Exploration and Practice of Diversified Assessment Model for Hydraulics Course

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Abstract

Responding to the challenges of monolithic assessment structures, limited assessment dimensions, insufficient methodological diversity, and weak pedagogical feedback mechanisms inherent in traditional hydraulics course assessment models, this study introduces a competency-focused and process-supported assessment reform framework under the dual influence of New Engineering Education Development initiatives and Outcome-Based Education (OBE) principles. The framework strategically integrates formative assessment (covering online learning outcomes, classroom interaction quality, and regular assignment performance) with summative assessment (closed-book written exams emphasizing students' capacity to synthesize knowledge for solving complex hydraulics problems). Empirical implementation demonstrates that this reform framework significantly enhances student engagement and learning initiative, strengthens knowledge retention and integrated application capabilities, fosters bidirectional teacher-student interaction, and cultivates disciplined learning habits. These outcomes collectively provide systematic support for improving course teaching quality while establishing an industry-representative practical model and evidence-based reference framework for assessment innovation in engineering education.

Keywords

Hydraulics, assessment reform, formative assessment, summative assessment, teaching quality.

1. Introduction

As a core technical foundation course for water conservancy, civil engineering, and environmental engineering programs, Hydraulics combines profound theoretical depth, prominent practicality, and broad applicability [1]. The course centers on studying the equilibrium and mechanical motion laws of liquids (primarily water) and their practical applications, with core content covering hydrostatics and hydrodynamics modules. Through systematic study of this course, students are expected to solidly grasp fundamental concepts, core theories, and analytical calculation methods of fluid motion, gain an in-depth understanding of the characteristics of different fluid flows, and develop proficiency in solving hydraulic calculation problems common in water-related engineering projects. This provides a solid foundation for subsequent specialized coursework, addressing hydraulics issues in engineering practice, acquiring new knowledge, and conducting scientific research.

As national requirements for engineering education quality continue to rise, curriculum teaching reform has entered the deep water zone of tackling tough issues, with traditional knowledge-centered teaching models urgently requiring transformation and upgrading. The supporting curriculum assessment system also faces systemic transformation, particularly

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under the dual guidance of the New Engineering Education Development initiative and Outcome-Based Education (OBE) principles [2]. Current assessment models for Hydraulics courses commonly exhibit severe shortcomings such as "emphasizing knowledge memorization over competency development" and "prioritizing outcome assessment over process supervision," directly leading to issues like vague learning objectives, insufficient student engagement, and lagging teaching feedback mechanisms. These problems seriously constrain the continuous improvement of teaching quality [3]. Based on this, our study proposes to systematically design a competency-oriented and process-supported assessment reform framework from the critical perspective of assessment system construction, exploring industry-representative reform pathways and practical outcomes.

2. Existing Problems in Hydraulics Course Assessment

2.1. The assessment structure is simple

Currently, most universities still adopt a final exam-dominated grading structure for hydraulics course assessment, where final exam scores typically account for 70% of the total grade, while traditional formative assessment components are limited to homework completion, classroom participation, or attendance records [4]. This structure lacks unified standards for continuous assessment, exhibiting high scoring flexibility and subjectivity, which fail to objectively reflect students' actual learning processes and levels of engagement. Consequently, some students lack motivation to invest in continuous learning, leading to a tendency to "prioritize exams over process."

Under this single-dimensional summative assessment orientation, students tend to concentrate their learning efforts on cramming for final exams rather than daily understanding and accumulation, which hinders systematic construction of the course knowledge framework and progressive development of competencies. Meanwhile, the teaching process lacks effective incentive and supervision mechanisms to guide sustained student engagement in learning and thinking. Ultimately, this creates a gap between assessment outcomes and students' actual capabilities, undermining the effective achievement of course educational objectives.

2.2. The assessment dimensions are limited

Traditional exam formats in hydraulics courses primarily consist of multiple-choice, fill-in-the-blank, and calculation questions, focusing on rote memorization of basic concepts and application of typical formulas. This knowledge-level assessment approach ensures foundational course rigor and systematic knowledge transmission but simultaneously restricts in-depth assessment of students' comprehensive capabilities. It fails to adequately measure higher-order cognitive skills such as analysis, synthesis, reasoning, and critical thinking.

