

Collaborative Optimization between Emerging Regional Industries and Local University Disciplines and Majors: Theoretical Models, Practical Challenges, and Implementation Paths

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Abstract: The “15th Five-Year Plan” period is a critical window for regions to cultivate new productive forces and reconstruct a modern industrial system. The structural mismatch between the supply of disciplines and majors in local universities and the demand of emerging industries in the region has become a prominent bottleneck restricting the deep integration of the education chain, talent chain, industrial chain, and innovation chain. Based on the integration of systems theory, synergy theory, and control theory, this study constructs a synergistic optimization model of “layered architecture - three major mechanisms - signal early warning” and uses questionnaires targeting three types of subjects (universities, enterprises, and government) and case studies from three local universities in Guangxi for empirical testing. The study found that the overall degree of synergy in the sampled region is low. Only 24.9% of respondents believed that the synergy between disciplines and majors and emerging industries was “relatively close” or “very close.” The combined percentages of “partially satisfied” and “not very satisfied” talent demand reached 61.4%, and the combined percentages of “few transformations” and “almost no transformations” of scientific research results reached 56.8%. Unreasonable distribution of benefits (62.4%), insufficient intellectual property protection (60.4%), lack of willingness to cooperate (58.9%), and information asymmetry (55.8%) constitute the four core obstacles, which are reinforced by the superposition of institutional, informational, and resource-related obstacles. Case studies show that the resource-based, industry-scenario-based, and discipline-derived models share a common mechanism in the closed loop of “focusing on discipline direction—co-constructing research platforms—producing key achievements—industry supporting disciplines.” Platform co-construction provides the organizational carrier, and talent circulation provides the flow channel. Based on this, a three-way collaborative path is proposed: the government strengthens top-level design and platform supply; universities restructure and dynamically adjust their training systems; and enterprises shift from “talent users” to “training participants.” This provides a regional solution for less developed regions to address the disconnect between industry and education.

Keywords: Emerging regional industries; Academic disciplines; Collaborative optimization; Industry-education integration

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1. Introduction of the problem

A new round of technological revolution and industrial transformation is accelerating, and strategic emerging industries are profoundly reshaping the factor structure and competitive landscape of regional economies. In August 2025, the Central Leading Group for Education Work issued the “Action Plan for Adjusting and Optimizing the Setting of Disciplines and Majors in Higher Education (2025–2027),” which deployed the establishment of six mechanisms and the implementation of six actions, requiring “targeting strategic emerging industries and future industries, and rapidly deploying a number of disciplines and majors”^[1]; the “Outline of the Plan for Building a Strong Education Nation (2024–2035)” also listed “promoting the reform and development of universities in a classified manner” as the core agenda of building a strong education nation^[2]. Disciplines and majors have shifted from the “small logic” of self-development within universities to the “big logic” of serving the country and the region^[3]. However, the speed of policy implementation has not naturally resolved the long-standing problem of the “two skins” between “production” and “education.” In the past two years, the proportion of national discipline and professional point adjustments has exceeded 20%, but the “quantity” of adjustment does not necessarily bring about the “quality” of matching^[3]. Although the coupling between the discipline structure and industrial structure of China’s higher education has approached the level of high-income countries, “the overall attention to the matching of the discipline structure of professional distribution with market demand is insufficient”, and the coupling coordination at the provincial level is also generally “insufficient and unbalanced”^[4–5]. The analysis of 103 typical cases also shows that the enthusiasm of universities to participate in industry-education integration is far higher than that of enterprises, and the lack of cooperation breadth and depth and the absence of a quality evaluation mechanism are prominent shortcomings^[6]. The deep-seated problem lies in the lack of an institutionalized intermediary mechanism that can transmit the industrial demand signal to the discipline and professional point setting in real time.

