

Teaching Reform and Effect Evaluation of Water Resources Planning and Utilization Course for the "Dual Carbon" Goals

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Abstract: "Carbon peak and carbon neutrality" has been elevated to a national strategy covering all aspects of the economy and society. Water resources development and utilization are closely related to carbon emissions, posing new requirements for the training of water-related professionals. This paper takes the water resources planning and utilization course as the object, addressing the issues of insufficient integration of the dual carbon concept in traditional teaching, relatively fixed teaching content and methods, and single assessment and evaluation. Focusing on the "knowledge - ability - value" tripartite goal, it designs a teaching reform plan for the course oriented towards the "dual carbon" goals from three aspects: teaching content reconfiguration, teaching method innovation, and assessment and evaluation reform, and constructs an effect evaluation index system including four dimensions: knowledge acquisition, ability cultivation, value recognition, and learning commitment. The research shows that embedding the dual carbon goals system into the course teaching helps students establish a professional perspective of water resources utilization and carbon emission reduction collaboration, enhances the ability to solve complex engineering problems and practice green development, and can provide reference for similar course reforms.

1. Introduction

Each stage of water resource development and allocation, engineering construction and operation, and water treatment involves carbon emissions and storage. Traditional water resource planning mostly focuses on indicators such as water supply and demand, water quality assurance, and engineering investment, and rarely quantifies the differences in carbon balance among different control schemes^[1-2]. With the advancement of disciplinary research, low-carbon nature has gradually become an important consideration dimension in the selection of water resource plans. The course of water resource planning and utilization emphasizes cultivating students' abilities in water resource system analysis, planning, and engineering decision-making. The course has long

been centered on classic hydrological calculations, reservoir scheduling, and optimal allocation of water resources, and the existing textbooks only cover limited content related to the carbon effect of the water resource system. The teaching lacks mature and cutting-edge case studies, which may lead students to form a mindset that only focuses on water volume and economic costs, making it difficult for them to establish a systematic understanding of the water-energy-carbon coupling system^[3]. To adapt to the new requirements of the discipline for the capabilities of water resources professionals, it is necessary to carry out curriculum teaching reforms and embed low-carbon-related theories and methods into the existing teaching framework.

2. Analysis of Current Curriculum Teaching Situation and Problems

Based on the course positioning and observation of teaching practice, the current teaching of water resource planning and utilization mainly has three problems. First, the integration of the dual-carbon concept is insufficient. The knowledge system of the course is mainly based on traditional water resource evaluation, allocation, and engineering utilization, and involves relatively little content on the correlation between water resource development and carbon emissions, the mechanism and path of water conservation and carbon reduction, and green water conservancy projects. Students are unable to form a systematic professional perspective towards the dual-carbon goal. Second, the teaching content and methods are relatively rigid. Classroom teaching is mainly based on theoretical lectures, and practical teaching methods such as case analysis, project-driven learning, and situational simulation are rarely used. Students' participation is not high, and their knowledge application and problem-solving abilities are insufficient. Third, the assessment and evaluation are relatively simple. The assessment is mainly closed-book final exams, which focus on knowledge memorization and do not pay enough attention to ability cultivation, value recognition, and the performance of the learning process. It is difficult to comprehensively reflect the effectiveness of talent cultivation.

The above problems are in contrast to the requirements of the national dual-carbon strategy for water resources professionals to "be both proficient in water resources specialties and have green and low-carbon qualities". Specifically, traditional teaching focuses on "able to use and sufficient knowledge" of engineering knowledge, and students can complete routine water resource evaluation and allocation calculations, but they seldom think about "how much energy is consumed, how much carbon emissions are produced, and whether the optimization of scheduling can reduce carbon footprints" and other issues with a contemporary and systematic nature. The cultivation of knowledge, ability, and value has not formed a synergy.

3. Design of Teaching Reform for the "Dual-Carbon" Goal

3.1 Reform Concept and Goals

The curriculum reform is based on the core concept of "knowledge - ability - value", and takes the dual-carbon goal as the main educational thread throughout the course. At the knowledge level, guide students to understand the intrinsic connection between water resource utilization and carbon emissions and the basic principles of water conservation and carbon reduction; at the ability level, cultivate students' engineering capabilities for water resource planning, allocation, and comprehensive utilization under dual-carbon constraints; at the value level, strengthen students' value recognition of green and low-carbon and their professional responsibility. The three goals support each other and jointly point to the cultivation of high-quality green water resources professionals. The introduction of the dual-carbon perspective does not weaken the core water resource knowledge of the course, but adds a low-carbon constraint dimension on top of the existing

knowledge system of water resource evaluation, allocation, and utilization, enabling students to master professional core capabilities and also possess the value judgment ability for green development.

