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Original Paper

Research on the Concept Reconstruction and Teaching Practice Strategy of Construction Equipment Course Based on the Full Life Cycle Resource Value Management

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Abstract

Under the background of the "double carbon" goal and the digital transformation of the construction industry, the traditional "building equipment" course focuses on equipment selection and terminal design, ignoring the value dimensions of resource consumption, operation energy efficiency and waste recycling of equipment system in the whole life cycle, resulting in students' lack of systematic resource view and value judgment ability. This paper is based on the theory of full life cycle resource value management, and integrates it into the knowledge system and educational objectives of the course of construction equipment. By reconstructing the curriculum concept of "resource input - efficient transformation - value retention - recycling", the modular teaching content throughout the whole process of design, construction, operation and maintenance and scrapping is constructed, and the teaching practice strategies such as case teaching based on real projects and interdisciplinary collaborative design are proposed. So as to help students change from "single technology thinking" to "full cycle value thinking", and provide a new path for the cultivation of interdisciplinary talents in the specialty of building environment and energy application engineering.

Keywords

Full life cycle, Resource value management, Construction equipment, Curriculum reconstruction, Teaching practice

1. Introduction

1.1 research Background

With the proposal of China's goal of "carbon peaking by 2030 and carbon neutralization by 2060", the construction industry, as the main field of energy consumption and carbon emissions, is facing profound transformation pressure. According to the Research Report on carbon emissions in the field of urban and rural construction in China (2025) issued by the China Building Energy Conservation Association in February 2026, the carbon emissions from construction (including building materials and construction) of the national construction industry in 2024 were 2.78 billion tCO_2, and the carbon emissions from the operation of civil buildings were 2.47 billion tCO_2, accounting for 48.3% of the total national carbon emissions. Among them, the carbon emissions from building operation accounted for 22.1% of the national energy consumption, and the carbon emissions from power accounted for 66.8% of the carbon emissions from building operation. Building equipment system (HVAC, water supply and drainage, electrical, intelligent, etc.) is the core energy consumption carrier in the building operation stage. Its design, type selection, operation and management directly determine the utilization efficiency and life cycle value of building resources.

It is worth noting that the growth rate of carbon emissions from building operation has shown a significant slowdown trend. The report shows that the average annual growth rate of carbon emissions from building operation has been controlled at 3.3% since 2015, which is 36% lower than that from 2005 to 2015. This trend not only reflects the effect of the large-scale development of green buildings and the increase in the proportion of renewable energy applications, but also highlights the urgency of further tapping the energy-saving potential of building equipment systems.

However, in the current higher education of architecture, building equipment, as the core course of architecture, civil engineering, building environment and energy application engineering, has been influenced by the idea of “technical practicability” for a long time, and the teaching content is often set up as “equipment selection calculation” and “end layout”. Traditional theory teaching focuses on teaching the working principle of equipment, load calculation method and standard drawing requirements. Students are used to applying formulas and completing drawings, but rarely think about the economy of the whole life cycle. For example, how much resources does this equipment system consume from production to scrapping? How much value is generated? What are the economic and environmental costs of its long-term operation?

This teaching mode of “emphasizing design over operation, emphasizing technology over value” has been difficult to meet the needs of civil engineering talents in the new era. The industry needs not only technicians who can draw pictures, but also compound engineers who have a full life cycle vision, understand resource value management, and can coordinate economic and environmental benefits.

1.2 Current Problems

Through the teaching research and related literature analysis of the course “building equipment” in many colleges and universities, the following prominent problems are found:

The knowledge system is fragmented: the course content is taught in blocks according to the type of equipment (HVAC, water supply and drainage, and electrical), which lacks horizontal connection and makes it difficult for students to form the concept of “interdisciplinary application”.

Life cycle fault: it mainly covers the “design stage”, and rarely involves “resource loss in the construction and installation stage”, “energy efficiency attenuation in the operation stage” and “recycling in the scrap stage”, leading students to mistakenly believe that the delivery of drawings is the end of the project.

Lack of value orientation: due to the lack of economic and environmental perspectives, students are unable to quantify the life cycle cost (LCC) and carbon emissions of equipment systems, and make decisions only based on initial investment or technical reliability.

Practice teaching lags behind: most of the experimental links are confirmatory experiments, lacking operation and maintenance management simulation based on real data, and students are difficult to understand the value change law of equipment in long-term operation.