Guangxi is a typical example. As a late-developing region with the triple characteristics of being bordering, coastal, and facing ASEAN, Guangxi is accelerating the layout of strategic emerging industries such as artificial intelligence, electronic information, and biomedicine. It has also taken the lead in issuing the “Implementation Opinions on Strengthening Standard Guidance and Quality Support to Accelerate the Construction of Guangxi’s Modern Industrial System,” proposing to lead or participate in the formulation and revision of more than 500 international and national standards by 2027^[7]. The rapid upgrading of the industry side and the structural lag in the talent side form a sharp contrast: the expansionary demand of industries for high-precision technical talents, compound talents, and practical talents coexists with the high proportion of traditional disciplines and majors in local universities, the lagging update of course content, and the lengthy adjustment cycle. This makes Guangxi a suitable sample for observing the collaborative dilemmas and breakthrough paths of late-developing regions. Based on this, this study answers three questions: What is the current state and main problems of the collaboration between regional emerging industries and local university disciplines and majors? What core components should the theoretical model that can explain and guide collaborative optimization include? Against the backdrop of the “15th Five-Year Plan,” how should the government, universities, and enterprises divide the work and collaborate to build a long-term mechanism?

2. Literature review and analysis framework

2.1. The two existing research lines and their unresolved aspects

Domestic research has generally followed two lines of thought. The first line focuses on the macro-matching of “structure-structure” and uses models such as coupling coordination degree and grey relational degree to measure the synergy level between discipline structure and industrial structure. The coordination degree and coordination development degree calculation model proposed by Liao Chongbin provides a methodological basis for this, while Wang Shujia et al. have made systematic corrections to the common problems in the use of this model, such as writing errors, missing coefficients, and misuse of weights^[8-9]. Under this framework, Zhao Zhiqiang et al. found that the coupling coordination degree between China’s discipline structure and industrial structure shows a fluctuating upward trend of “rapid at first and slow later,” and Shang Runze et al.’s international comparison further pointed out that “moderately forward-looking planning” is still needed to improve the forward-looking nature of discipline and professional settings^[4, 6]. This line of thought is accurate and highly comparable, but it is difficult to reveal the micro-mechanism and subject behavior of synergy.

Article 2 focuses on the micro-level governance of “subject-mechanism.” Xie Xiaozhen proposed from the perspective of systems theory and holism that the mechanism design of industry-education integration should cover three levels: macro (national industrial system and higher education system), meso (regional industrial cluster and regional discipline cluster), and micro (integrated innovation higher education mechanism)^[10]; Zhuang Xizhen pointed out that the inherent contradictions of industry-education integration need to be resolved through institutional arrangements^[11]; Shi Weiping and Hao Tiancong proposed that the shift from “school-enterprise cooperation” to “industry-education integration” is a shift in thinking in the reform of school management model^[12]; Mao Caisheng et al. introduced the theory of symbiosis to explain the integration path of local applied undergraduate colleges^[13]; recent studies further believe that industry-education integration can empower the development of new productive forces by optimizing the material space of production factors, shaping the social space of school-enterprise cooperation and symbiosis, and creating the spiritual space of industry-education collaborative innovation^[14].

In summary, existing research has three shortcomings: there is a gap between macro-structural measurements and meso- and micro-mechanism analyses; tools such as coupling coordination can characterize “whether there is coordination” but cannot answer “how there is coordination”; research on quantitative methods and decision support tools for the dynamic adjustment of disciplines and specialties is weak, and professional early warnings mostly remain at the level of empirical judgment; and there is a lack of empirical research on specific regional contexts such as less developed regions and ASEAN. This study attempts to make marginal contributions in these three areas.

2.2. Theoretical analysis framework

This study’s framework is built upon the integration of three perspectives: systems theory provides a holistic perspective, requiring that emerging regional industries and local universities be viewed as open, dynamic, and multi-objective complex systems; synergy theory provides an evolutionary perspective, revealing how subsystems can move from disorder to order through self-organization and generate a multiplier effect; and control theory provides an operational perspective, emphasizing the formation of a closed loop through state monitoring, deviation identification, and feedback correction. These three perspectives complement each

other at the analytical level, forming a comprehensive explanatory chain that connects the macro-meta-micro levels (Table 1).

