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THE CONSTRUCTION OF "OPERATIONS RESEARCH" CURRICULUM SYSTEM FOR MANAGEMENT SCIENCE MAJORS UNDER THE PERSPECTIVE OF NEW BUSINESS

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Abstract: With the extensive penetration of data and intelligent technology in the field of management science and engineering, the application of operations research in supply chain optimization, service operation, platform scheduling, finance and risk management, public management and other scenarios has become more and more in-depth. The undergraduate majors of management science in various universities generally offer the course of "operations research (or management operations research)". However, due to the high degree of interdisciplinary, theoretical and algorithmic nature of the course, the large number of contents, and the great dependence on practical tools, it is necessary to construct a course system that matches the course objectives and learning conditions. This paper takes “basic concepts and theories, practical training, industry applications” as the overall framework, focuses on the concepts and theories of the module's content selection and organization, and proposes a combination of classroom teaching, practical interspersed with post-course expansion of the teaching method. It is also emphasized that the course system should be optimized based on the technology development trend, students' background and learning feedback, in order to ensure the systematicity, applicability and effectiveness of the course.
Keywords: Operations research; Curriculum system construction; Management science; Teaching reform

1 INTRODUCTION

Operations research takes resource optimization and scientific decision-making under uncertainty as its core methodology and is the key foundation for supporting digital and intelligent operations of organizations. In order to meet the industry's demand for complex, data-driven operations and analysis talents, college management science majors have successively set up relevant courses to strengthen students' modeling analysis, computational experiments and decision-making capabilities. The quality of courses is directly related to the quality of talent training[1]. However, operations research originates from the intersection of multiple disciplines such as mathematics, computer science, economics and management science. Its content covers multiple areas such as deterministic optimization, random models, simulation and decision analysis, and is both abstract and practical. For undergraduate students in management science, they usually have a certain foundation in advanced mathematics, linear algebra and probability statistics, but there are differences in programming ability, data literacy and algorithm intuition; there are learning difficulties in abstract modeling, uncertainty thinking, and the connection between theory and software; due to the limited class time, the selection of teaching content and hierarchical design are particularly critical.
Based on the OBE concept, curriculum values, knowledge-competence-literacy objectives, and student learning dynamics, this article proposes a curriculum framework characterized by "basic concepts and theory as the foundation, practical training as the support, and industry application as the final destination." These three elements intertwine and permeate each other: theory provides paradigms and tools for practice and application, practice feeds back into theoretical understanding and forms methodological intuition, and application drives topic selection and ability transfer. Within this framework, this article proposes development strategies and corresponding teaching methods.

2 CURRICULUM CONCEPTS AND RELATED THEORIES

From the nature of the course, "operations research" emphasizes the comprehensive application of operational thinking, modeling paradigms and optimization/decision-making techniques. Management science majors generally do not have a deep optimization principle course. Students have uneven foundations in optimization algorithm mechanisms, random processes and numerical calculations. Without key concepts and basic principles, subsequent software solutions, case analysis and industry applications are difficult to carry out effectively. Therefore, the early basic concepts and theoretical teaching are indispensable and need to serve the subsequent practical training and application scenarios, reflecting the systematicness and practicality of the course system[2]. It is recommended to collaboratively complete the concept and theory modules from the following three approaches:

2.1 Core Concepts and Basic Theories Systematically Taught in Class

Aimed at all students, based on the principles of "sufficient, transferable, and explainable", the course selects core content that must be firmly established, emphasizes modeling paradigms, structural insights, and result interpretation, and focuses on intuitiveness and examples in algorithmic details, avoiding excessive proof stacking.

2.1.1 Operations research thinking and modeling paradigm

(1) Decision variable-objective function-constraint ternary structure; data-model-algorithm-decision closed loop.

(2) Ways to characterize deterministic and uncertain problems, including two paradigms: parameterization and data-driven.

(3) Model simplification and effectiveness, interpretability and robustness, case verification and sensitivity analysis.

2.1.2 Linear programming (lp) and duality/sensitivity

(1) Standardized modeling: typical structures such as resource allocation, production planning, transportation/assignment, etc.

(2) Dual problems and shadow prices, constraint tightness/redundancy determination, and the role of sensitivity analysis in managerial explanations.

