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Algorithms for Social Good: Integrating Ethical Values into Combinatorial Optimization through Food Delivery Scheduling

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Abstract: *This paper takes the combinatorial optimization problem in food delivery as an example to conduct a case study on the ideological and political education in the "Combinatorial Optimization" course. By analyzing the food delivery scheduling problem, it enables students to understand the evolution of platform algorithms from "efficiency first" to "multi-party balance" through in-depth analysis, and comprehend the humanistic care and social responsibility behind it, thereby cultivating their systematic thinking and patriotic sentiments.*

Keywords: *Combination Optimization, Ideological and Political Teaching, System thinking*

1. Introduction

Currently, the global landscape is undergoing profound transformations, with the technological revolution and industrial transformation advancing deeply. The competition in comprehensive national strength ultimately boils down to the competition for talent, particularly top-notch innovative talents with excellent professional skills and firm ideals and convictions. Combinatorial optimization research seeks the best mathematical theories and methods for decision-making among discrete or finite choices, and its concepts are widely applied in critical fields related to the national economy and people's livelihoods, such as artificial intelligence, logistics scheduling, integrated circuit design, and financial technology[1]. However, traditional teaching models often focus on model establishment, algorithm derivation, and computational implementation, exhibiting a tendency to "prioritize technique over thought"—that is, overemphasizing instrumental rationality (how to solve) while somewhat neglecting value rationality (why to solve, for whom to solve, and where the ethical boundaries lie). This may lead to students acquiring proficient technical skills but lacking a corresponding sense of social responsibility, historical mission, humanistic care, and systems thinking ability, potentially even resulting in blind worship of technology.

Therefore, the systematic integration of ideological and political elements into the combinatorial optimization curriculum is by no means a simple, rigid political add-on[2]. Rather, it is an essential requirement for deepening the curriculum's own substance and returning to its educational function . It aims to address the disconnect between knowledge impartation and value guidance. While teaching the "techniques of optimization," it also enlightens students on the "principles of optimization," guiding them to understand the worldview and methodology embedded within algorithms, fostering an ambition to serve the nation through science and technology, adhering to rigorous and honest scientific norms, and examining the potential social impacts of technological applications. This is not only an inevitable requirement in response to the national "Curriculum Ideology and Politics" education strategy but also an intrinsic need for the discipline of combinatorial optimization itself to address contemporary challenges and achieve long-term development.

2. Teaching implementation path

In order to effectively transmit ideological and political education elements, meticulous design of teaching procedures is essential. We have explored and practiced the following four integration modes:

Mode 1: Case-Infused Teaching. The teacher selects real-world cases that embody Chinese wisdom and serve national strategies. For instance, when teaching "transportation problems," mathematical models are constructed based on major national initiatives such as the West-East Power Transmission Project and South-to-North Water Diversion Project. Beyond analyzing cost optimization during problem-solving, students are guided to explore the profound significance of such projects in advancing coordinated regional development, safeguarding the security of national strategic resources, and improving people’s wellbeing. This enables them to personally experience the advantage of "nationwide coordination as a unified whole"[3].

Mode 2: Inquiry-Based Problem-Solving Teaching. The teacher designs open-ended topics involving ethical dilemmas and organize classroom discussions. For example, when teaching "scheduling and sequencing," pose the design question: "Resource Scheduling Algorithms in Disaster Relief" — How to balance the urgency of "needs-based allocation" with the fairness of "maximum coverage" under extremely constrained conditions? Students are encouraged to debate from multiple perspectives, including humanitarian ethics, operational feasibility, and social psychology, thereby deepening their understanding of the value-laden nature of engineering and technical solutions[2].

Mode 3: Project-Driven Teaching. The teacher develops group-based practical research projects and encourage students to apply optimization methods to address social realities. Examples include "Optimization of Urban-Rural Public Library Network Layout Based on Coverage Models" and "Design of a Campus Shared Bike Dispatching System Considering Green Commuting." Students engage in the full process—from problem delineation and model construction to algorithm implementation and result presentation. This hands-on experience allows them to perceive the value of professional knowledge in serving social wellbeing and people’s livelihood, while fostering comprehensive capabilities and a sense of social responsibility to solve complex practical issues[4].

Mode 4: Historical Genealogy Teaching. The teacher traces the evolutionary context of key algorithms and ideas, and share stories of prominent scientists. For example, the teacher can introduce the Chinese Postman Problem and the contributions of Chinese mathematician Professor Guan Meigu[5], or recount how Professor Hua Luogeng promoted "optimization methods" and "overall planning methods" by engaging directly with frontline production teams[6]. By integrating the discipline’s developmental history with the life stories of trailblazers, we promote the spirit of scientists—characterized by patriotism, innovation, rigor, dedication, collaboration, and commitment to nurturing talent.