Notably, current assessment content has not effectively aligned with the engineering education emphasis on "integrating knowledge to solve complex engineering problems." Course assessment rarely incorporate open-ended questions, real-world engineering scenario analysis, or multi-step integrated computations. This limits opportunities to cultivate students' ability to transfer theoretical knowledge to practical challenges, creating a significant gap between assessment objectives and the graduation requirements established by engineering education accreditation. Such misalignment impedes the systematic transformation of the course's educational functions.

2.3. The teaching feedback mechanism is weak

The current assessment system for hydraulics courses predominantly relies on centralized final exams, thereby lacking dynamic feedback mechanisms throughout the teaching process. Consequently, instructors often only gain insight into student performance through final grades post-course completion, without the support of phased feedback tools or process data. This

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prevents timely adjustments to teaching content and pacing, resulting in outdated pedagogical strategies, misaligned priorities, and other issues that hinder the formation of a beneficial closed-loop teaching system [5].

Meanwhile, students face challenges in receiving timely and effective feedback regarding their learning processes. The absence of real-time diagnostic mechanisms in classrooms and the lack of systematic assessment in routine exercises and quizzes leave students unaware of their knowledge gaps, making self-adjustment of learning approaches difficult. In the long term, this feedback-deficient assessment system undermines student learning initiative and course engagement, while also restricting opportunities for continuous improvement in teaching quality.

3. Reform of Hydraulics Course Assessment

To comprehensively and objectively evaluate students' mastery of hydraulics course knowledge, practical application skills, and learning attitudes, and to facilitate the transition from 'exam-oriented learning' to 'competency development', the course assessment adopts a combination of formative and summative assessment methods to holistically measure learning outcomes [6-7]. This paper takes the hydraulics course of the water conservancy and hydropower engineering program at Jiangxi Water Resources and Electric Power University as a case study, reducing the final exam weight from 70% to 60% while strengthening formative assessment practices.

3.1. The formative assessment has been further strengthened

The formative assessment framework constitutes 40% of the total course grade (as detailed in Table 1), with its core objective being to transcend the limitations of the traditional single-examination assessment model. This framework establishes a dynamic tracking and comprehensive assessment system that monitors students' entire learning journey. Through meticulously designed multi-dimensional and multi-stage assessment methods, the focus is precisely directed toward critical aspects such as students' online learning effectiveness, classroom engagement, depth of knowledge comprehension, and quality of homework completion. This approach thereby fosters continuous learning and capability development in a holistic and multi-tiered manner.

Table 1. Hydraulics course assessment framework

Number	Assessment type	Assessment item	Content	Score
1	Formative assessment	Online learning	Video Viewing, Online Quizzes	15
2		Classroom performance	Attendance, Class interaction	10
3		Regular assignments	Post-class exercises, Comprehensive assignments	15
4	Summative assessment	Final exam	Basic questions, Intermediate questions, Difficult questions	60

The online learning component constitutes 15% of the formative assessment framework, implemented through Chaoxing learning platform. This segment is subdivided into two assessment criteria: completion rate of instructional video viewing (5%) and online quizzes (10%). Regarding video engagement, students must achieve a minimum 90% completion rate to earn corresponding credits. This stringent requirement ensures sufficient autonomous learning duration, effectively curbing superficial or passive learning behaviors, and promoting thorough knowledge absorption through video content. The online self-assessment questions are meticulously designed to comprehensively cover foundational knowledge across all course chapters. This serves dual purposes: first, to provide timely assessment of students' mastery of key concepts; second, to facilitate early identification of knowledge gaps, enabling targeted reinforcement in subsequent study phases.

The classroom performance assessment constitutes 10% of the formative assessment framework, encompassing two core dimensions: attendance rate (5%) and interactive engagement (5%). Attendance assessment strictly quantifies actual class participation, implementing proportional score deductions for unauthorized absences to reinforce learning discipline and cultivate regular study habits. The interactive component focuses on proactive classroom involvement, assessing contributions through teacher-student dialogues, group collaboration, and constructive idea generation. Instructors employ a dynamic scoring mechanism that evaluates real-time performance during these interactions, creating a feedback loop that not only motivates active participation and fosters vibrant learning environments but also enables immediate pedagogical adjustments based on student responses. This integrated approach bridges quantitative attendance metrics with qualitative engagement assessment, forming a balanced assessment paradigm that aligns with contemporary outcomes-based education standards while facilitating personalized skill development.