Table 1. Theoretical basis and functional positioning of the collaborative optimization model

Theoretical basis	Core essence	Functional positioning
Systems Theory	Holistic, interconnected, hierarchical, and dynamic	Define system boundaries and hierarchy, and complete goal decomposition and architecture design.
Synergetics	Subsystems interact to generate collective effects, and self-organization enables a transition from disorder to order.	Explain the coupling mechanism between the industry chain and the education chain, and define the order parameter.
Control Theory	Feedback mechanisms and cyclic causality, state monitoring and deviation correction	Provides tools for information sharing, process monitoring, early warning response, and dynamic adjustment.

Meanwhile, this study uses the triple helix theory as a reference for understanding the relationship between multiple subjects. Etzkowitz and Leydesdorff pointed out that universities, industry, and government constitute a triple overlapping institutional domain, and innovation arises from the overlapping areas of the three and the hybrid organizations generated therefrom, which provides a direct explanation for the “hybrid organizations” such as industry colleges and joint laboratories that appear in the case studies below ^[15].

3. Research design

This study employed a hybrid strategy of “theoretical modeling—questionnaire survey—case comparison”: first, a conceptual model was constructed through literature analysis; then, the real-world problems and their relative weights were identified through questionnaires; finally, the explanatory power of the model was tested and differentiated patterns were extracted through multi-case comparisons. The questionnaire was distributed to personnel from universities, enterprises, and relevant government departments within Guangxi Province, covering three dimensions: current status of collaboration, existing problems, and proposed solutions. It was collected online using a combination of single-choice, multiple-choice, and open-ended responses, with a total of 197 valid questionnaires collected. The sample consisted of 49.7% university teachers, 15.7% university administrators, 17.3% enterprise personnel, 12.2% government personnel, and 5.1% from other sectors, covering nine academic disciplines. Limitations to note include: the 65.4% representation of university personnel suggests a stronger “educational” perspective; and the sample was obtained through convenience sampling, so the conclusions should be considered exploratory judgments within a regional context rather than general inferences. The case studies were selected based on the dual principles of “typicality” and “distinctiveness”: Guangxi University’s biology discipline has achieved a leap forward by leveraging its subtropical resources; Guangxi University of Science and Technology’s mechanical engineering discipline has been integrated into the Liuzhou automotive industry cluster, realizing “discipline built on the industrial chain”; and Guangxi Normal University’s education discipline has established a “discipline-industry-governance” chain through the productization of original theories. All three are first-class disciplines in Guangxi and have clear industry alignment goals. The materials were derived from the research team’s field research and publicly available information from the case schools.

4. Current status and problems of collaboration

4.1. The overall level of collaboration is low, and cooperation is mainly superficial

The survey shows that respondents' evaluations were concentrated in the low to medium range: 38.1% rated it as "average," 22.3% as "not very close," and 14.7% as "very not close," while only 13.2% and 11.7% rated it as "relatively close" and "very close," respectively (Table 2). Positive evaluations accounted for about a quarter, while negative evaluations accounted for 37.0%. This is consistent with the national-level measurement conclusion that "the degree of coupling coordination is fluctuating upwards, but the overall level is not high", indicating that the slow improvement of the macro structure has not yet been fully translated into the sense of gain of micro-entities^[5].

Table 2. Evaluation of the degree of synergy between academic disciplines and emerging regional industries

Rating level	Very close	Closer	Generally	Not very close	Very infrequent
Percentage (%)	11.7	13.2	38.1	22.3	14.7

In terms of cooperation models, internships (63.5%), scientific research cooperation (61.4%), and technical consulting (59.9%) ranked first, while joint laboratory construction involving deep organizational embedding accounted for only 20.0%, indicating that collaboration mainly remained at the level of resource exchange and project docking.