3. Case teaching based on the combinatorial optimization problems in food delivery services

The key to the design of this case is to avoid treating ideological and political education content as an "external add-on module." Instead, by analyzing the core technical thread—the design and evolution of algorithmic objective functions—we naturally reveal the embedded value judgments and ethical choices. By guiding students to think like decision-makers about "how to define objectives," they deeply understand the dialectical unity between technology and society, as well as between efficiency and fairness, thereby achieving the internalization of value guidance.

3.1 Teaching Process and Design for the Integration of Ideological and Political Education

3.1.1 Pre-class Warm-up—Situational Activation

Play a video clip: an excerpt from CCTV's documentary “I Am a Delivery Rider” (highlighting order acceptance, constant rushing around, time pressure, and interactions with customers).

Guiding Questions: “If you were a delivery rider, how would you expect the platform to allocate orders?” “If you were a customer, would you prioritize speed or delivery riders' safety?” Ideological and Political Integration Point: Empathic experience enables students to think from the dual perspectives of laborers and users, laying the foundation for a people-oriented classroom keynote.

3.1.2 Order Selection and Quasi-Newton Model

Session 1: Problem posing

During peak hours, multiple orders from different regions pop up simultaneously on delivery riders' apps—how should they make a choice? The traditional solution is to only select the orders with the highest returns. But what if the highest-return orders are all concentrated in a certain busy downtown area, leaving orders in remote areas unclaimed? The teacher guides students to conduct an ideological and political discussion: What does the "order-waiting period" function—which allows riders to wait for

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more route-convenient orders within a specified period of time—reflect? After students share their opinions, the teacher summarizes: This reflects technology's respect for laborers. It does not treat people like machines, but rather grants them a certain degree of autonomy and buffer space.

Session 2: Modeling and Algorithms

Introduce the matroid model: take "select at most one order per region" as the independence axiom. Further explain the matroid greedy algorithm.

Definition of a Matroid : A matroid is an ordered pair $M = (E, \mathcal{I})$, where: E is a finite set (the set of all orders); $\mathcal{I}$ is a family of subsets of E, satisfying the following two axioms: if $A \in \mathcal{I}$ and $B \subseteq A$, then $B \in \mathcal{I}$; if $\{A, B\} \subseteq \mathcal{I}$ and $|A| < |B|$, then there exists an element $e \in B \setminus A$ such that $A \cup \{e\} \in \mathcal{I}$. In order selection, E = the set of all pending orders and $\mathcal{I}$ = {the family of order subsets where at most one order is selected per region}. This indeed forms a partition matroid (Partition Matroid).

The teacher explains the Matroid Greedy Algorithm in detail. Key Questions to Be Raised Here: Why is the constraint of regional balance necessary? (To avoid resource monopolization and ensure full coverage of services). What principle in the allocation of social resources is this similar to? (Fairness of opportunity and prevention of regional discrimination).

Ideological and Political Integration Point: Algorithms are equivalent to rules, and the design of technical rules embodies value orientations. Fair algorithms can facilitate the rational flow of social resources.

Session 3: Classroom interaction

Suppose you are a product manager. There is an old residential community without elevators, and the order revenue is low, so delivery riders are unwilling to accept orders for this area. How to adjust the dispatching strategy through algorithm rules? The teacher guides students to discuss possible solutions: subsidy weighting, priority dispatching, extended delivery time, etc.

Ideological and political summary: Technology for good is not an empty slogan; it manifests as care for disadvantaged scenarios in trivial details, and technology should warm people's hearts.

Session 4: Practical Application of Specific Issues

The teacher guides students to develop appropriate MATLAB code based on the data in Table 1 to solve the order selection problem.

Table 1: The order situation faced by the rider.

Order Number	District ID	Base Income(Yuan)	Order difficulty coefficient (1-5)	Is it a remote area(0=No/1=Yes)	Time window
1	1	20	1	0	30
2	1	15	4	1	45
3	2	30	2	0	25
4	2	25	3	0	35
5	3	10	5	1	50
6	3	18	2	0	30
7	4	40	1	0	20
8	4	35	3	1	40
9	5	22	4	1	45
10	5	19	2	0	30

Formulated Fair Subsidy Rules: for difficult orders (with a difficulty coefficient of 4 or higher), a subsidy of 8 yuan will be granted; for medium-difficulty orders (with a difficulty coefficient of 3), a subsidy of 4 yuan will be granted. An additional subsidy of 5 yuan will be provided for orders in remote areas.