3.2 Curriculum Content Reconstruction

Based on the above goals, map the traditional teaching modules and the dual-carbon goals item by item, and clearly define the key integration points and reform focuses of each module, as shown in Table 1.

Table 1 Mapping of Course Teaching Modules to the "Carbon Neutrality" Goals and Key Reform Points

Teaching module	The integration of the dual-carbon goal	Key points of the reform
Water resource assessment	The correlation between water resources and carbon footprint; regional water resources - energy - carbon emissions coupling	Introduce the "water-energy-carbon" collaborative evaluation case and analyze the carbon effects of different utilization methods
Water resource allocation	Prioritize water conservation and coordinate carbon reduction; integrate economic, ecological and low-carbon aspects in the planning scheme	Add multi-objective configuration tasks with carbon constraints and conduct scheme comparison
Flood control and disaster mitigation as well as comprehensive utilization of reservoirs	The dual attributes of carbon sink and carbon source of the reservoir; ecological dispatch and carbon reduction through power generation	Based on the cases of green hydropower and ecological dispatching, this paper discusses the reduction of sources and increase of sinks in the operation of the project
Utilization of water energy and integration with new energy sources	The carbon reduction benefits of hydropower and clean energy; the complementary use of water, wind and solar energy	Taking a typical hydropower project as an example, calculate the carbon reduction benefits and discuss multi-energy complementarity
Water resource conservation and protection	The mechanism and approaches of water conservation being equivalent to carbon reduction	Design a water-saving scenario analysis project to quantify the effectiveness of water conservation and carbon reduction

3.3 Teaching Method Reform

Firstly, promote case-driven and project-based learning. Design teaching cases based on real scenarios such as the South-to-North Water Diversion Project, coordinated water and carbon management of cascade reservoirs, and green hydropower construction. Organize students to work in groups to develop water resource planning schemes. Require the schemes to meet the goals of water supply and flood control while providing a trade-off analysis under the constraints of low-carbon emissions, such as water savings, hydropower generation, and carbon reduction^[4]. Secondly, implement blended and contextualized teaching. Use online platforms to distribute explanations of dual carbon policies, industry frontiers, and engineering cases for students to study independently before class. In offline classes, conduct discussions, debates, and role-playing to enhance learning initiative and participation^[5-6]. Thirdly, integrate course ideological education.

Naturally embed dual carbon strategies and the mission and responsibility of water conservators to protect river safety into professional teaching. Trigger resonance through examples of water carbon reduction in the water conservancy field and achieve the unity of knowledge imparting and value guidance. Fourthly, strengthen team collaboration and outcome presentation. The group schemes undergo peer review, defense presentations, and teacher evaluations, which not only enhance collaboration and communication skills but also enable students to implement the dual carbon concept in specific planning outcomes.

3.4 Assessment and Evaluation Reform

Integrate dual carbon-related capabilities and qualities into the assessment, forming a combination of "process assessment + outcome assessment + value-added evaluation", reducing the weight of the final closed-book exam, and increasing the proportion of ability-based assessments such as case analysis, scheme design, and group presentations, guiding students to continuously invest in the learning process.

4. Implementation and Effect Evaluation of Teaching Reform

4.1 Construction of Effect Evaluation System

To systematically evaluate the reform results, a evaluation index system from four dimensions: knowledge acquisition, ability and quality cultivation, value recognition, and learning engagement, is constructed. The weights are determined using the analytic hierarchy process and expert consultation, as shown in Table 2.

Table 2 Evaluation Index System for the Effect of Teaching Reform towards the "Carbon Neutrality" Goal

Primary indicator	Secondary indicator	Evaluation method	Weight
Knowledge acquisition	Knowledge on the connection between carbon neutrality and water resources; Principles and methods of planning	Course tests, assignments, student self-evaluation	0.25
Competency and Literacy	Solution design ability; Data and case analysis ability; Team collaboration ability	Project outcomes, presentation defense, case analysis, student self-evaluation	0.35
Value identification	Green and low-carbon awareness; Professional responsibility	Course-based ideological and political education feedback and learning reflections	0.20
Learning Engagement	Classroom participation; Online learning behavior; Process performance	Attendance records, platform logs, process evaluations	0.20

