Research on Teaching Innovation Practices Based on Project Collaboration and the Rain Classroom Smart Platform: A Case Study of the "Water Planning and Management" Course

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Abstract. With the development of digital transformation in education, the traditional teaching mode confronts such challenges as low participation and inadequate knowledge transmission ability of students. This study takes the Water Planning and Management course as an example, constructs a teaching framework of "student-centered, competence-oriented, interdisciplinary integration", combines the Project-Based Learning approach (PBL) with the Rain Classroom Intelligence Platform, to explore systematic innovations in teaching concepts, methods, and evaluation systems. This study shows that the model significantly improves students' comprehensive ability (e.g., problem-solving, collaborative innovation) and internal motivation to learn, improves students' grades in the final exam by 15% on average, and allows them to obtain provincial competition awards. In addition, this study further verifies the effectiveness of blended teaching in engineering education by literature comparison and empirical data, which provides a replicable practical approach for higher education reform in the new generation.

Keywords: Innovations in Teaching; Teaching Concepts; Project-Based Learning Approach (PBL); Rain Classroom Smart Teaching

1 Introduction

With the rapid advancement of information technology, post-00s students have expressed a growing demand for increased interactivity and innovation in the classroom. However, many university classes face challenges associated with the "heads-down" phenomenon, low participation, and student disinterest.

While a paradigm shift is occurring within higher education from "knowledge delivery" to "competency development", traditional engineering courses still struggle with passive learning. Almulla (2020) demonstrates that project-based learning (PBL) enhances engagement through real-world applications, but requires structured teacher support[1]. In parallel, Almusaed et al. (2023) warn that AI-driven platforms risk superficial learning if pedagogy is neglected[2]. In response to these challenges, the

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Chinese Ministry of Education has published the "New Engineering Education Construction Guidelines," which explicitly call for the integration of information technology to reform teaching models (Ministry of Education, 2018). Balleisen et al. (2023) further emphasized that applied PBL in higher education not only improves technical competency but also cultivates interdisciplinary problem-solving skills, aligning with global trends in engineering education reform[3]. This study aims to explore multidimensional teaching innovations suited for the digital era.

This study explores a teaching model to meet the current era's demands, integrating project-based collaborative learning with intelligent teaching platforms. This innovation not only enhances teaching quality but also cultivates students' comprehensive abilities. The findings provide practical insights for enhancing higher education teaching methods.

2 Research Innovation

This study constructs a "three-dimensional innovation model" comprising the conceptual, methodological, and evaluative layers. Conceptual Layer: Grounded in constructivist theory, it emphasizes student-centered learning. Methodological Layer: It dynamically integrates Project-Based Learning (PBL) with the functional modules of the Rain Classroom platform (pre-class preparation, in-class interaction, and post-class evaluation). Evaluative Layer: It employs a multi-dimensional formative assessment system, covering knowledge, skills, and attitudes. This study selects water engineering students from a university as research subjects, dividing them into two groups: an experimental group (2021 cohort, 25 students, innovative model) and a control group (2018 cohort, 16 students, traditional teaching).

2.1 Conceptual Layer Innovation

This study adopts a new teaching model—student-centered, competency-oriented, and interdisciplinary-integrated.

A student-centered approach is defined as a pedagogical model that prioritizes students' needs, interests, and individual differences as key elements of education. This paradigm shift from conventional, one-way knowledge transmission by instructors entails the recognition and accommodation of each student's distinct characteristics, ensuring the personalized design of learning pathways, and cultivating active engagement. In this model, students evolve into the primary agents of their own learning, participating in classroom discourse, project-based endeavors, and other interactive educational experiences.

The pedagogical model has shifted from focusing on knowledge transmission to prioritizing the cultivation of students' comprehensive abilities. Critical thinking enables students to independently analyze and solve problems. Innovation encourages them to break conventions and propose novel ideas and solutions. In addition, communication and collaboration skills, developed through group work, teach students to effectively interact and accomplish tasks collectively. These competencies are essential for students' future success and development in society.