2. Connotation and Enlightenment of Resource Value Management in the Whole Life Cycle

2.1 Whole Life Cycle Theory

The whole life cycle theory emphasizes the whole process management from raw material acquisition, production and manufacturing, transportation and storage, use and maintenance to final disposal. In the field of architecture, the theory is extended to “the whole life cycle of architecture”. ISO 14040:2006 issued by the international organization for standardization provides a standard framework for the full life cycle assessment, requiring the assessment to cover the whole process from raw material acquisition to final disposal, mainly including the following stages:

Material production stage: Mining and processing of equipment raw materials (copper, steel, aluminum, plastics, etc.)

Construction and installation stage: energy consumption and resource loss during equipment transportation, hoisting and commissioning

Operation and maintenance stage: equipment operation energy consumption, water consumption, repair and replacement of parts

Scrap disposal stage: equipment removal, classified recycling, waste landfill or incineration

Figure 1 process diagram of building life cycle

2.2 Resource Value Management Theory

Resource value management is an important branch of environmental management accounting. Compared with the limitation that traditional cost accounting only focuses on “money flow”, it calculates “resource flow” (materials, energy, water) and “value flow” (positive product value and negative product value) synchronously. The core point is:

Resources are valuable: every kilowatt hour of electricity, every ton of water, and every kilogram of copper tube have resource value

Value is time-varying: the value (performance, efficiency and residual value) of the equipment changes dynamically during use due to wear, aging and technical iteration

Waste is a negative value: waste output represents the invalid consumption of resources and potential environmental liabilities

2.3 Curriculum Enlightenment from the Dual Perspective

Combining the above full life cycle theory with resource value management, the enlightenment to the course of construction equipment is mainly reflected in the following aspects:

From “steady-state design” to “dynamic management”: the equipment system should not be regarded as a static system that is fixed after the design is completed, but as a dynamic asset that is constantly declining, needs maintenance, and finally eliminated in the whole life cycle.

From “technical indicators first” to “value indicators first”: To evaluate the advantages and disadvantages of the equipment system, we should not only look at the energy efficiency ratio (COP) or equipment cost, but also introduce comprehensive value indicators such as full life cycle cost (LCC), investment payback period and carbon footprint.

From “linear thinking” to “circular thinking”: the traditional teaching is the linear logic of “mining - using - discarding”; The new curriculum should be embedded with the circular economy logic of “resources - products - renewable resources”, and guide students to consider the modularity, easy disassembly and recyclability of equipment and materials at the design stage.

3. Reconstruction of Curriculum Concept: From “Technology Teaching” to “Value Governance”

Based on the above theory, this study systematically reconstructs the concept of “construction equipment” course, and establishes the teaching concept framework of “one main line, three dimensions and five stages”.

3.1 Priority Concept of Resource Value in the Whole Life Cycle

The core goal of the course is no longer to “teach students how to calculate load and select equipment”, but to “cultivate students’ decision-making ability to minimize resource consumption and maximize value retention in the whole life cycle of building equipment system”. Through the study of this course, students should have the following abilities:

Comprehensive decision-making ability: be able to use the life cycle cost (LCC) analysis method to comprehensively weigh the relationship between initial investment and operation energy consumption in equipment selection, scientifically judge the economic rationality of the “high energy efficiency, high initial investment” scheme, and quantify the carbon emission reduction benefits.

System optimization capability: Based on the principles of heat transfer and engineering economics, the dynamic trade-off model of insulation thickness and heat loss can be established to find the optimal economic insulation thickness and realize the balanced allocation of materials and energy.

Operation and maintenance management ability: be able to use the equipment performance degradation law and fault data, and use the marginal cost analysis method to formulate the optimal preventive maintenance plan, and accurately determine the economic life of the equipment and the optimal scrapping and updating time.

3.2 Three Value Dimensions

Idea reconstruction needs to visualize the abstract “value” into three measurable and teachable dimensions:

Economic value dimension: full life cycle cost (LCC) analysis is introduced, covering initial investment, operation cost, maintenance cost (MC), failure cost and residual value. Cultivate students’ ability of “cost awareness” and “investment return analysis”.

Environmental value dimension: introduce carbon emission accounting and resource consumption accounting. During the teaching process, students are required to calculate the implied carbon and operating carbon of the equipment system, and understand the scarcity value of resources (water, metal, refrigerant, etc.). According to the latest research report, the greenhouse gas emission of refrigerants in the construction field has become an important concern. The new topic “greenhouse gas emission of refrigerants in residential buildings” provides new teaching content for the equipment course.

Functional value dimension: the fundamental value of the equipment system is to provide a comfortable, healthy and safe building environment. The course needs to teach the equipment performance attenuation curve and how to maintain the functional value through management means.