(3) Comparison of the intuitive mechanism and computational experiments of the simplex method and the interior point method (without going into the proof in detail).

2.1.3 Integer programming and network optimization (mip/graph optimization)

(1) 0-1 modeling expression skills: logic, confidence interval selection, piecewise function linearization, balance/conflict constraints.

(2) The basic idea of branch and bound/cut plane and the behavior of the solver are intuitive.

(3) Classic models such as network flow, shortest path, minimum spanning tree, matching/assignment and their management significance.

2.1.4 Stochastic operations and basic team survival model

(1) Review of probability and Markov chains, Little’s law and its verifiability.

(2) Performance indicators and parameter sensitivity of basic queuing models (M/M/1, M/M/c).

(3) Structural intuition of inventory management (EOQ, (s,S)) and service level/cost trade-offs.

2.1.5 Introduction to simulation and simulation optimization

(1) Event scheduling, randomized experiments, variance control, and result interpretation; the role of simulation in difficult-to-analyze systems.

(2) Simulation optimization: first simulate and obtain data, then optimize the decision; or find the best solution in the simulation loop.

2.2 Key Theoretical Points and Methodological Intuitions Interspersed with Practice

Theory is embedded in tool and case studies, and visualization and experimental tasks build intuition for methods, avoiding a crammed approach. Modeling and problem-solving demonstrations using tools like Excel Solver, Python (PuLP /OR-Tools/ Gurobi), R, and LINGO are presented alongside explanations of dual prices, sensitivity intervals, branch-and-bound trajectories, and cutting plane effects. Students are guided to independently verify their conclusions using small-scale data. Core propositions are validated using reproducible experiments, such as verifying Little's law with simulation data, adjusting parameters to observe the service level-cost trade-off, and testing policy robustness against perturbations in the input distribution. Classroom activities are designed to be driven by "micro-projects": 5-10 minute instant modeling exercises, real-time voting and discussion, and model debugging using a blackboard/projector interface to promote collaborative development and error correction.

After-class expansion and follow-up learning in cutting-edge directions:

Emphasize independent learning outside the classroom, focus on technological evolution and industry needs, and form a cycle of theory- practice -application. This section can include the following content.

(1) Introduction to cutting-edge topics: Data-driven optimization (from prediction to decision/PO to DO), distributed robust optimization, application of reinforcement learning in dynamic scheduling and inventory, simulation optimization and metaheuristics, sustainable and low-carbon operation optimization, and mechanism design in platform economy.

(2) Industry branch cases: supply chain and logistics, service operations and human resource scheduling, medical and public services, finance and risk, energy and transportation[3].

(3) Formative assignments: reading reports/short essays on selected topics, case-based experiments, and modeling and replication of open-source data; students are encouraged to participate in mathematical modeling/operations research competitions to promote learning through competitions and teaching through research.

To ensure that the top-level course design resonates with the "basic concepts - practical training - industry application" framework and better aligns with the Chinese economic management context and the new business education goals, this paper introduces a holistic design approach centered on student development in teaching organization, serving as a supporting approach to connecting objectives, content, methods, and evaluation. This approach emphasizes starting from real management problems, using reproducible computational experiments and explainable management language to achieve a closed loop "from data to decision-making", and using an OBE approach to ensure the gradual alignment of training objectives with teaching implementation and effectiveness evaluation.

In developing and designing the curriculum, we prioritized the context and practice of Chinese economic management, embodying the strengths of the new business discipline: interdisciplinary, internally integrated, and balanced between the arts and sciences. Focusing on addressing key teaching challenges, the course team constructed a student-centered, development-focused "One Body, Two Wings, and Three Auxiliary" curriculum design framework.