Matroid Constraint Rules: Only one order can be selected per area, which prevents riders from

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concentrating in a single area and ensures full coverage of services.

The results obtained using MATLAB are shown in Figure 1：

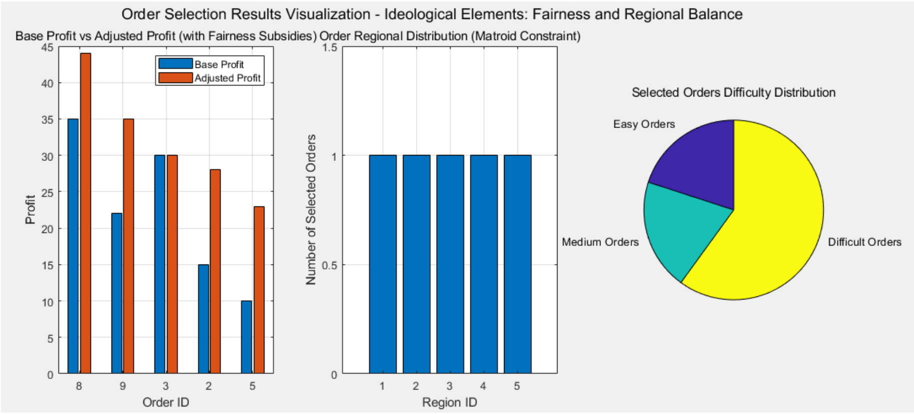

Figure 1: Order selection result visualization.

3.1.3 Path planning and TSP model

Session 1: Problem posing

If a rider has already selected 5 orders, how to plan the shortest route? At this point, the Traveling Salesman Problem (TSP) model is introduced: minimizing the total travel distance. Traveling Salesman Problem (TSP): Given n cities (order points) and the distance $d(i,j)$ between them, find the shortest circuit that visits each city exactly once and returns to the starting point. Mathematical formulation:

$$\min \sum_{i=1}^{n-1} d(\pi(i),\pi(i+1)) + d(\pi(n),\pi(1)) \tag{1}$$

where π is a permutation of the points. Subsequently, the algorithms for solving this problem will be explained in detail.

Session 2: The nearest neighbor algorithm

Algorithm Idea: Starting from the origin point, select the nearest unvisited point as the next destination each time.

Session 3: The safety-prioritized nearest neighbor algorithm

Algorithm Improvement: On the basis of the nearest neighbor method, multi-objective optimization is introduced to balance travel distance and delivery safety.

Objective function：

$$score(i,j) = \frac{safety(i,j)\cdot w_{safety}}{distance(i,j)+\epsilon} \tag{2}$$

Where: $safety(i,j) \in [0,1]$: the safety coefficient from point i to point j; $w_{safety} = 10$: the safety weight coefficient; $\epsilon = 0.1$: a small constant to prevent division by zero.

Algorithm Pseudocode: Similar to the nearest neighbor method, except that the distance comparison is replaced with score comparison.

Integration of Ideological and Political Concepts**:** Translate the value of "safety first" into mathematical weight parameters.

Session 4: Green Path Algorithm

Algorithm Design: Take into account the differences in carbon emissions across different road types and select the route with the minimum total carbon emissions.

Carbon emission model：

$$emission(i,j) = distance(i,j) \times emission\_factor(road\_type(i,j)) \tag{3}$$

Integration of Ideological and Political Concepts: Quantify the concept of "green development" into carbon emission coefficients to guide algorithm decision-making.

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Session 5: Practical Application of Specific Issues

For the 5 selected orders, implement and compare three route planning strategies respectively: Strategy 1 (Efficiency-oriented): The teacher guides students to adopt the nearest neighbor method to plan the shortest route and calculate the total travel distance; Strategy 2 (Humanistic Care-oriented): The teacher guides students to adopt the safety-priority nearest neighbor method for route planning and calculate both the total travel distance and the total safety coefficient; Strategy 3 (Green Development-oriented): The teacher guides students to adopt the low-carbon route algorithm for route planning and calculate both the total travel distance and the total carbon emissions.

Assume the coordinates of the regions corresponding to the five selected orders are listed in Table 2:

Table 2: Regional coordinates.