3.3 Five Stage Value System

The curriculum knowledge system is no longer cut horizontally according to “HVAC, water supply and drainage, and electrical”, but is connected in series according to the longitudinal stages of the whole life cycle of the building, with the flow of resource value as the main line. Through this reconstruction, the curriculum has formed a knowledge series of “vertical connection and horizontal integration”, so that students can be related to their value orientation in the whole life cycle when learning each technical principle.

Table 1. Five Stage Value System

Life cycle phase	Core teaching content from the perspective of resource value	Weak links in traditional textbook
design phase	Equipment selection optimization based on LCC; BIM based pipeline synthesis and material consumption control; Design for recyclability	Lack of economic evaluation methods; Neglect of material waste
construction stage	Carbon emission accounting of equipment transportation; Resource loss management during on-site installation; Finished product protection and value preservation	Almost blank; Students mistakenly believe that construction has nothing to do with design
Commissioning phase	Equipment performance verification and energy efficiency benchmark setting; Water system	Only a brief reference to “commissioning” without

	balance debugging and energy waste control	emphasizing its value
Operation and maintenance stage	Equipment energy efficiency monitoring and diagnosis; Preventive maintenance and replacement strategy (based on bathtub curve); Energy trusteeship and contract energy management business model	Very little space; Lack of dynamic data analysis
Scrap stage	Equipment residual life assessment; Dismantling and high-value recycling of waste equipment and materials; Refrigerant recovery and treatment	Basically no relevant content; Students lack awareness of circular economy

4. Reconstruction and Design of Teaching Content System

Based on the above ideas, this study rearranged the syllabus of the course of building equipment. Taking 32 class hours (24 theory+8 practice) as an example, a three-level progressive content system of "basic theory module - value analysis module - full cycle actual combat module" is constructed. The unit teaching contents are shown in Table 2:

Table 2. Curriculum Content System

Week	Hours	Module	Unit Theme	Core Teaching Content	Type
1	2	Fundamental Theory	Equipment Principle & Resource Composition	Internal structure of air conditioning chiller; key resources (copper, aluminum, refrigerant) and environmental costs	Lecture
2	2	Fundamental Theory	Load Calculation & Carbon Correlation	Principles of load calculation; simulation of building envelope impact on carbon emissions	Lecture
3	2	Fundamental Theory	Water Supply & Drainage Systems & Water Conservation Value	Pump principles, water resource value, water-saving fixtures	Lecture

Week	Hours	Module	Unit Theme	Core Teaching Content	Type
4	2	Fundamental Theory	Electrical Systems & Energy Efficiency Management	Transformers, motor energy efficiency, power factor, and losses	Lecture
5	2	Value Analysis	Fundamentals of LCC Analysis	Net present value, discount rate, annual value; LCC calculation for equipment selection	Theory+Pratice
6	2	Value Analysis	LCC Sensitivity Analysis	Impact of electricity price and interest rate changes on decisions; graphical analysis	Practice
7	2	Value Analysis	Carbon Emission Accounting	Embodied carbon and operational carbon, emission factor method, GB/T 51366	Lecture
8	2	Value Analysis	Carbon Footprint Calculation Practice	Lifecycle carbon footprint calculation of a fan coil unit	Practice
9	2	Value Analysis	Equipment Residual Value Assessment	Depreciation methods, technological obsolescence, economic life judgment	Theory+ Case Study
10	2	Full Lifecycle Practice	BIM & Bill of Materials	Extracting BOM from BIM model, pipeline integration optimization to reduce waste	Theory+ Computer Lab
11	2	Full Lifecycle Practice	Digital Twin & Operation & Maintenance	BAS/BMS systems, fault diagnosis using sensor data	Theory+ Demonstration

Week	Hours	Module	Unit Theme	Core Teaching Content	Type
12	2	Full Lifecycle Practice	VR Equipment Disassembly & Recycling	Virtual disassembly, identification of recyclable materials, refrigerant handling	Practice
13	2	Full Lifecycle Practice	Comprehensive Case Study (I)	Presentation on LCC comparative analysis of equipment selection	Seminar
14	2	Full Lifecycle Practice	Comprehensive Case Study (II)	Presentation on O&M decisions and replacement/end-of-life plans	Seminar
15	2	Assessment	Course Design Presentation	Group project presentation and peer review	Assessment
16	2	Assessment	Course Summary & Feedback	Knowledge review, assessment feedback, course feedback	

In the first 4 weeks of this course system, the basic theory is consolidated and the value gene is injected; In the middle four weeks, we concentrated on teaching LCC, carbon emissions and residual value; In the next 8 weeks, the full cycle actual combat was carried out around digital technologies such as BIM, digital twins and VR. Present a three-tier progressive model of theory tool practice.