4.2. The coexistence of talent supply and demand mismatch and inefficient technology transfer

Regarding the satisfaction of talent needs, "partially satisfied" accounted for the highest percentage at 39.6%, followed by "basically satisfied" at 31.5%, "not quite satisfied" at 21.8%, and "completely satisfied" and "completely dissatisfied" combined at 3.6% (the rest did not explicitly answer). Combining "partially satisfied" and "not quite satisfied" responses, the perceived proportion of a significant gap reached 61.4%, reflecting a triple mismatch in quantity, structure, and quality: the overall supply is still manageable, but the supply in emerging interdisciplinary fields is insufficient, and the fit between practical skills and innovation capabilities is low.

Regarding the commercialization of research results, "few commercializations" accounted for 28.9%, "almost no commercialization" accounted for 27.9%, totaling 56.8%; "basic commercialization" accounted for 21.3%, "partial commercialization" accounted for 15.7%, and "complete commercialization" accounted for only 6.1%. This confirms Xie Xiaozhen's judgment: universities have accumulated a large number of scientific and technological achievements but lack the capital support and commercialization skills for industrialization, while the industry has commercialization capabilities but has shortcomings in technological research and development. The two should be coupled in the dimension of commercialization, but in reality, they are difficult to connect due to the lack of intermediate links^[10].

4.3. Obstacle recognition: The superposition and reinforcement of three types of obstacles

Categorized by nature, the aforementioned obstacles can be divided into three categories: institutional obstacles, namely, unclear rules for property rights definition and benefit distribution, leading to unreliable expectations for cooperation; informational obstacles, namely, the lack of real-time transmission channels for supply and demand signals, creating a two-way blind spot where "enterprises cannot find technology and universities cannot find problems"; and resource obstacles, namely, insufficient continuous supply of

funds and policies, making it difficult for collaboration to cross the critical scale from project cooperation to platform co-construction. These three factors reinforce each other, jointly constituting a “low-level equilibrium trap” for deepening collaboration. The summary of open-ended questions shows that respondents’ countermeasures are concentrated on optimizing professional settings based on market demand (26.4%), establishing long-term cooperation agreements (24.4%), and building regional industry-university-research information platforms (20.3%), with increasing the proportion of internships and practical training (66.7%) listed as the highest priority—this echoes the aforementioned “shallow cooperation,” reflecting insufficient attention to deeper collaboration such as the restructuring of disciplines and the co-construction of platforms (Table 3).

Table 3. Identification of obstacles (multiple choice questions)

Category	Main options	Percentage (%)
Barriers to cooperation	Unfair distribution of benefits	62.4
Barriers to cooperation	Insufficient intellectual property protection	60.4
Barriers to cooperation	Lack of willingness to cooperate	58.9
Barriers to cooperation	Information asymmetry	55.8
Barriers to cooperation	Inadequate cooperation mechanism	53.3
Conversion disorder	Lack of funding	66.0
Conversion disorder	Insufficient intellectual property protection	63.5
Restraining factors	Insufficient funding	62.9
Restraining factors	Insufficient policy support	60.9

5. Guangxi’s practice of collaborative optimization: A comparison of three models

5.1. Resource-dependent type: Biology of Guangxi University

Guangxi boasts the largest subtropical biological resource bank in China, but has long faced a mismatch between its resource advantages and industrial disadvantages. Guangxi University has designated biology as a first-class discipline in Guangxi and proposed a three-step strategy of “resource specialization, cutting-edge research, and high-end industry development,” precisely aligning its disciplinary focus with the region’s emerging industries: synthetic biology with the big health industry, crop genetics and bioinformatics combined with artificial intelligence to serve the smart seed industry, microbiology and enzyme engineering into green manufacturing, and marine biotechnology linked to the Beibu Gulf marine industry.