District ID	X coordinate(km)	Y coordinate(km)
1	10	20
2	30	40
3	18	50
4	25	35
5	40	15

Road Type Matrix (the element in the *i*-th row and *j*-th column represents the type of road from Region *i* to Region *j*; where: 1 = arterial road, 2 = secondary road, 3 = branch road, 0 = self-loop):

$$\begin{matrix} 0 & 2 & 3 & 2 & 3 \\ 2 & 0 & 2 & 1 & 2 \\ 3 & 2 & 0 & 3 & 1 \\ 2 & 1 & 3 & 0 & 2 \\ 3 & 2 & 1 & 2 & 0 \end{matrix} \tag{4}$$

Safety Coefficient Matrix (based on road types; 1.0 indicates the highest level of safety)：

$$\begin{matrix} 0 & 0.9 & 1.0 & 0.9 & 1.0 \\ 0.9 & 0 & 0.9 & 0.8 & 0.9 \\ 1.0 & 0.9 & 0 & 1.0 & 0.8 \\ 0.9 & 0.8 & 1.0 & 0 & 0.9 \\ 1.0 & 0.9 & 0.8 & 0.9 & 0 \end{matrix} \tag{5}$$

Wherein the emission factors are as follows: arterial road: 0.15 kg/km; secondary road: 0.12 kg/km; branch road: 0.08 kg/km.

The results obtained using MATLAB are shown in Figure 2：

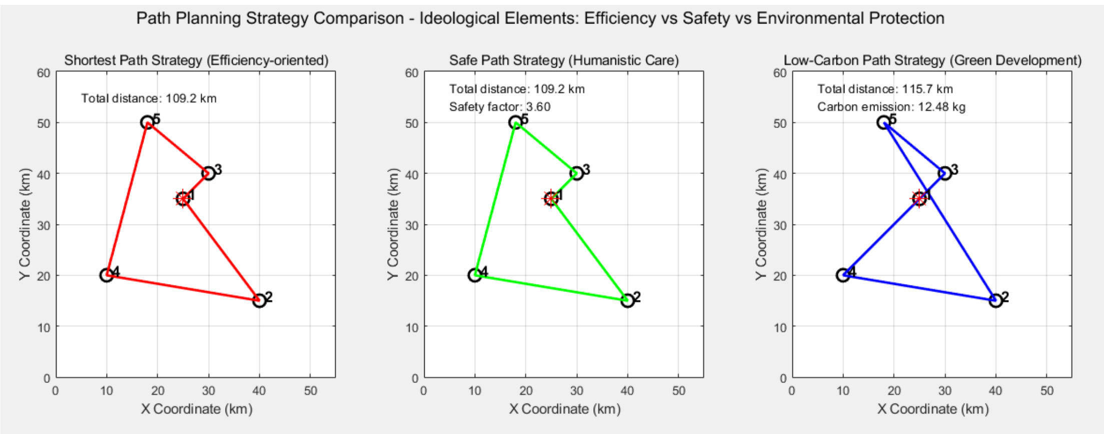

Figure 2: Comparison of path planning strategies

3.2 Classroom debate

Organize students to debate on the motion "Efficiency First or Safety/Green Development First". Pro Side: The food delivery platform industry is highly competitive, and efficiency is vital to survival. Con

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Side: Safety and sustainable development are the only paths to long-term viability.

Teacher's Guidance: How should enterprises balance commercial interests and social responsibilities? A superior algorithm should seek Pareto optimality among multiple objectives.

3.3 Class Summary and Outlook

Knowledge Point Recap: Matroid → Fair Selection; TSP → Efficient Planning; Dynamic Constraints → System Resilience.

Ideological and Political Elevation: One Core Principle: The ultimate goal of all technologies should be centered on people. Two Dimensions: For users: we should provide efficient and reliable services; For laborers: we ought to guarantee a safe, fair, and dignified working environment. Three Capabilities: Technical capability, ethical judgment capability, and system design capability.

4. Conclusion and Prospect

The systematic integration of ideological and political elements into the Combinatorial Optimization course is a teaching reform initiative that boasts both theoretical value and practical significance. It has successfully transformed abstract algorithm models into an education carrier with depth, warmth and breadth, preliminarily achieving the organic unity of knowledge logic and value logic[1]. Practice has shown that such integration can not only effectively enhance students' professional identity and learning motivation, but also imperceptibly shape their correct worldview, outlook on life and values, laying a solid ideological foundation for them to grow into outstanding and responsible scientists and technologists in the future.

Looking ahead, the ideological and political construction of the Combinatorial Optimization course still needs to be continuously deepened in the following aspects: First, build a teaching case resource library with more Chinese characteristics and closer alignment with cutting-edge technologies; second, strengthen interdisciplinary collaboration, and jointly develop interdisciplinary ideological and political teaching modules with teachers from fields such as philosophy, public administration and economics; third, explore the use of digital teaching tools (e.g., ethical algorithm simulation platforms, virtual simulation scenarios) to create more immersive ideological and political teaching situations; fourth, construct a more scientific and long-term tracking and evaluation model for education effectiveness[4].

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