5. Teaching Practice Innovation Strategy

The reconstruction of ideas and contents must be implemented through specific teaching practice. According to the characteristics of the course "construction equipment", this study implemented a set of teaching practice strategies of "project driven, virtual and real combination, multiple evaluation".

5.1 "Full Cycle Simulation" Teaching Method Based on Real Projects

The course takes "the whole life cycle management of building equipment system in a small office building" as the main project, and runs through the whole semester.

Role play: students act as "designer", "constructor", "operator" and "owner" in groups. Switch roles at different stages and understand the different definitions of "value" by different stakeholders. In the real project situation, students are forced to comprehensively use technology, economy and management knowledge, and deeply realize the far-reaching impact of “design decision” on “operation and maintenance cost”.

5.2 Interdisciplinary Collaborative Design Workshop

Building equipment system is closely related to architecture, structure and interior design. Introduction of interdisciplinary workshops:

Participate in the practical case project with the school of architecture. The equipment specialty puts forward the requirements for the space occupied by the equipment, and the architecture specialty optimizes the space. The two sides play a game to find the balance point of “building beauty, space utilization rate and equipment energy efficiency”.

Through a real case project, the company cooperates with the engineering management specialty to build a five stage full life cycle cost monitoring system of “decision-making - Design - Construction - operation and maintenance - demolition and recycling”, and innovatively adopts the “economy+environment” two-dimensional cost control mode.

6. Teaching Practice Cases and Results

In the course teaching practice, the following teaching links are designed based on the teaching case of Zhengzhou JK prefabricated building project developed by the school of management, Xi’an University of architecture and technology, and the equipment life cycle management practice of Shanghai highway and Bridge Group in municipal road construction

6.1 LCC Decision Simulation of Equipment Selection

Referring to the five-stage framework of Zhengzhou JK project “decision-making - Design - Construction - operation and maintenance - demolition and recycling”, students are required to complete LCC comparative analysis of two equipment schemes for a given construction project. Students need to consider the following factors:

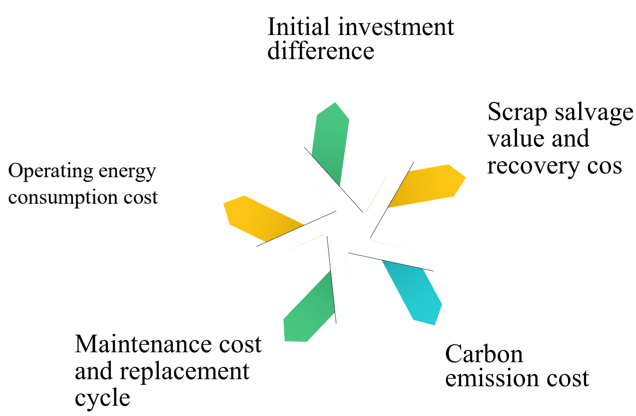

Figure 1. LCC Comparison Elements

6.2 Simulation of Optimal Scheduling of Construction Equipment

With reference to the “efficiency cost double objective optimization algorithm” in the case of municipal road construction, students are grouped to simulate the scheduling decision of construction equipment. Through the construction of a two-dimensional collaborative system of “logistics support economic control”, the equipment configuration scheme is optimized, and the changes of equipment utilization rate, idle rate and total cost are calculated.

6.3 Life Extension Decision of Existing Construction Equipment

Referring to the research case of Platt college on the extension of the life cycle of existing building facilities, students analyze the remaining life and performance degradation of a building equipment system that has been operating for 15 years, and make decisions on whether to replace, when to replace, and how to carry out preventive maintenance.

7. Conclusion and Prospect

Aiming at the problem of “emphasizing design over operation, emphasizing technology over value” existing in the traditional course of “building equipment”, this study introduces the theory of resource value management in the whole life cycle, and carries out systematic reconstruction and teaching practice of the course. Through the teaching practice verification of 32 class hours in 2024-2025 academic year, combined with the reform experience of brother colleges, the following research conclusions are formed.

