



# Evaluation and Analysis of Course Learning Outcomes Achievement for Road Survey and Design under Engineering Education Certification

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**Abstract.** The core idea of engineering education certification is results-oriented (OBE), which requires the establishment of a scientific evaluation system for the achievement of curriculum goals to ensure the quality of personnel training. As the core course of civil engineering, the teaching effect of Road Survey and Design directly affects the formation of graduates' engineering practice ability. Based on the certification standard of engineering education, combined with the characteristics of curriculum practicality, this paper constructs a three-dimensional curriculum objective system of "theory-practice-innovation", designs the achievement evaluation covering formative and summative evaluation, verifies the effectiveness of the evaluation system through the analysis of case data, and puts forward the continuous improvement path based on the evaluation results, which provides reference for the teaching reform of similar courses.

**Keywords:** engineering education certification; road survey and design; results-oriented; achievement evaluation; continuous improvement

## 1 Introduction

### 1.1 Research Background

Since China's formal accession to the Washington Accord, engineering education certification has become the cornerstone for achieving international mutual recognition of engineering education. The advocated philosophy of "student-centered, outcome-oriented, and continuous improvement" has been deeply integrated into higher education reform in engineering disciplines. As a pivotal course bridging theoretical knowledge and practical engineering for civil engineering majors, "Road Survey and Design" plays a crucial role in cultivating students' capabilities in route selection, alignment design, and problem-solving. The achievement of its teaching objectives directly correlates with the quality of fulfilling professional graduation requirements. Against the backdrop of intelligent transformation in transportation infrastructure development, road survey and design now faces challenges in deep application of

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computer software technologies, demanding students to possess enhanced comprehensive competencies. Consequently, precise evaluation of course instruction has become even more critical.

Most universities currently face limitations in course evaluation: the assessment primarily relies on final written exams while neglecting practical skill assessments; evaluation criteria lack clear alignment with graduation requirements; and there is no teaching optimization mechanism based on evaluation results, making it difficult to meet the certification's demand for measurable and improvable output quality. Under the impetus of engineering education certification, traditional evaluation models can no longer meet the needs of course teaching or reflect students' practical abilities and competencies. Therefore, establishing a scientific achievement evaluation system has become the core task of curriculum reform and a crucial support for enhancing the alignment between talent cultivation and industry demands.

## 1.2 Research Status

In recent years, academic research has explored evaluation frameworks for course achievement. Southeast University pioneered an assessment system integrating field internships with student feedback, demonstrating practical teaching's crucial role in engineering competency development. Studies have proposed the "Three-Dimensional Integration" experimental teaching model <sup>[1]</sup>, enhancing practical outcomes through diversified evaluation methods. Other research emphasizes establishing a closed-loop mechanism of "documentation-evaluation-feedback-improvement" <sup>[2-4]</sup> to prevent superficial assessments. While these efforts provide valuable references for curriculum reform, three key limitations remain: First, existing systems predominantly exclude new technology application assessments, failing to align with the newly added digital competencies in the 2024 Engineering Education Certification Standards. Second, evaluation metrics primarily focus on theoretical aspects, with insufficient attention to competency-based objectives like ideological and political education, thus failing to comprehensively meet graduation requirements. Third, some evaluation schemes suffer from redundant data collection and ambiguous criteria, rendering results ineffective for instructional improvement. Therefore, it is imperative to refine evaluation frameworks and develop a course achievement assessment model that meets accreditation standards while ensuring practical feasibility.

## 1.3 Research Content and Methods

This study focuses on the Civil Engineering course "Road Survey and Design," employing literature review to analyze accreditation standards and develop an integrated goal-evaluation-improvement framework tailored to the course's characteristics <sup>[5-6]</sup>. Using case analysis with 2022 cohort students from a university as samples, the research calculates and analyzes achievement levels. By aligning with the 2024 Engineering Education Certification Standards—particularly regarding engineering problem-solving and digital tool application—the study optimizes evaluation metrics and weighting design. This provides clear guidance for continuous course improvement,

ultimately establishing replicable evaluation frameworks and pedagogical reform pathways.

## 2 Construction of Achievement Degree Evaluation System

### 2.1 Course Objectives Breakdown: Alignment with Graduation Requirements

In accordance with the General Requirements of the Engineering Education Certification Standards (2024 Edition) and the supplementary standards for civil engineering programs [7], the course objectives are structured into three dimensions with four specific indicators, clearly mapping to the graduation requirement indicators as detailed in Tables 1 and 2 below.