Illustration:
(1) Integration: Focusing on improving students' practical ability
Under the OBE concept, the course objectives are focused on improving students' practical ability, especially the ability to apply operations research in actual decision-making. The syllabus is reversely designed to ensure that all teaching activities and assessments revolve around this core goal.
(2) Two wings: combining theory with practice
In terms of theoretical learning, the course content will cover the basic theories of operations research, such as linear programming, integer programming, transportation problems, etc. Through a concise theoretical framework, students will be able to master the basic concepts and methods of operations research. In terms of practical application, students will be enhanced in practical application by combining actual cases and projects. For example, by introducing practical problems such as logistics optimization and production scheduling, students will learn how to apply theoretical knowledge to solve complex practical problems[4]. At the same time, students are encouraged to use data analysis tools (such as management operations research, Excel, MATLAB, etc.) for simulation and optimization to improve their hands-on ability.
(3) Three aids: multi-faceted support for student learning
In classroom teaching, teachers will promote students' active participation through group discussions, case analysis, etc. Breaking the traditional one-way teaching model, the classroom becomes a place for teacher-student interaction, encouraging students to raise questions and opinions, and enhancing their sense of participation in learning.
(IV) Teaching methods and evaluation suggestions
There are many teaching methods: blackboard writing + case deduction, demonstration software experiments, flipped classroom micro-videos and in-class tests; emphasis is placed on "few but good" examples and explainable conclusions.
In terms of learning evaluation, the following forms are combined according to the hours and the categories of the courses in the major: basic concept test (closed book/open book mixed) + modeling homework (including interpretation of duality and sensitivity) + concept experiment report (verification of Little's law/parameter sensitivity) + cutting-edge review essay; the weight of process assessment is not less than the final assessment, highlighting the ability of continuous learning and reflection[5].
Course concepts and theoretical modules provide a solid foundation for practical training and complement the contextualized case studies of industry applications. Throughout the course, the focus and depth of instruction will be continuously revised based on student feedback, problem-solving performance, and application transferability, combined with technological developments and industry needs, to ensure the integrity, systematicity, and iterative nature of the curriculum.

3 PRACTICAL SUPPORT

Practical training is the core and key link of the "Operations Research" curriculum system for management science majors. If students cannot truly master the basic techniques and methods of modeling and solving, it is impossible to apply them to complex decision-making problems in management and engineering scenarios[6]. Compared with abstract theories, practice can enable students to intuitively perceive "the structure of the model, the effectiveness of the algorithm and the interpretability of the conclusion", and form a closed-loop capability of "from problem to model, from data to decision". Therefore, the practical part of this course should not only cover the basic operations of tools and methods, but also highlight the whole process of modeling paradigm, computational experiments and industry implementation.

3.1 Modular Design and Advancement Rhythm of Practice Content

To adapt to the learning pace of students with different foundations and majors, we recommend adopting a progressive structure of "tool introduction - micro-task training - computational experiments - comprehensive cases - project practice", which is consistent and step-by-step. Specifically, it includes:
(1) Tool introduction and environment configuration: Based on Excel Solver/open solvers (such as Python+OR-Tools /open source MILP solvers), commercial solvers (such as Gurobi /CPLEX, teaching licenses can be provided if conditions permit), R or Julia (JuMP) and other multi-tool parallel tools, help students establish the programming expression habit of variables-constraints-goals; guide students to become familiar with the solver interface, modeling syntax, log information, common parameters (such as MIP Gap, time limit, Cuts/Heuristics switch) and result export and visualization methods; supplement simulation tools (such as Python-based event-driven simulation library) and decision analysis drawing tools to form a complete tool chain.
(2) Micro-task training (reinforce methodological intuition with "short, simple, and fast" problems): Design "get-started" tasks that can be completed within 1-2 hours, centering on core topics such as linear programming, integer programming, network optimization, basic nonlinearity, queuing and inventory, simulation, and decision analysis. Each micro-task includes a problem description, a data set, modeling prompts, expected outputs, and reflection questions, emphasizing the minimum closed loop of "reproducibility" and "explainability."
(3) Computational experiments and result interpretation: Students are systematically guided to conduct parameter sensitivity analysis, scenario analysis, robustness test, interpretation of dual price and shadow price, branch and bound process observation and comparative experiments (such as cutting strategy opening/closing, gap and time trade-off),

simulation repeated experiments and confidence interval estimation, etc.; students are required to follow the experimental report specifications, including experimental design, variables and indicators, result presentation, insights and suggestions, limitations and follow-up plans.
(4) Comprehensive case study: Students work in groups and select one or two complete cases from the case library provided by the teacher (such as site selection and network design, production and scheduling, service scheduling and capacity configuration, inventory strategy and agreement design, price and revenue management, etc.), and complete the end-to-end process from business understanding, data preparation, model building, solution and parameter adjustment, verification and communication.
(5) Project practice and results presentation: Based on real or near-real data, the course project is completed using the method of "problem collection - project review - mid-term inspection - final defense", and a standardized technical report, a reproducible code repository and manager demonstration materials are produced, which are then defended in class and reviewed by peers.