This integration process effectively dismantles barriers between various academic domains, facilitating synergies among distinct fields of study. Through the amalgamation of diverse disciplinary approaches, students cultivate a more expansive cognitive framework, characterized by increased comprehensiveness and systematic organization. Consequently, this enhances their capacity to address complex problems, effectively preparing them to address the multifaceted challenges in future professional endeavors.

2.2 Methodological Layer Innovation

2.2.1 The Project-Based Learning (PBL).

PBL emphasizes "learning by doing" to develop critical thinking, yet success depends on teacher guidance. Barak & Yuan (2021) highlight that culturally responsive PBL boosts innovation in diverse classrooms, while Chen et al. (2021) identify challenges like equitable group participation in engineering education[4][5].

A case in point is the “Water Planning and Management” course, which is structured around two primary projects: “Urban Water Supply Planning” and “Urban Drainage Planning.” These projects are completed by students collaborating in groups. The steps involved are as follows: task release, group collaboration, result presentation, problem diagnosis, and iterative optimization (for a more detailed overview, please refer to Table 1).

Table 1. Implementation Process of PBL

Process	Teacher's Role	Students' Tasks
Task Release	Designer, Facilitator	Define objectives, assign roles
Collaborative Inquiry	Consultant, Resource Provider	Data collection, model building
Presentation of Results	Evaluator	Report and defend, peer feedback
Problem Diagnosis	Mentor	Analyze errors, refine solutions

In the course of exploring “Urban Water Supply Planning,” an assignment was given to students in which the “maximum daily water consumption,” “peak hourly water consumption,” and "specific flow rate" required calculation for a given project by each group. Following the distribution of these tasks, each group proceeded with establishing objectives, assigning roles, and performing calculations to derive results (refer to Table 2 for specifics).

Table 2. The results of the student's calculations

Group	Maximum Daily Water Consumption (10,000 m^3/day)	Peak Hourly Water Consumption (L/s)	Specific Flow Rate (L/s·m)
I	2	347.2	0.0044
II	2	324	0.05
III	4	560.58	0.0287
IV	4.4	649.4	0.03

Based on the analysis of the above calculation results, this study concludes the following: (1) Groups I and II differ significantly from Groups III and IV in their “maximum daily water consumption” calculations, mainly due to differences in water usage quotas. Groups III and IV used more standardized quotas. (2) The “specific flow rate” results of Groups III and IV are close, indicating that students have mastered this knowledge point. (3)The “specific flow rate” results of Groups I and II show a large discrepancy. The discourse revealed that Group I committed mathematical miscalculations in the pipeline length estimation process, resulting in erroneous parameter values and substantial discrepancies in the results.

In this PBL approach, students were encouraged to present their learning outcomes, identify problems, discuss issues, and solve them. This approach resulted in students' enthusiasm for learning and cultivated their problem-solving abilities. Moreover, PBL enabled teachers to better understand students' learning progression, allowing them to focus on key points and effectively adapt their teaching methods.

2.2.2 The Rain Classroom Smart Teaching Model.

The advent of smart teaching platforms, such as Rain Classroom, has precipitated a paradigm transition in education, enabling precision through data-driven approaches (Tan et al., 2021)[6]. A case analysis from the National University of Singapore (NUS) reveals that real-time interaction and personalized feedback can augment course pass rates by 12%. However, it is imperative to ensure that technological tools remain deeply integrated with teaching methodologies to circumvent the potential pitfall of "technology for technology's sake".

2.2.2.1 Before Teaching Process.

To achieve these goals of courses, it's crucial to use AI tools efficiently before teaching. ① AI Workbench: Builds a knowledge base integrating related resources, e-textbooks, research papers, and practice exams, broadening the scope of teaching content.② AI Applications: Features like 24/7 tutoring bots, smart lesson preparation, and one-click question generation significantly enhance teachers' efficiency.

2.2.2.2 In Teaching Process.

Leveraging the Rain Classroom platform, this study fully utilizes its smart teaching tools. Taking “Urban Rainfall Prediction” in the “Water Planning and Management” course as an example, the application of the Rain Classroom smart platform in teaching is illustrated as follows.

