A Study on the Construction of a Diversified Assessment System for Mechanics Courses in the Context of Digital and Intelligent Transformation

Cuiping Hu*, Meiying Su

PLA Naval Submarine Academy, Qingdao, 266199, China

*Corresponding author: 438828862@qq.com

Abstract. Against the backdrop of digital transformation in education, there is an urgent need to establish a scientific and effective assessment system for mechanics courses. Traditional assessment methods for mechanics courses suffer from issues such as "limited assessment content, a single evaluator, and monotonous assessment methods." Based on "multidimensional assessment theory," this study constructs a diversified assessment system for mechanics courses in the era of artificial intelligence, characterized by "multidimensional competencies, diverse evaluators, and varied methods." Utilizing this system, the study creates individual student profiles to provide precise feedback on learning progress, thereby driving the shift of mechanics course assessment toward process-oriented, intelligent, personalized, and developmental approaches, and providing scientific support for cultivating high-quality engineering talent.

Keywords: Artificial Intelligence; Mechanics Courses; Multi-dimensional Evaluation

1 Introduction

Amid the accelerating digital transformation of global higher education, artificial intelligence (AI) technology is profoundly reshaping traditional teaching structures. Promoting the digital integration of AI and teaching is an inevitable trend in the future development of education. Mechanics courses (such as Theoretical Mechanics and Materials Mechanics) are core foundational courses for engineering disciplines including mechanical, civil, and aerospace engineering. They serve as the theoretical foundation for students to address engineering problems [1]. These courses place equal emphasis on theory and application, and are characterised by their abstract and logical nature; they are therefore vital for cultivating students' engineering thinking, innovative abilities and practical skills.However, traditional teaching evaluations merely provide overall scores or chapter-level accuracy rates, failing to reveal deep-seated deficiencies in students'knowledge structures and making it difficult to deliver precise, personalized feedback. AI technology enables the automated collection, in-depth

C. V. Garcés et al. (eds.), *Proceedings of the 6th International Conference on Internet, Education and Information Technology (IEIT 2026)*, Atlantis Highlights in Social Sciences, Education and Humanities 53,
https://doi.org/10.2991/978-94-6239-733-0_18

analysis, and intelligent mining of massive, multimodal learning data, thereby constructing a more refined, dynamic, and personalized teaching evaluation system.

2 Bottlenecks in Traditional Teaching Evaluation Models for Mechanics Courses

Traditional evaluation models for mechanics courses face significant bottlenecks in terms of evaluation content, evaluators, and methods, making it difficult for them to meet the new requirements of the digital and intelligent era for a competency framework that cultivates talent with comprehensive literacy.

(1) Limited Evaluation Content. As a foundational course for engineering disciplines, the core objective of mechanics courses is to cultivate students'ability to apply mechanical knowledge to solve real-world engineering problems. Traditional evaluation places excessive emphasis on knowledge mastery and problem-solving skills, while neglecting the assessment of core competencies such as engineering practice, innovative thinking, teamwork, and scientific inquiry. Consequently, it fails to provide a scientific basis for talent development.

(2) A single evaluator. Traditional assessment relies solely on the teacher as the evaluator, resulting in a ‘teacher-led, one-way grading’ model. However, mechanics courses involve a significant number of collaborative tasks, such as experiments, group modelling and team discussions. Due to the lack of diverse participation and collaborative data analysis, the assessment lacks objectivity and comprehensiveness. For example, the ‘Inertial Mass Measurement Experiment’ in the Theoretical Mechanics course and the ‘Modelling of Axial Torsion Problems’ in the Materials Mechanics course require group collaboration to complete; the traditional model is unable to objectively measure students’ contributions and collaborative skills within the team.

(3) Evaluation methods are limited. Traditional mechanics course evaluations primarily rely on summative assessments, confined to conventional formats such as homework assignments and final exams. They fail to cover critical learning components such as pre-class preparation, in-class interaction, laboratory procedures, and group collaboration. Teachers can only judge student learning outcomes based on limited static data, resulting in evaluation results that deviate from students’ actual ability levels and a lack of timely intervention recommendations targeting individual weaknesses.