7.1 Concept Innovation Is the Core Breakthrough of Curriculum Reform

This study established the core concept of “optimal value of resources in the whole life cycle”, and promoted the teaching goal from “training technicians” to “training value managers”. This change has achieved remarkable results in Teaching: more than 90% of the students reported that their understanding of the equipment system was no longer at the technical level, they began to actively focus on the value trade-off between the economic and environmental dimensions, and were able to use LCC tools to make decisions. The reconstruction of the concept level effectively touches the students’ cognition and injects the interdisciplinary connotation of resource value management into engineering courses.

7.2 Content Reconstruction Is the Key to Curriculum Reform

The research broke the traditional knowledge structure divided by equipment types, and established a value stream knowledge system of “design construction commissioning operation and maintenance scrapping” five stages, filling the blank of traditional teaching materials in operation and maintenance management and circular economy. Teaching practice shows that 85% of the students have learned to use LCC tools for decision-making, and they can actively query energy efficiency data, market recycling prices and other information when selecting equipment, forming a habit of life-cycle value assessment. The course has built a BIM based equipment life cycle teaching case library, developed LCC Analysis spreadsheet templates and teaching instructions, and provided solid resource support for content reconstruction.

7.3 Practice Orientation Is an Effective Path for Curriculum Implementation

Through real project driven, interdisciplinary collaboration, digital simulation and other teaching strategies, students' systematic thinking ability and sustainable development literacy are effectively improved. Learning from the teaching reform experience of Shandong Urban Construction Vocational College, Hubei Urban Construction Vocational and technical college, Xi'an University of architecture and technology and other colleges, the course practice fully proves that the deep integration of digital technology (BIM, digital twin, VR) and full life cycle value management can significantly improve the practicality and cutting edge of teaching.

7.4 The Reform Has Achieved Remarkable Results and Is Worth Popularizing

The reform direction of this course is highly consistent with the development trend of the industry. Taking the construction equipment specialty group of Shandong Urban Construction Vocational College as an example, it has won 6 national awards and more than 30 provincial awards in the skills competition of Vocational Colleges in the past five years, with an average professional counterpart employment rate of more than 90% and enterprise satisfaction of more than 95%. Its BIM technology and application course has been rated as a national on-line excellent course. These results show that the curriculum reform based on the full life cycle resource value management can effectively improve the quality of talent training, and has good promotion value.

In the process of reform, it also faces challenges such as high requirements for teachers' multidisciplinary background, large investment in teaching resources, and great difficulty in evaluation standardization. Looking forward to the future, the curriculum reform can be deepened in the following directions: first, digital upgrading, introducing AI technology to achieve equipment failure prediction and energy efficiency optimization; Second, international benchmarking, the introduction of ISO 14040 standards and LEED, BREEAM and other green building certification systems; The third is the deep integration of production and education, and the establishment of the "school enterprise dual tutor" system; Fourth, deepen the content of carbon accounting, and timely follow up the frontier research results such as refrigerant emissions.

In a word, the reconstruction of construction equipment course based on the full life cycle resource value management is not only an innovation of teaching content and methods, but also a remodeling of engineering education values. It urges future engineers to keep the resource account, economic account and environmental account of the whole life cycle of the building in mind when designing drawings, which is the proper meaning of cultivating outstanding engineers with a sense of responsibility for sustainable development under the background of new engineering construction.

References

China Building Energy Efficiency Association. Research Report on carbon emissions in the field of urban and rural construction in China (2025). (2026). Beijing: China Construction Industry Press.

Guan, Z. D. (2025). Research on equipment life cycle management and economic optimization in asphalt construction of municipal roads. *urban roads and bridges and flood control*, (11), 274-277.

Hubei Urban Construction Vocational and technical college. Drive the class to the construction site! Teachers and students' immersive experience of "robot building". (2025). *China Education online*.

ISO 14040: 2006 Environmental management- Life cycle assessment - Principles and framework. (2006). Geneva: International Organization for Standardization.

Li, L. Y. et al. (2025). *Create a full cycle cost monitoring system to lead the cost reduction and efficiency increase of prefabricated buildings - Taking Zhengzhou JK project as an example*. MEM case library of China professional degree case center.

Liu, P. P., Zhang, J Q., & Qiao, L. M. (2025). Research on teaching reform of construction equipment based on Ideological and political construction of curriculum. *university education*, *2025*(15).

Ministry of housing and urban rural. development Gb/t 51366-2019 building carbon emission calculation standard. (2019). Beijing: China Construction Industry Press.

Safin, W. (2025). *Extending the Life Cycle of an Existing Facility*. Pratt Institute.

Shandong Urban Construction Vocational College. Innovative practice of the practical teaching system of "three floors and five levels · all around connection" in the construction equipment specialty group. (2025). Shandong education network.