**Table 1.** Course Objectives and Their Connotations

order number	Course Objective	The connotation of the target
(1)	Basic knowledge and theory of route geometry design and ability to analyze problems	Students should master the basic theories of road geometry design, understand the fundamental knowledge and standards of road plan, longitudinal section, transverse section and overall design, and be capable of applying relevant theories to analyze problems. They should also systematically analyze complex engineering issues in route design and comprehensively consider the mutual influences among various factors on the route.
(2)	Complex engineering capability	Students are capable of applying professional knowledge, standards and specifications to solve complex route design problems, and possess the engineering quality to independently complete geometric design work and innovative consciousness in route design.
(3)	environmental assessment capacity	The theory of integrated application of route geometry design, and the impact of the design process on the sustainable development of the terrain, geology, natural conditions, and can be a simple evaluation of the above impact.
(4)	Objectives of the course on ideological and political education	The purpose of the course is to train students to establish the correct survey and design concept and team spirit, so that students can minimize the damage and hidden danger to human beings and the environment in the engineering practice of road route survey and design, and make them have a high sense of social responsibility, good professional ethics and the excellent quality of pursuing excellence.

**Table 2.** Correspondence between Course Objectives and Graduation Requirements Indicators

index point number	Graduation requirement indicators	Course Objective			
		(1)	(2)	(3)	(4)
2.3	The basic principles of natural science and road and bridge engineering are used to analyze the complex engineering prob-	H			

	lems in the process of road survey and design, structural design and construction organization and management, and the mutual influence of each factor is considered.	
3.2	It can carry out structural calculation in the solution of complex road and bridge engineering problems and reflect the consciousness of innovation.	H
7.2	The students should be able to recognize and understand the impact of road and bridge engineering practice on the environment and social sustainable development, and be able to evaluate the impact.	H

### 2.2 Evaluation Index and Weight Design

The first-level indicators are weighted according to the principle of "comprehensive coverage and emphasis on key points", which are theoretical knowledge (65%), complex engineering and innovation consciousness (30%), social influence and innovation quality (5%). The breakdown of the secondary indicators is shown in Table 3 below.

**Table 3.** Course Assessment Criteria

Course Objective	Support the graduation requirement indicators	Proportion of scores by category(%)			Final Assessment(%)	Percentage of achievements(%)
		Process-based assessment(%)				
		Course Summary	sectional test	mid-semester		
Course Objective 1	2.3	10	10	10	35	65
Course Objective 2	3.2		10	10	10	30
Course Objective3	7.2				5	5
amount to		10	20	20	50	100

### 2.3 Evaluation Implementation Process

By combining formative and summative assessments, we establish a comprehensive evaluation framework throughout the entire lifecycle.

1. Process data collection: Conduct quizzes per chapter, compile course summaries (knowledge maps), organize group discussions, and maintain synchronous records of student participation; administer midterm exams during the semester.

2. Implementation of Summative Assessment: The final written exam adopts a "theoretical calculation + case analysis" format, focusing on evaluating the ability to justify design solutions under complex conditions.

3. Achievement Calculation Method: The "Indicator Point Scoring Method" is applied. First, calculate the individual indicator achievement (average score divided by

full score), then calculate the overall course achievement by weighting the scores according to their respective weights, with 0.7 set as the expected achievement threshold.

### 3 An Analysis of the Achievement Degree Evaluation

#### 3.1 Data Source

This study analyzed 51 first-year civil engineering students from a university, collecting 204 valid data points from course evaluations during the second semester of the 2024-2025 academic year, including chapter quizzes, course summaries, midterm exams, and final exams.

#### 3.2 Achievement Calculation Results

##### Achievement of Goal 1.

Course Objective 1's Grade Composition (full score of 65 points) = Process Assessment (30 points) + Final Assessment (35 points), with process assessment accounting for 46.2% and final assessment for 53.8%. The scatter plot of all students' achievement in Course Objective 1 is shown in Figure 1 below.