The regular assignments component, accounting for 15% of the formative assessment framework, features diverse content spanning post-class exercises and phased comprehensive assignments. Assessment criteria extend beyond mere completion rates and answer accuracy to emphasize normative and logical problem-solving approaches, knowledge application capabilities, and conceptual mastery. For inquiry-based and open-ended assignments - such as hydraulic system analysis incorporating real-world engineering cases - additional assessment focus on innovative thinking and data processing ability. This multi-dimensional assessment strategy aims to guide students beyond foundational knowledge acquisition toward practical problem-solving competencies, fostering holistic development of integrated skills and creative capacities that form the bedrock for future academic and professional success.

3.2. The optimization of summative assessment

The summative assessment constitutes 60% of the final course grade assessment, administered through closed-book written examinations. This assessment method aims to comprehensively examine students' capacity to apply acquired knowledge in solving complex hydraulic engineering problems, emphasizing systematic and comprehensive assessment to objectively reflect students' learning outcomes. The examination content is rigorously designed based on the course's core knowledge framework, covering essential modules including hydrostatics, fundamentals of hydrodynamics, flow resistance and head loss, orifice/nozzle discharge, and open-channel flow. Specifically, the hydrostatics section focuses on pressure calculation and practical applications; the hydrodynamics component emphasizes energy equations and their engineering implementations; while flow resistance and head loss require mastery of analytical calculation methods. Key assessment points also include hydraulic calculations for orifice/nozzle discharge and open-channel flow systems. The question design prioritizes interdisciplinary integration of knowledge domains, with approximately 40% of marks allocated to integrated application questions. These problems are set within authentic hydraulic engineering contexts, evaluating students' ability to synthesize theoretical knowledge with practical engineering scenarios while bridging conceptual understanding and real-world problem-solving. This assessment structure aligns with Washington Accord

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engineering education standards, ensuring graduates possess the requisite competencies for professional practice.

The summative assessment employs a closed-book written examination (100 points total) contributing 60% to the final course grade. The exam structure features three tiered components: Basic Questions (60%) focusing on fundamental concept recall and direct application of formulas/principles; Intermediate Questions (30%) requiring integration of multiple knowledge domains to solve practical engineering problems; and Difficult Questions (10%) emphasizing logical reasoning, knowledge transfer, and innovative approaches to complex scenarios. Approximately 40% of the questions are integrated application problems grounded in hydraulic engineering practices, systematically evaluating students' comprehensive knowledge utilization and bridging theoretical learning with engineering practice.

The closed-book examination serves as the summative assessment component, objectively and accurately reflecting students' mastery and comprehensive application of the course knowledge system. It functions not only as a conclusive assessment of learning outcomes, providing reference for students' academic development, but also enables instructors to analyze exam results for assessing teaching objective achievement. This process helps identify pedagogical issues, optimize instructional content and methods, enhance teaching quality, and drive continuous improvement in curriculum delivery.

3.3. The organic integration of formative and summative assessment

The course establishes a dual-dimensional assessment system combining formative assessment modules (online learning, classroom performance, regular assignments) and summative assessment components (final examination modules). Formative assessment tracks learning trajectories through video viewing duration analysis and quiz performance diagnostics, with classroom interaction measured via real-time response systems. Regular assignments feature tiered tasks: foundational exercises for knowledge consolidation and integrated projects for cross-chapter synthesis. The summative assessment employs modular design with basic questions verifying principle mastery, intermediate questions assessing application skills, and advanced questions stimulating innovative thinking. Assessment data generates visualized reports through the teaching system, enabling instructors to compare performance across modules. For instance, if quiz averages lag behind interaction scores, micro-lecture difficulty is adjusted; when integrated assignment quality fluctuates, case teaching ratios are increased. This system creates synergy between formative and summative components, guiding students through knowledge construction while systematically verifying core competencies, effectively supporting the course's triple objectives of value cultivation, knowledge transmission, and competency development.