3.2 Typical Microtasks and Practical Topics

Based on talent cultivation goals, the practical themes of operations research courses can be categorized and set according to professional requirements. This article uses applied undergraduate institutions as an example to highlight the needs of the times and reflect the characteristics of digital talent cultivation . The practical themes are as follows.
(1) Linear programming foundation and duality/sensitivity: transportation and assignment problems (data balanced and unbalanced scenarios), production batching and cost minimization; guiding students to read “shadow prices” from dual variables, explaining resource scarcity and marginal value; completing sensitivity interval verification by changing the right-hand side term and cost coefficient.
(2) Integer programming modeling skills: 0-1 logical constraints, mutual exclusion/implication, piecewise linearization, time windows and ordinal relationship modeling; typical problems include facility location, project portfolio, workshop sequence and changeover, packing and cutting, etc.; observe the impact of branch and bound tree size and parameter settings.
(3) Network optimization: shortest path, minimum cost maximum flow, matching and assignment, Steiner approximation, etc.; emphasize the versatility of network flow in supply-demand balance, capital and information flow.
(4) Basic nonlinear and convex optimization intuition: convex costs of capacity expansion, concave returns of price-demand, and management interpretation of KKT conditions; practice linearization/convexification strategies and identification of local-global optima.
(5) Queuing and Simulation: Comparison of the performance indicators of M/M/1 and M/M/c by calculation and simulation to verify Little's law; design of experiments on arrival rate and service rate to observe the critical point of congestion and fluctuation effect; and optimization based on simulation to search for the approximate optimal solution for the number of service stations.

3.3 Evaluation Mechanism and Learning Support

With the OBE orientation, we ensure the step-by-step alignment of training objectives with teaching implementation and effectiveness evaluation, and set up the following evaluation methods.
(1) Process evaluation: experimental report (including sensitivity/robustness analysis), micro-project achievement, classroom quizzes and peer evaluation, learning log and reflection, recommended proportion $\geq$ 50%.
(2) Final evaluation: Comprehensive project quality, defense performance, and engineering standards (code readability, version management, and result visualization).
(3) Layering and mutual assistance: Provide "Basic Edition/Challenge Edition" dual-track tasks, set up office hours for learning partners and teaching assistants; provide template scaffolding for students with weak programming foundation.
(4) Resources and Environment: Build a cloud-based solution environment and mirror to reduce configuration costs; establish a question bank and FAQ for continuous iteration.
(5) Competition and Certification: Organize students to participate in mathematical modeling/operational research competitions and case challenges, which will be recognized as course bonus points or alternative assessments; issue micro-certificates such as "Excellent Computational Experiments" and "Excellent Engineering Practices" as incentives.
Through serialized and layered practical training, students can repeatedly hone the core capabilities of "digital talents" in the digital age in real or near-real problems, which not only enhances the internalization and transfer of theories, but also lays a solid technical foundation for industry implementation.

4 APPLICATION AND DEVELOPMENT TREND OF OPERATIONS RESEARCH IN MANAGEMENT SCIENCE

In the context of the digital economy and intelligent operations, operations research, with its core focus on optimization and decision-making methods, has become a key tool for improving quality and efficiency, reducing costs and emissions, and mitigating risks across all industries. For students majoring in management science, the curriculum must emphasize field applications and demonstrate a closed-loop capability from problem to model, from data to decision. Teaching should be structured around a "typical scenario-driven + project-based practice" approach, supplemented by industry lectures and visits, to help students develop interdisciplinary cognitive maps and professional competencies.