(1) Pre-class Preparation: Use the “Announcement” feature to assign preparation tasks: ①Review Section 5.2, “Rainfall Calculation,” in the Urban Drainage Engineering Planning Standards (GB 50318-2017). ② Investigate sponge city design elements in groups. This allows students to familiarize themselves with the course content in advance.

(2) Pre-class Assessment: Use Rain Classroom's objective questions (single-choice and multiple-choice) to test students' understanding of the previous lesson's topic, “Urban Drainage Systems.” Students can submit answers via their mobile devices, enabling teachers to adjust the teaching pace based on feedback.

(3) In-class Teaching: By activating Rain Classroom's real-time interaction features, the teacher can use it for student check-in, and quickly assessing student attendance. Additionally, enabling the live comments and reward functions enhances student engagement and creates a more dynamic classroom atmosphere.

The study found that the level of engagement in live comment interactions varied based on the class timing (Figure 1).

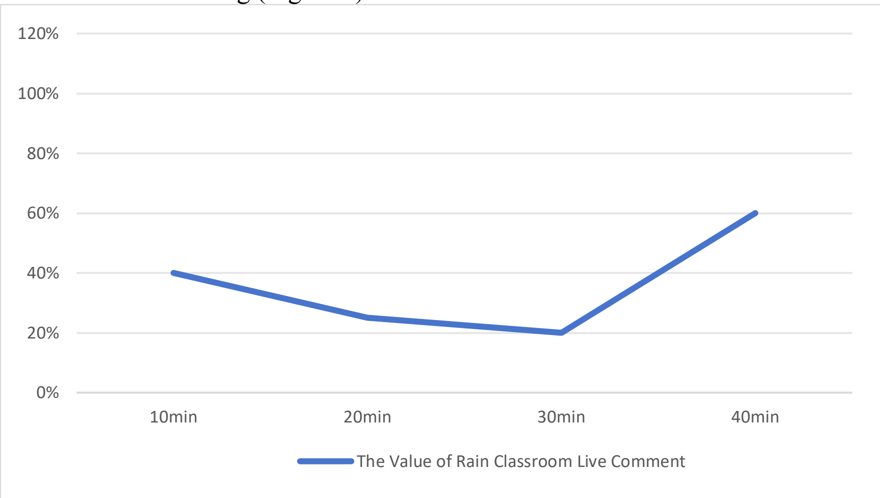

Fig. 1. Heatmap of live comment interactions on Rain Classroom

Analysis of peak: The peak in the heat map, the most active time for pop-up interaction, is the 10-minute “pre-test” session of the class. It may be that the teacher is explaining a key knowledge point, a controversial topic, or an activity such as a time-limited test that prompts students to focus on posting pop-ups. The second peak is near the end of class, probably due to students feeling hungry and frequently sending pop-ups to remind the teacher that it is time to finish the lesson.

Analysis of lows: The lows, which indicate the periods of less interaction, mostly appear in the middle of lessons, perhaps because the content is boring, or difficult, or the teacher's explanation methods are not engaging enough to make the students participate lower.

Analysis of pace: The heat map can be used to understand whether the classroom interaction pace is reasonable, such as whether the interval between the peak and valley interaction is appropriate, and whether there is a long period of low interaction, so that the teacher can adjust the teaching pace and reasonably arrange the interaction links.

(4) Class test: Teachers introduce calculation problems, through the rain classroom “random name” to choose students to answer the question, this section can strengthen students' concentration, which can be called “thrilling” for the students.

(5) After class: Students can set up assignments through the “Upload Test Papers” function of Rain Classroom, and set the submission time. Students can submit their homework by taking photos and uploading pictures, and teachers can realize paperless

correction of homework. Teachers can realize paperless correction of homework. The classroom courseware and extension materials can also be shared again, which is convenient for students to review and consolidate.