4. Analysis of Implementation Effect

The dual-dimensional assessment system constructed in this study has achieved remarkable outcomes in the hydraulics course, realizing synergistic enhancement of student learning engagement, knowledge transfer capability, and teaching interaction quality [8]. Formative assessment, through regularized assessment of online learning and classroom interaction, effectively guides students to establish disciplined study habits and form sustained knowledge construction mechanisms. Students demonstrate significantly improved analytical and application abilities when solving complex problems, with notable enhancement in knowledge internalization and transfer effectiveness. Concurrently, real-time formative assessment data provides immediate feedback to the teaching system, enabling instructors to precisely identify pedagogical weaknesses and dynamically adjust strategies. Summative assessment results

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further validate teaching effectiveness, forming a closed-loop optimization mechanism that effectively drives continuous improvement in instructional quality.

4.1. The student learning engagement has been significantly enhanced

The integration of formative assessment into online learning and classroom performance assessment has effectively transformed students from passive listeners to active learners. In the online learning component, students are required to complete instructional video viewing and knowledge self-assessment on schedule, which compels them to proactively manage study time and develop disciplined learning routines. Regarding classroom interaction, students demonstrate greater willingness to engage in discussions, voluntarily answer questions, and contribute constructive insights, fostering a more vibrant academic atmosphere. This paradigm shift has dismantled the traditional "cramming before exams" pattern characterized by periodic laxity, with sustained learning motivation being substantially strengthened.

4.2. The knowledge mastery and application competency has been significantly strengthened

The diversified design and process-oriented tracking of regular assignments have provided students with a platform for timely knowledge consolidation. Assignment content extends beyond routine exercises to include phased comprehensive tasks, with assessment criteria encompassing both answer accuracy and the normative, logical quality of problem-solving approaches as well as flexible knowledge application. For exploratory and open-ended assignments such as hydraulic problem analysis based on real engineering cases, students are required to integrate learned concepts and demonstrate innovative thinking alongside data processing skills. The closed-book final examination thoroughly assesses students' holistic grasp of the knowledge system, revealing not only proficiency in foundational concepts and formulas but also significantly enhanced analytical and applied capabilities when addressing complex practical problems, thereby achieving remarkable improvement in knowledge internalization and transfer effectiveness.

4.3. The bidirectional teaching interaction has been significantly intensified

The learning data collected through formative assessment provides teachers with precise basis for adjusting teaching strategies. By analyzing issues reflected in students' online learning, classroom interaction, and assignment performance, educators can promptly optimize teaching content and methods, including supplementary explanations for prevalent knowledge gaps and adjustments to teaching pace and difficulty levels. The results of summative assessment further validate instructional effectiveness, forming a virtuous cycle of "teaching-assessment-improvement" that facilitates steady enhancement of teaching quality.

5. Conclusions

Addressing the core issues of single-structure assessment, insufficient competency assessment, and delayed feedback in traditional Hydraulics course assessment, this study has constructed a diversified assessment system integrating "formative-summative" assessment under the guidance of engineering education accreditation standards and the Outcome-Based Education (OBE) concept. The system achieves whole-process tracking of learning pathways through formative indicators including online learning, classroom interaction, and tiered assignments, while incorporating complex engineering problem-oriented summative assessment to emphasize assessment of students' systematic thinking and innovative practice capabilities. This dual-track parallel mechanism has established a teaching closed-loop of "assessment-feedback-improvement", effectively realizing the unification of competency orientation, process optimization, and outcome transformation.

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Teaching practice has demonstrated remarkable outcomes from the assessment reform: Students' classroom participation and autonomous learning duration have significantly increased, with the compliance rate of knowledge transfer competency showing substantial improvement. By leveraging formative assessment data, instructors can precisely diagnose learning conditions and dynamically optimize teaching strategies, fostering a virtuous interactive ecosystem of "teaching-assessment-feedback-improvement". This model deeply integrates the new engineering core concepts of "student-centered, outcome-oriented, and continuous improvement", not only establishing an operational paradigm for assessment reform in water conservancy professional courses but also driving a fundamental transformation in engineering education from knowledge transmission to value creation through competency-based assessment systems. It holds positive demonstration and dissemination value for assessment innovation in similar courses.

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