reduce instructors' teaching burden while ensuring assessment precision and evaluative validity is a key issue that needs to be balanced in subsequent reform efforts.

Overall, the diversified assessment practice aligns with the core requirements of emerging engineering education talent cultivation, effectively addressing the prominent issues of traditional assessment models that overemphasize results while neglecting process, and prioritize theory while undervaluing practice. The reform direction is both feasible and replicable. The core educational objective of engineering courses is to cultivate application-oriented talents with engineering practice capabilities and innovative thinking; therefore, the assessment system must evolve dynamically in alignment with educational goals. In the future, we will continue to systematically organize course assessment data, continuously optimize the scoring criteria and weight allocations at each level, and refine the closed-loop assessment mechanism to further enhance the scientific rigor of the evaluation system. This may also provide referential practical insights for the assessment reform of similar core engineering courses.

Acknowledgments

This work was supported by the 2025 Beijing Information Science and Technology University teaching reform project "Exploration and Design of Diversified Process Assessment Methods in Automatic Control Principles" (Grant No. 2025JGYB13) and the 2023 Beijing Information Science and Technology University teaching reform project "Research and Practice of Intelligent Assessment Systems under the Background of Emerging Engineering Education—Taking the Computer Control Systems Course as an Example" (Grant No. 2023JGZD02).

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