Its mechanism comprises two aspects: First, a three-pronged platform co-construction mechanism involving the government, universities, and enterprises. This mechanism spearheaded the establishment of the National Key Laboratory for the Conservation and Utilization of Subtropical Agricultural Biological Resources (Guangxi) and the China-ASEAN Big Health Industry Technology Research Institute. Enterprises, acting as “problem setters,” established joint research funds, enabling “instant integration of enterprise needs into the classroom, and on-site conversion of research results into production lines.” Second, a talent circulation mechanism transforming “top research teams into industry-leading teams.” The discipline team incubated Guangxi’s first GMP-level mRNA vaccine production line, with the team leader simultaneously serving as the director of the Guangxi Big Health Industry Expert Committee, achieving a composite role

of “scientist—industry consultant—enterprise director.” This creates a closed loop of “papers—patents—products” at the academic level, with microbiology newly entering the top 1% of ESI globally. The essence of this model is to transform immovable natural endowments into coded disciplinary directions and then compile them into industrial increments. Its limitation lies in the fact that the breadth of industrial feedback is constrained by the length of the resource development industrial chain.

5.2. Industry-specific scenarios: Mechanical engineering, Guangxi University of Science and Technology

Liuzhou is the only city in China that simultaneously has production bases of four major vehicle groups. However, emerging sectors such as new energy vehicles and intelligent connected vehicles face the pain points of “insufficient high-end production capacity and lack of core technologies.” The Mechanical Engineering Department of Guangxi University of Science and Technology proposed “building disciplines on the industrial chain,” precisely aligning three disciplines with Liuzhou’s “new four modernizations” and incorporating them into the “Liuzhou Strategic Emerging Industries Technology Roadmap,” forming a correspondence between “discipline task list = enterprise technology demand list.”

Its mechanism manifests in two ways: First, a platform co-construction mechanism involving government, universities, and enterprises, which has led to the establishment of the Ministry of Education’s Engineering Research Center for Advanced Design and Manufacturing of Heavy Vehicle Components and the Guangxi New Energy Vehicle Laboratory. It has also partnered with leading enterprises to co-build a regional-level joint postgraduate training base, forming a closed loop of “enterprise setting the questions—disciplinary answering—market grading.” Second, a “dual-mentor + dual-identity” system, where key personnel in the discipline are appointed as technical vice presidents of enterprises, and senior technicians from enterprises are appointed as industry professors at the university. Students graduate with both “engineer” and “technician” certificates. The Intelligent Vehicle (Manufacturing) and New Energy Vehicle Industry College, built based on this model, was selected as one of the first batch of modern industry colleges by the Ministry of Education, and its educational model has been incorporated into the autonomous region’s “Implementation Plan for Deepening the Integration of Industry and Education.” The essence of this model is to transform “manufacturing” into “intelligent manufacturing” by leveraging the existing advantages of industrial clusters. Its limitation lies in the high degree of reliance on a single industrial chain, meaning that fluctuations in the industrial cycle directly impact the discipline.

5.3. Discipline-derived type: Education at Guangxi Normal University

Unlike the previous two, the education discipline at Guangxi Normal University does not address existing material industrial clusters, but rather the emerging demands arising from the autonomous region’s designation of “digital education public services,” “ethnic cultural research and study,” and “new forms of teacher training” as strategic emerging industries. The discipline centers on its original theory of “education through the symbiosis of nature and humanities,” transforming academic achievements into tradable and replicable educational products and services: guiding the construction of practice bases and demonstration schools, developing local characteristic school-based curriculum resource packages, creating the brand of the “International Conference on Culture and Symbiotic Education,” and forming a new integrated “education + cultural tourism” business model.