(6)Classroom Report Creation: After finishing a lesson, Rain Classroom immediately generates a classroom report. This report records students' learning data in detail, such as the length of time students spent watching courseware and answering questions. Teachers can analyze students' learning effectiveness accordingly.

2.2.2.3 After Teaching Process.

After a course, a knowledge map (a mind map covering all the teaching content) can be generated from all the precipitated teaching materials and made available to students for review and fulfillment of the training objectives.

2.3 Evaluative Layer Innovation

The research shows that it is necessary to establish a diversified evaluation system and change the single examination results assessment method. The evaluation indexes include students' classroom performance, group collaboration ability, stage examination, etc., which reflect students' learning process and effect on comprehensively and objectively, motivate students to actively participate in teaching activities by focusing on the improvement of their own comprehensive quality.

In this study, we designed the “80+20” dynamic grading rules for the usual grades, including the base points (80%) for attendance and assignment submission; and the bonus points for innovative programs and excellent performers as well as the penalty points for absenteeism and missing assignments, which are the reward and penalty points (20%). The details of the criteria for evaluating regular grades are shown in Table 3.

This mechanism is borrowed from the University of Alberta's formative assessment model (Nicol & Macfarlane-Dick, 2006), which balances fairness and incentives[7].

Table 3. Criteria for assessing usual grades

Category	Evaluation Criteria	Score Adjustment
Base Score	Attendance and assignment submission meet requirements	80
Bonus Points	Excellent Rain Classroom assignments (top 10%)	+2 points per instance
	Core member of project group	+5 points
	Excellent written assignments (Grade A, innovative)	+5 points per instance
Penalty Points	Missing Rain Classroom assignments	-1 point per question
	Missing written assignments	-5 points per instance
	Absence from class	-5 points per instance

3 Results and Discussion

3.1 Analysis of Learning Effectiveness

This study shows that the students' learning interests and comprehensive abilities are significantly improved through teaching innovation.

First, students' performance significantly improved, the average score of the experimental group increased by 15% compared with the control group, especially in the practical topics with obvious advantages, and students' enthusiasm to participate in scientific research competitions increased significantly, and they won provincial competition awards.

Second, students' ability is effectively developed, through the questionnaire survey of students in the experimental group, 85% of the students think PBL enhances their problem-solving ability (Table 4).

Thirdly, students' acceptance of the technology improved significantly: the Rain classroom was 89.3% satisfied, but 5.2% of students reported that the complexity of the interface interfered with its use.

Table 4. The results of the questionnaire on PBL enhanced problem-solving skills

Category	Specific Item	Details	Percentage
Perception of PBL Enhancing Problem-Solving Abilities	**Degree of Enhancement**	Significant Enhancement (90% - 100%)	20%
		Moderate Enhancement (60% - 89%)	35%
		Slight Enhancement (30% - 59%)	30%
		Minimal Enhancement (1% - 29%)	10%
	Most Helpful Phase for Improvement	Problem Identification and Analysis	20%
		Solution Design and Planning	25%
		Practical Implementation	30%
		Presentation and Reflection	15%
		Team Collaboration Process	10%
Other Feedback	**Suggestions for Improvement**	Increase Project Difficulty and Challenge	30%
		Provide More Guidance and Resources	40%
		Optimize Team Grouping Methods	20%
		Extend Project Duration	10%

3.2 Teachers' Professional Development

Teachers' teaching level has been improved, and the course has been recognized as a first-class undergraduate course at the university level, and the teaching quality evaluation grade is B.

3.3 Limitations and Improvements

First, there may be a risk of technology dependency, as some students in remote areas have web access problems.

Second, the cross-cultural applicability of the model needs to be further verified for the model's generalizability in diverse educational environments.

4 Conclusion

The innovative model of "PBL + Rain Classroom Smart Platform" has been popularized and applied in several professional courses, benefiting over 600 students. This study confirms the effectiveness of this innovative model in engineering education.

In the future, it can be combined with virtual simulation technology to construct a "meta-universe classroom" to further enhance the immersive learning experience. The innovation of education should always take students' development as the key point, and seek the balance between technological empowerment and humanistic care.

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