3 Theoretical Foundation and Technical Applications

3.1 Theoretical Foundation

The theory of diversified assessment originates from Gardner’s theory of multiple intelligences [2], whose core tenet is that “assessment should focus on students’ holistic development, conducting comprehensive evaluations of their learning processes and outcomes from multiple dimensions and perspectives to overcome the limitations of single-dimensional assessment.” This theory emphasizes the diversification of assessment content, assessors, and methods, while prioritizing individual differences and personalized development—a philosophy that aligns with the core principles of the AI-enabled mathematics curriculum’ s multi-dimensional assessment system.

3.2 Technological Applications

Knowledge Graph.

A knowledge graph for the theoretical mechanics course was constructed based on the SuperStar FanYa platform. It systematically organizes core concepts, theorems, and other elements within the course to establish a knowledge network with clear hierarchies and relationships. By using directed graphs to annotate the prerequisite and extension relationships between knowledge points, it achieves a structured representation of content[3]. Additionally, it closely integrates various teaching resources—such as textbooks, courseware, exercises, videos, and supplementary materials—with the knowledge graph,with each resource mapped to a corresponding knowledge node, thereby forming a systematic and comprehensive learning resource system. Knowledge graph technology can be applied to all stages of the ‘teaching-learning-assessment’ process to analyse students’ pre-class, in-class and homework data, identify their grasp of key concepts in mechanics, and pinpoint their knowledge gaps. As illustrated in Figure 1, this includes the learning progress regarding the ‘inertial forces’ topic in a theoretical mechanics course, as well as their mastery of prerequisite and related knowledge.

Fig. 1. Feedback on the learning of ‘inertial forces’

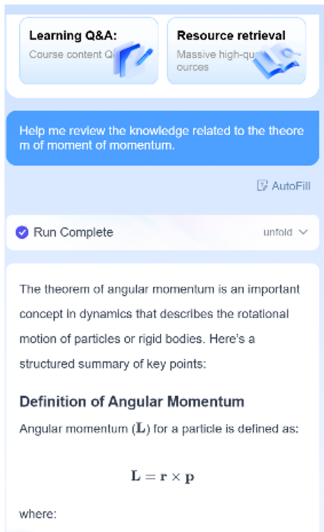

Fig. 2. AI Teaching Assistant

AI Teaching Assistant.

Leveraging large language models and learning analytics, the AI Teaching Assistant provides 24/7 real-time responses to students'questions during the learning process and dynamically allocates instructional resources,as shown in Figure 2.The "brain" of the AI teaching assistant for the theoretical mechanics course developed by the course team is derived from a multimodal knowledge base, whose core content includes: mechanics textbooks, course videos, a question bank, and a database of common misconceptions. In response to difficult concepts raised by students, the AI teaching assistant explains the material, recommends relevant videos, and suggests practice questions to reinforce learning. For complex problems, it intelligently guides students through targeted exercises, enabling personalized and differentiated learning. The system automatically records interaction data between students and the AI teaching assistant.

Virtual Simulation Experiments.

Virtual simulation technology is a method that uses computer technology to construct virtual scenarios and simulate real-world experimental and practical processes, offering extensive application value in mechanics courses.In mechanics laboratory instruction, a three-pronged approach combining "recording of operational procedures + virtual simulation data + analysis of lab reports" is adopted. By integrating virtual simulation technology with AI algorithms, the system can collect real-time data on students' experimental procedures, operational standards, and experimental results. Through AI algorithm analysis, it evaluates students' practical operational skills and problem-solving abilities, providing an objective and precise basis for practical assessment.

4 AI-Enabled Construction of a Diversified Assessment System for Mechanics Courses

To overcome the limitations of traditional mechanics course assessment, a multi-dimensional evaluation indicator system for mechanics courses has been developed based on "multi-dimensional evaluation theory." By leveraging digital and intelligent technologies, this system enables precise, full-cycle, multi-dimensional, and personalized assessment, as well as tailored instruction, with the aim of cultivating high-caliber talent capable of meeting the demands of the AI era, as shown in Table 1.

Table 1. Multi-dimensional Evaluation System for Mechanics Courses.