Its mechanism manifests in three ways: First, it aligns with the national “Strengthening Teachers Plan” to construct a full-cycle training system from pre-service to in-service, establishing a teacher professional development alliance with over 300 primary and secondary schools, and integrating practical courses of “observation, internship, and research” with in-service training modules of “diagnostic, workshop, and shadowing.” Second, it implements a “targeted, customized, and job-specific” training model, with first-year teacher trainees working in border classrooms and receiving dual certificates of “teacher qualification certificate + digital teaching ability certification” upon graduation, leading to a decrease in teacher attrition rates in ethnic minority areas. Third, it leverages the Ministry of Education’s Key Laboratory of Educational Blockchain and Intelligent Technology to tackle educational big data governance, focusing on international education applications in the ASEAN region. This model, starting with original theories, proactively fosters rather than passively adapts to emerging industries through a chain of “theory providing standards—standards generating products—products activating industries—industries feeding back into disciplines,” which is particularly enlightening for teacher training and humanities and social science disciplines.

5.4. Common mechanism

Although the starting points of the driving forces are different, the three models are highly consistent at the mechanism level, which can be summarized as a closed loop of four links: “focus on discipline direction—joint construction of scientific research platform—output of key results—industry feeding back to discipline.” Among them, joint construction of the platform solves the problem of the organizational carrier of knowledge production, and talent circulation solves the problem of bidirectional flow of knowledge and skills between the two types of organizations. This is consistent with the judgment of the triple helix theory that “innovation is generated in the mixed organization at the intersection of institutional fields” (Table 4)^[16].

Table 4. Comparison of three collaborative driving modes

Dimension	Resource-dependent	Industry scenario type	Discipline Derivative
Driving Start	Regional natural resource endowment	Existing industrial cluster upgrading needs	Original theories and knowledge products in disciplines
Dominant Logic	Resources → Disciplines → Industries	Industry → Discipline → Industry	Discipline → Industry → Discipline
Key carrier	National Key Laboratories and Industrial Technology Research Institutes	Modern Industry College, Joint Postgraduate Training Base	Teacher Professional Development Alliance, International Conference Brand
Talent Circulation	Scientist - Industry Consultant - Corporate Director	Engineer—Teacher—Graduate Student	Teacher trainees — backbone teachers — trainers
Main limitations	Constrained by resource attributes and industrial chain length	Being tied to a single industrial chain makes it vulnerable to cyclical fluctuations.	The industry is limited in scale and takes a long time to show results.

6. Construction of collaborative optimization model

6.1. Overall architecture and layered design

Based on the above analysis, this study constructs a three-in-one collaborative optimization model of “hierarchical architecture—three major mechanisms—signal early warning” (**Figure 1**).