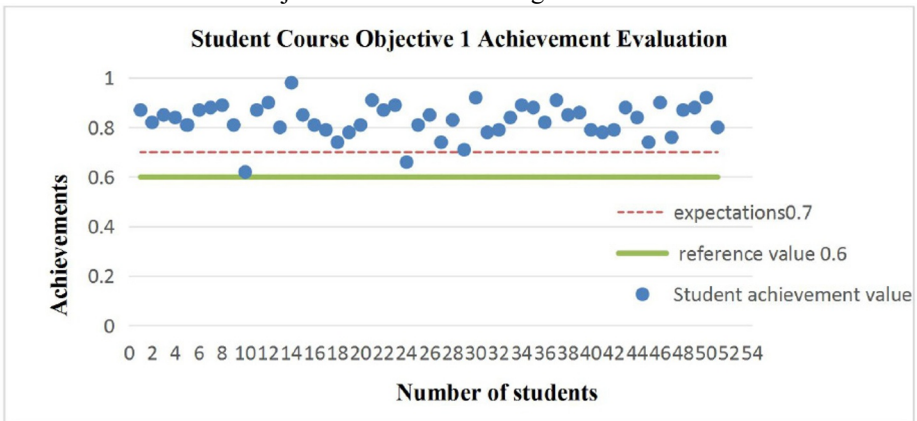


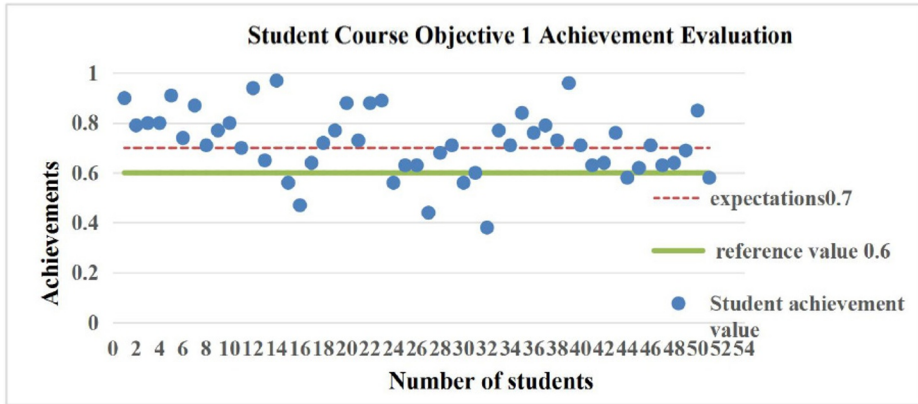
Fig. 1. Scatter plot of the achievement evaluation for Goal 1 of the course

Course Objective 1 primarily evaluates students' mastery of fundamental theories in road geometry design, including essential knowledge and standards for road plan, longitudinal section, cross-section, and overall design. It assesses their ability to apply theoretical knowledge in problem-solving and analysis. The average achievement score for this section was 0.83, with the highest score reaching 0.98, indicating excellent overall comprehension. The lowest score was 0.62, with 2 students (3.92%) scoring below the expected value (0.7) and none below the reference value (0.6). This reflects that most students demonstrated strong grasp of basic knowledge and simple application skills. Process and final assessments revealed that the two students below the

expected value need to strengthen their understanding of fundamental road geometry design theories and improve practical application abilities.

**Achievement of Goal 2.**

Course Objective 2's score composition (full score of 30 points ) is calculated as: 66.7% from formative assessment (20 points) and 33.3% from summative assessment (10 points). The distribution of all students' scores for this objective is shown in Figure 2 below.



**Fig. 2.** Scatter plot of the achievement evaluation for Goal 2 of the course

Course Objective 2 primarily evaluates students' comprehensive application of professional knowledge, standards, and specifications in problem analysis and computational skills for route geometry design, demonstrating engineering competencies to independently complete road survey and design tasks. The average achievement score for this section was 0.72, with the highest score reaching 0.97, indicating excellent overall mastery of the knowledge. The lowest score was 0.38, with 20 students (39.2%) scoring below the expected threshold of 0.7, reflecting average but not exceptional proficiency in route geometry design calculations. Process assessments showed satisfactory regular performance, but final evaluations were mediocre. While these students maintained high attendance without tardiness or absences and passed chapter quizzes, their average final score of 4.02 in route geometry design calculations revealed superficial understanding of design principles and practical application. Students with weak computational skills in geometric design directly hinder comprehension of subsequent course content. Targeted interventions are needed to address knowledge gaps, enhance learning outcomes, and ultimately improve the quality of road survey course design and practical training.

**Achievement of Goal 3.**

Course Objective 3's score (full score of 5 points) is entirely derived from the final exam, accounting for 100% of the total. The scatter plot illustrating all students' achievement of this objective is shown in Figure 3 below.