Learning Objectives	Assessment Indicators	Assessment Methods	Data Collection
Knowledge Mastery	Mastery of basic concepts, principles, and formulas in mechanics.	Pre-class assessments, in-class assessments, and homework assignments	Using knowledge graph technology and AI-powered teaching assistants, the system records students' pre-class, in-class, and homework data to automatically identify their mastery of mechanics concepts and

Learning Objectives	Assessment Indicators	Assessment Methods	Data Collection
			pinpoint areas of weakness.
Skill Development	Preliminary skills in mechanics modeling and engineering applications, as well as innovative approaches to solving mechanics problems.	Lab Performance Grading, Real-World Problem Assessments, and Peer Group Evaluations	Using the teaching platform and virtual simulation technology, we record students' experimental operation data, case analysis data, classroom interaction data, and peer evaluation data.
Competency Development	Scientific inquiry literacy, rigorous and pragmatic attitude, and independent learning skills	Scoring of inquiry projects, completion of independent learning tasks, observation records, and student self-assessments	Combine records from the teaching platform with teacher observations and questionnaire surveys to document students' competency development, and conduct analysis and evaluation.

4.1 Diversification of Assessment Content

To address the issue of "narrow evaluation scope," the assessment of mechanics courses must move away from evaluation goals centered solely on knowledge mastery and problem-solving skills, and instead emphasize comprehensive evaluation focused on cultivating students'diverse competencies. By integrating the teaching objectives and disciplinary characteristics of mechanics courses, and based on the three-dimensional framework of "knowledge mastery—skill enhancement—competency development," a diversified evaluation indicator system for mechanics courses is established.Knowledge mastery serves as the foundation of mechanics course evaluation, focusing on assessing students' understanding and retention of fundamental concepts, principles, and formulas in mechanics. By leveraging knowledge mapping technology and intelligent teaching assistants, we can precisely pinpoint students'proficiency at individual knowledge points;Competency enhancement constitutes the core of the mechanics course evaluation, focusing on students' ability to apply mechanics knowledge for modeling and solving real-world engineering problems, as well as their capacity to propose innovative solutions to mechanics problems. This encompasses competency demonstrations across multiple learning components, including laboratory operations and case analysis;Competency development constitutes the advanced component of mechanics course evaluation, focusing on assessing students'scientific inquiry competencies, rigorous and pragmatic academic attitudes, self-directed learning abilities, and teamwork skills demonstrated during coursework. This aligns with the training requirements for engineering talent in the new era. The evaluation content across these three dimensions is interconnected and progresses in a stepwise manner, enabling a comprehensive assessment of students' learning outcomes and developmental potential.

4.2 Diversification of Evaluation Agents

To address the issue of "single evaluator" the evaluation model has shifted from traditional teacher-only assessment to a "teacher-student-AI collaborative evaluation community" [4-5]. During the evaluation process, AI leverages its efficiency in data collection, automated grading, and learning analytics, while preserving the teacher's irreplaceable role in qualitative judgment, in-depth feedback, and contextual understanding, thereby forming a human-machine complementary evaluation model .Specifically, as shown in Figure 3, teachers serve as professional evaluators, responsible for in-depth assessment of core competencies and qualitative feedback; AI technology acts as an intelligent assistant, handling data collection, behavioral analysis, automated grading, and personalized recommendations; students are both evaluation subjects and participants, engaging deeply in the evaluation process through self-reflection, peer evaluation, and group evaluation.The synergistic interaction among these three parties forms a closed-loop evaluation system, which not only ensures the professionalism and depth of evaluation but also enhances its efficiency and coverage, while simultaneously strengthening students' sense of agency and metacognitive abilities.

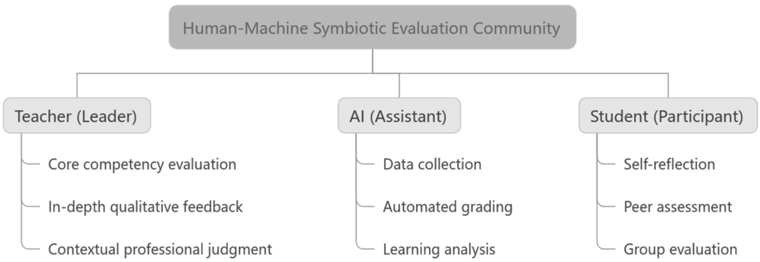

Fig. 3. "Teacher-Student-AI" Collaborative Assessment Community.

4.3 Diversification of Assessment Methods

Addressing the issue of "monotonous evaluation methods" in traditional teaching, the diversified evaluation system for mechanics courses emphasizes a shift from "a single final exam" to a model that "combines formative and summative assessments with complementary evaluation methods." Assessment permeates all teaching phases—including pre-class, in-class, post-class, laboratory work, and projects—while leveraging artificial intelligence technology to improve assessment efficiency and the immediacy of feedback, thereby forming a complete assessment chain that spans from pre-class diagnostic assessment to in-class interaction, and from post-class consolidation to comprehensive application.