4.1 Typical Industry Application Scenarios and Key Points

(1) Supply chain and logistics network optimization
Application content: Facility site selection and hierarchical network design, capacity layout and flexibility strategy, trunk and branch line coordinated transportation, inventory-transportation integration, reverse logistics and closed-loop supply chain[7].
Key points of corresponding operations research methods: mixed integer programming, network flow and decomposition algorithms (such as Benders' idea), multi-objective trade-offs (cost-service-carbon emissions), scenario planning and robust optimization; support "flexible supply chain" decision-making through sensitivity analysis and scenario design.
(2) Production and operation management
Application content: batch and single-piece flow, changeover and parallel machine scheduling, bottleneck identification and buffer configuration, constraint synchronization and beat optimization, production and sales collaboration and master production planning.
Key points of the corresponding operations research methods: combining heuristics and metaheuristics with mathematical programming, simulation-optimization iteration, and constraint programming to express complex process constraints; emphasizing feasible scheduling and schedule generation.
(3) Service operation and manpower scheduling
Application content: multi-skill service desk configuration, appointment and arrival management, time-based scheduling and shifts, fairness constraints and incentive mechanisms.
Key points of the corresponding operations research methods: linkage of demand forecasting, capacity planning, and scheduling optimization, queue model and simulation evaluation of service levels, chance constraints/robust handling of uncertain arrivals, and combining integer programming with local search to improve feasibility and efficiency.
(4) Marketing and revenue management
Application content: dynamic pricing and quota control, promotion and inventory linkage, product portfolio and display optimization, and cross-channel coordination.
Key points of corresponding operations research methods: joint optimization of demand elasticity estimation and pricing-quota, multi-objective (revenue -experience-brand) trade-offs, A/B experiments and causal inference to support strategy evaluation.
(5) Public management and emergency dispatch
Application content: Emergency resource pre-positioning and rapid response, public facility layout and equitable accessibility, post-disaster recovery and phased resource allocation.
Key points of corresponding operations research methods: multi-objective and fairness measurement, robust and online optimization, simulation and deduction, and digital twin-assisted solution coordination.
(6) Energy system and dual carbon governance
Application content: Coordinated optimization of sources, grids, loads and storage, demand response and peak-valley shifting, carbon quotas and emission reduction paths, and uncertain output absorption of renewable energy.
The key points of the corresponding operations research methods are: stochastic optimization, robust optimization and decomposition and coordination, incorporating carbon costs and environmental constraints, and carrying out multi-scenario simulation-optimization linkage.
(7) Platform Economy and Algorithm Governance
Application content: matching, allocation and incentive mechanisms, supply and demand bilateral pricing, rider/driver scheduling and rebalancing, quality and compliance management.
Key points of the corresponding operations research methods: online optimization and reinforcement learning, mechanism design and game equilibrium, constrained optimization and explainability; emphasis on real-time and fairness.

4.2 Applied Path of Teaching Implementation

Case teaching is organized along the main line of "problem-data-model-decision", first clarifying business goals and constraints, then matching model families with solution strategies, and finally outputting executable suggestions in management language. The combination of "multiple cases and small incisions" classroom exercises and "few but fine, deeply polished" semester projects ensures both coverage and representative results. A joint school-enterprise question bank is established, and enterprise mentors are invited to co-build projects, providing real data or desensitized data, and organizing mid-term reviews and final roadshows. Additional industry lectures and practical visits are offered, such as to supply chain centers, call centers, hospital operations departments, energy dispatch centers, etc., to allow students to understand the role and boundaries of models in "visible systems."

4.3 Cutting-Edge Trends and Capability Transfer

The rapid development of the digital age has brought about trends in several aspects.
(1) Data-driven optimization and decision intelligence. From “post-prediction optimization” to “decision-oriented learning”, the impact of prediction error on optimal decision-making is incorporated into the training objective; distributional robustness and chance constraints are used to ensure the robustness of the strategy in an uncertain

environment[8].
(2) Simulation-Optimization-Digital Twin: Use simulation to build a “trial-and-error” virtual environment in complex systems, and then use simulation optimization to search for strategies; realize program coordination and sandbox simulation in supply chain and emergency management[9].
(3) Low-carbon and sustainable operations: Incorporate carbon costs, energy consumption, and fairness into optimization objectives and constraints, and build a trade-off framework for the three goals of “cost-service-green”.
Practical support and industry application are the two pillars of the operational research curriculum. Practical support strengthens students' modeling and computational experimentation capabilities through systematic, engineering-based, and reproducible training. On-demand application, driven by problems and value, truly embeds methods into business scenarios, forming communicable, executable, and evaluable decision-making solutions[10]. Applied universities must continuously optimize their curriculum based on technological evolution and student feedback, building a high-quality curriculum tailored to the training objectives of management science professionals. This ensures that students can not only "model, calculate, and solve problems," but also "understand the business, articulate value, and implement solutions."

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