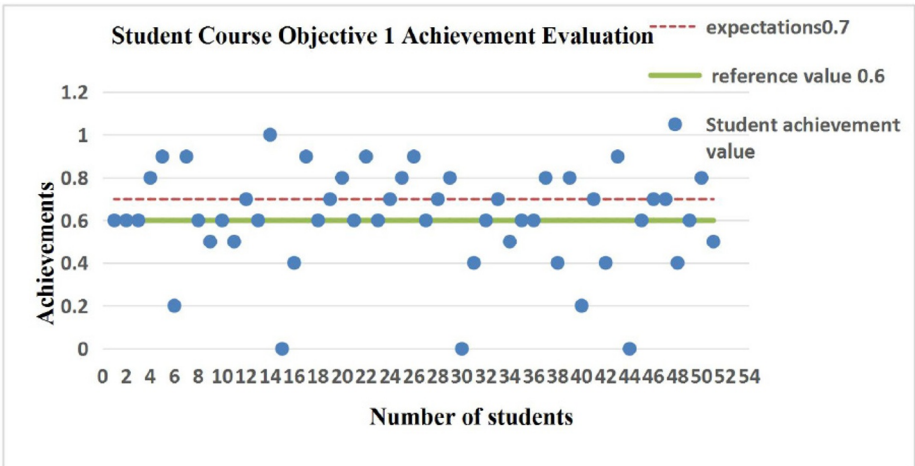


Fig. 3. Scatter plot of the achievement evaluation for Goal 3 of the course

Course Objective 3 primarily evaluates students' ability to apply new knowledge and technologies to identify and solve practical problems, as well as their capacity for lifelong learning. The average achievement score for this objective is 0.61, with a maximum of 1 and a minimum of 0. All scores in this section are derived from the final exam. Exam results show an average score of 3.04, with the highest score being 5 and the lowest being 0, indicating significant variation among students. Most students scored poorly in this section, suggesting inadequate overall mastery of the knowledge. Students need to further enhance their ability to flexibly apply the theoretical knowledge of line geometry design to solve practical problems.

**Overall achievement of the course objectives.**

The distribution of the total scores for the course is shown in Figure 4.

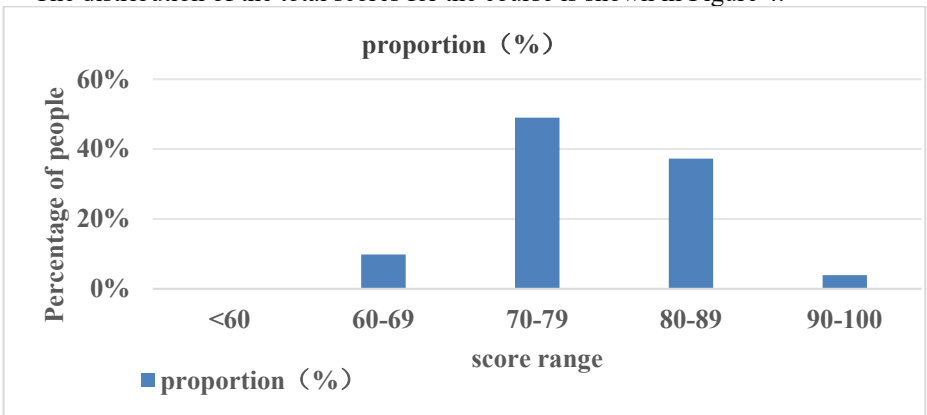


Fig. 4. Distribution of the total course assessment scores

### 3.3 Problem Attribution

1. A small number of students lack solid mastery in the calculation and design of route geometry. While they can keep up with classroom pace, their insufficient post-class practice leads to inadequate understanding of complex topics like horizontal, vertical, and diagonal alignment design, resulting in incomplete knowledge systems. Moreover, their unfamiliarity with relevant standards often causes improper parameter values in calculations. Therefore, the curriculum should emphasize the application of standardized practices.

2. Many students lack solid mastery of route geometry design theories and practical application skills, resulting in limited problem-solving capabilities. The root cause lies in insufficient integration of theoretical knowledge with real-world engineering scenarios. Current case studies predominantly feature outdated classic examples rather than contemporary engineering contexts, hindering students' ability to connect theory with practical design. Furthermore, students demonstrate inadequate proficiency in digital tools. Most still rely on manual calculations, hand-drawn diagrams, and manual data entry, failing to leverage technical tools like Geodis to enhance computational efficiency and drafting speed. This approach makes it challenging for them to meet the demands of digital transformation.