Before class, students use knowledge graph technology and AI teaching assistants to complete pre-class preparation and assessments. Instructors analyze students' preparation data and questions to identify their mastery of key concepts and pinpoint knowledge gaps, thereby dynamically adjusting the focus and pace of classroom instruction. The completion rate of preparatory tasks, accuracy of assessments, and quality of questions raised are all incorporated into the scoring for formative assessment, enabling a quantitative evaluation of students' readiness for independent learning.

During class, the smart teaching platform automatically collects data on student learning behaviors, such as attendance, interactive responses, and group discussion presentations. The AI teaching assistant can perform real-time preliminary analysis and statistics on students' classroom engagement and understanding of key concepts. It quickly flags common misconceptions based on students'in-class responses, assisting teachers in delivering targeted explanations and immediate feedback. During laboratory sessions, it integrates data on operational procedures and experimental results collected through virtual simulation experiments.

After class, the AI teaching assistant automatically grades assignments. Based on the characteristics of students'incorrect answers, it pushes targeted practice exercises and explanatory resources for corresponding knowledge points, while automatically recording process-based data such as assignment completion status and the correction process for incorrect answers. Instructors conduct qualitative evaluations of lab reports to comprehensively assess students'practical operational skills and engineering problem-solving abilities.For comprehensive tasks such as course design and group projects, the system integrates multi-source scoring—including instructor evaluations, student self-assessments, and peer reviews—into the formative assessment score. This is ultimately combined with the summative final exam score, and the student's overall grade is calculated according to predefined weighting ratios. This approach covers the entire learning cycle and comprehensively reflects the student's actual competency level.

4.4 Precise Feedback on Evaluation Results

Precise feedback is key to achieving the goals of 'promoting learning through assessment' and 'promoting teaching through assessment'; it provides students with personalised feedback based on the results of intelligent data analysis. By integrating full-cycle learning data — including pre-class preparation, in-class interaction, post-class assignments, laboratory work, group collaboration and examination results —we construct dynamic and precise learning profiles for students in mechanics courses. These profiles cover three key dimensions: knowledge mastery, competency levels and overall academic proficiency. They track students' knowledge gaps, competency development trajectories and learning habits in real time. Based on these profiles, students are provided with personalised learning resources and remedial plans tailored to their individual needs, helping them to effectively address their specific weaknesses.

5 Conclusion

This study addresses the bottlenecks in the evaluation of traditional mechanics courses—such as 'limited scope of assessment, a single evaluator, and a single evaluation method'—by drawing on multi-dimensional assessment theory. It integrates technologies including knowledge graphs, AI teaching assistants and virtual simulation to construct a multi-dimensional assessment system that encompasses the scope, evaluators and methods of assessment. This ultimately generates precise student profiles, providing teachers with heatmaps of student performance and recommendations for differentiated instruction. Subsequent teaching practice will further validate the effectiveness of this system, driving a profound transformation of mechanics course assessment towards process-oriented, intelligent, personalised and developmental approaches, thereby providing robust support for the cultivation of high-calibre engineering talent in the new era.

References

1. Li Baohui, Li Huijun, & Yang Yan. Exploring the Teaching of Basic Mechanics Courses Focused on Cultivating Innovative Abilities [J]. University, 2025, (25): 127–131.
2. Harb, H., El Hajj, M., Alyasin, A., & Nasser, R. (2025). Multiple Intelligences Theory and Educational Implications: A Critical Review. TEM Journal, 14(3), 2557–2569.
3. Lin J, Zhao Y, Huang W, et al. Domain knowledge graph-based research progress of knowledge representation[J]. Neural Computing and Applications, 2021, 33(2): 681-690.
4. En L D C, Jingjing Z, Peng J, et al. AI-Based Adaptive Learning Framework for Enhancing Educational Management in Malaysia Using the EduAdaptNet Model [C]. 2025 International Conference on Frontier Technologies and Solutions (ICFTS). IEEE, 2025: 1-9.
5. Perkins M, Roe J, Furze L. The AI Assessment Scale Revisited: A Framework for Educational Assessment [J]. arXiv preprint arXiv:2412.09029, 2024.