4.2 Evaluation Implementation and Data Sources

The evaluation was conducted on a total of 61 students from two teaching classes after the reform. Information was collected through course tests, project outcome scoring, questionnaire surveys, and learning platform behavioral data. Baseline data was obtained before the course began. The evaluation adopted a "quantitative + qualitative" approach. The quantitative part calculated the scores of each indicator and their change ranges, and paid attention to the dynamic changes in

learning engagement throughout the teaching process; the qualitative part relied on students' reflections, classroom observations, and teacher-student discussions to supplement and explain the reasons behind the quantitative results, identifying which reform measures were effective and which parts still needed adjustment. The evaluation questionnaire used a 5-point Likert self-assessment scale, where students provided subjective evaluations of their own knowledge reserves, engineering capabilities, value cognition, and classroom engagement. The results were converted to a percentage scale, with higher scores indicating a higher self-perceived level.

4.3 Effect Analysis and Discussion

Table 3 presents the statistical results of the self-assessment questionnaires of students before and after the reform.

Table 3 Evaluation Results of Teaching Reform Effects (n = 61)

Indicators	Before the reform	After the reform	Main manifestations
Knowledge acquisition	66.8	86.5	Understanding the water-energy-carbon correlation and the mechanism of water conservation and carbon reduction
Competency and Literacy	63.5	85.1	The comparison of carbon-constrained schemes, data analysis and collaboration have significantly improved
Value identification	70.2	84.0	The sense of responsibility for green and low-carbon development has strengthened, but there are still differences in internalization
Learning Engagement	68.4	82.3	Classroom participation, task completion, and online learning are more consistent

From Table 3, it can be seen that all four indicators have improved after the reform. Among them, the increase in ability and literacy was the greatest, followed by the improvement in knowledge acquisition, while the increase in learning commitment and value recognition was relatively moderate. In the knowledge acquisition dimension, after integrating the content of dual carbon and water resource planning, students' understanding of the correlation between water, energy, and carbon and the mechanism of water conservation and carbon reduction became more systematic; in the ability literacy dimension, case-based and project-based learning enhanced students' ability to select carbon-constrained solutions, analyze data, and collaborate; in the value recognition dimension, the integration of course ideological education strengthened students' sense of responsibility for serving the green water conservancy cause; in the learning commitment dimension, process-based assessment and diversified teaching improved classroom participation and task completion quality. Objectively, the average score of course tests increased from 68.3 to 82.6; the excellent rate of project outcomes (80 points and above) increased from 41.0% to 73.8%; the completion rate of online tasks on time increased from 76.4% to 93.2%. These results are consistent with the self-assessment trend in Table 3, indicating that the reform effectiveness has objective basis.

Process feedback shows that students generally reported that the project tasks enabled them to first link water resource planning with carbon reduction goals, recognizing the intrinsic connection between professional work and green development. This indicates that the value of integrating dual carbon is not only in supplementing knowledge, but also in reshaping engineering system thinking.

However, it also exposes practical constraints. There is insufficient reserve of water-carbon cases and engineering data for undergraduate teaching; differences in students' foundations and teacher conditions will interfere with evaluation comparisons. If the integration of dual carbon only remains at the level of scattered knowledge points, it is prone to be formalistic. The implementation of the reform requires a complete teaching chain from goals to content, methods, and evaluation.

5. Discussion and Suggestions

Carrying out teaching reform for the course of water resource planning and utilization with the goal of dual carbon is essentially converting national strategic requirements into the course's self-awareness of talent cultivation. The sustainability of the reform's effectiveness depends on three points: First, the support of teachers' capabilities; the teaching instructors need to update their knowledge structure and deeply understand the connection between water resources and carbon reduction, so as to organically integrate dual carbon elements in teaching; second, the support of teaching resources; continuous construction of case libraries, project tasks, and online resources under the dual carbon background is needed to provide material guarantees for the reform; third, the improvement of the evaluation mechanism, a tracking evaluation mechanism covering multiple rounds of teaching should be established, combined with the assessment of the achievement of course goals to test the support of the reform for graduation requirements, forming a "evaluation - feedback - improvement" closed loop.

6. Conclusion

This paper designs a teaching reform plan for the course of water resource planning and utilization with the goal of dual carbon from three aspects: teaching content reconstruction, teaching method innovation, and assessment and evaluation reform. It also constructs an effect evaluation system including four dimensions: knowledge acquisition, ability literacy, value recognition, and learning commitment. In the future, it is necessary to continuously improve supporting teaching resources, establish a multi-round teaching tracking evaluation closed loop, and promote the integration of low-carbon concepts in the professional curriculum system, continuously optimizing the reform model, and cultivating water conservancy talents with solid professional abilities and green and low-carbon literacy.

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