3. Course Objectives 3 The low achievement rate and significant student disparities primarily stem from insufficient integration of real-world engineering practices in teaching. Students lack systematic analysis and practical training regarding factors like topography and geology. Moreover, the evaluation system overemphasizes summative assessments (final exams) while neglecting formative evaluations to identify deficiencies in students' environmental impact assessment capabilities and provide targeted guidance. This results in students' lack of initiative in learning this knowledge area.

## 4 Teaching Improvement Path Based on Evaluation Results

### 4.1 Optimizing Teaching Content and Methods: Developing an Integrated Teaching System that Combines Theoretical Instruction with Practical Training

To improve the teaching quality of the course of route geometry design, it is necessary to optimize systematically from three aspects: theoretical knowledge, ability cultivation and value shaping.

1. Enhance classroom interaction and strengthen theoretical foundations.

By employing heuristic and discussion-based teaching methods—such as real-time Q&A, group debates, and discussions—teachers can guide students to actively explore core concepts in route geometry design, including horizontal curve radius calculations and longitudinal slope design. Using multimedia tools, educators can dynamically demonstrate how changes in design parameters affect road alignment, transforming abstract theories into visual representations to deepen students' understanding.

## 2. Case-based teaching drives knowledge transfer.

We present representative engineering cases (e.g., mountainous road alignment selection) to analyze their design challenges and innovative approaches. For instance, in ecologically sensitive area road design, we compare environmental protection measures (such as animal passage design and vegetation restoration techniques) across different solutions. This helps students master how to optimize alignment design while complying with the Highway Environmental Protection Design Code, achieving a balance between economic benefits and ecological conservation.

## 3. Problem-oriented approach to cultivating engineering thinking

By simulating real-world engineering projects and designing complex problem tasks, students are required to propose feasible route solutions by integrating topographic and geological survey data. Teachers can introduce intelligent tools like BIM and GIS to assist in analysis, thereby cultivating students' ability to make comprehensive decisions from multiple dimensions including safety, cost, and sustainability.

### **4.2 Improve the Evaluation and Safeguard Mechanism: Establish a Scientific and Dynamic Curriculum Quality Monitoring System**

#### 1. Multi-dimensional quantitative evaluation criteria

The evaluation indexes of innovation achievements are refined: technical rationality, economic feasibility, environmental protection innovation, and the percentage or grade system is used to quantify the score, so as to reduce the subjective deviation.

#### 2. Cross-domain collaborative evaluation team

The evaluation team is composed of teachers who provide theoretical guidance, engineers who provide practical verification, and surveying and mapping teachers who provide technical support, so as to ensure that the evaluation results can reflect academic requirements and meet the actual needs of engineering.

#### 3. Closed-loop continuous improvement mechanism

The "three systems and four-in-one" management model is adopted, the evaluation results are used as the premise of improvement, the rectification list is made according to the problems, and the follow-up evaluation is carried out in the next round of teaching, thus forming a virtuous cycle of "evaluation-feedback-improvement-motivation".

### **4.3 The Improvement Effect Prediction: the Dual Verification of the Index Quantification and the Ability Promotion**

The reforms are expected to achieve the following outcomes:

The achievement of objectives has been significantly enhanced: the attainment of social impact and innovation literacy will exceed 0.7, while the overall course objectives are expected to surpass 0.75, meeting the excellent standards of engineering education accreditation.

The leapfrog development of core competencies: Students have made remarkable progress in applying linear optimization and intelligent tools, with their achievements meeting the industry's demands for tackling complex engineering challenges.

Long-term tracking data reveals that graduates' "practical innovation capabilities" in employer evaluations have also seen significant improvement.

## 5 Conclusion

The evaluation system for road survey and design courses achieves precise alignment between curriculum objectives and engineering education accreditation standards. Through a "three-dimensional objectives, multi-dimensional evaluation, and closed-loop improvement" framework, it effectively addresses the traditional evaluation issue of "overemphasizing theory over practice and prioritizing results over process." Case studies demonstrate that this system accurately identifies teaching deficiencies and provides clear directions for improvement. Future research will further optimize the application of intelligent evaluation tools, integrate the latest requirements of the "Engineering Education Accreditation Standards (2024 Edition)," enhance the dynamic adjustment mechanism of the evaluation system, and continuously improve course quality to provide stronger support for cultivating civil engineering professionals.

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