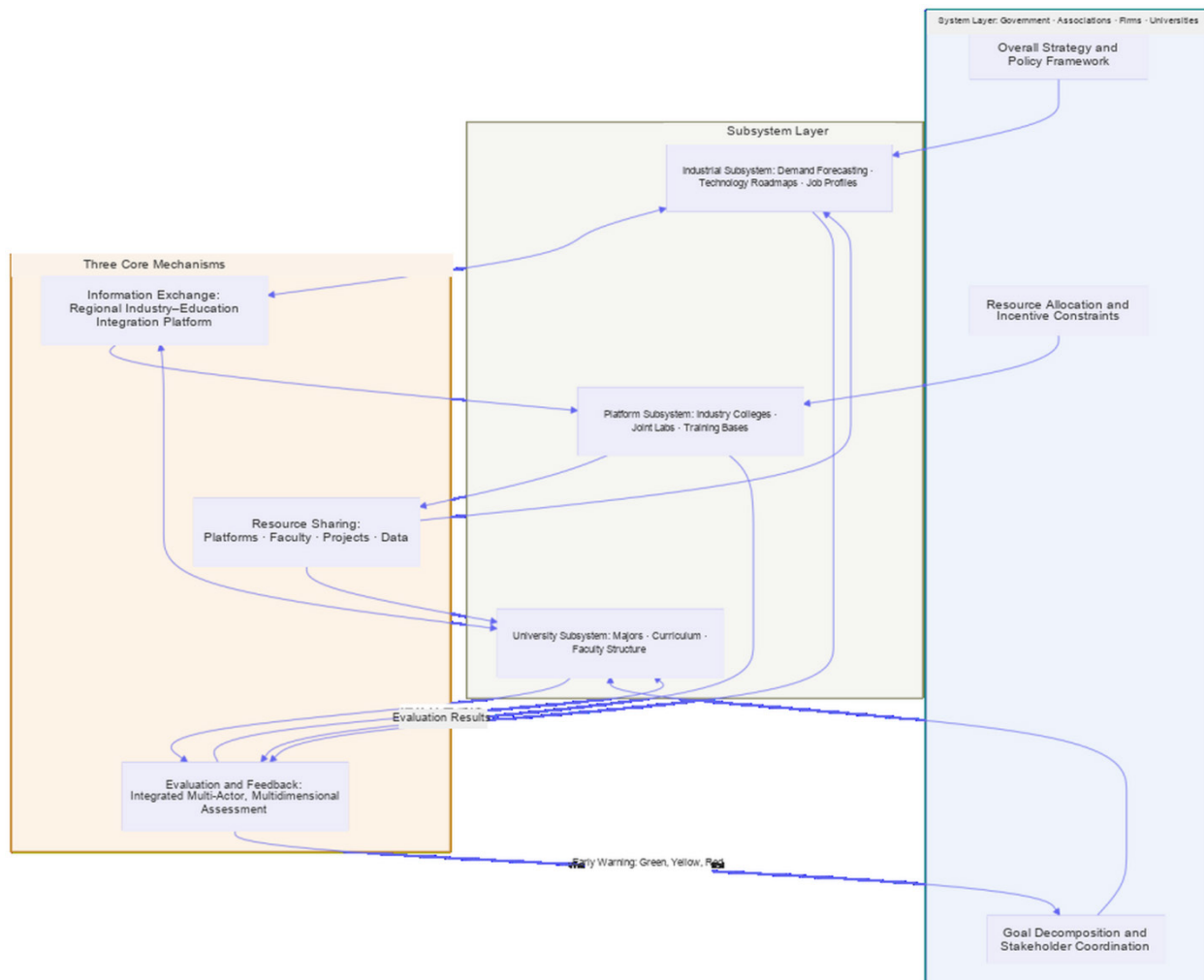


Figure 1. Schematic diagram of the collaborative optimization model between regional emerging industries and local university disciplines and majors

Drawing on the design optimization ideas of multidisciplinary approaches, the collaborative problem is decomposed into two levels: the system layer is the macro-planning layer, composed of government, industry associations, leading enterprises, and university decision-makers, responsible for formulating overall strategies and macro goals, and its core function is to coordinate the conflicts of interest between subsystems; the subsystem layer is the implementation layer, including various emerging industry clusters and specific disciplines and majors of universities, which achieve their own optimization under the constraints of the system layer’s goals. The significance of the layered design lies in separating “who coordinates” from “how to execute”: the system layer indirectly guides through goal setting, resource supply, and evaluation constraints, while the subsystem layer retains its autonomy under the given constraints. This design responds

to the dilemma of “misalignment of political logic, market logic and academic logic” in the autonomous adjustment of university majors — the three logics need to obtain institutionalized expression channels respectively ^[16].

6.2. Three core mechanisms

The information communication mechanism addresses the obstacle of “information asymmetry” (55.8%) and advocates building a regional industry-education integration information-sharing platform. This platform is not a one-way release channel, but a dynamically updated two-way information pool: the industry side releases talent demand forecasts, job skill profiles, and technology roadmaps, and the university side releases discipline characteristics, curriculum system, and scientific research results. The platform achieves supply and demand matching through intelligent matching, which directly corresponds to the national requirement of “building a national talent supply and demand matching big data platform.”

The resource-sharing mechanism achieves added value through four types of sharing: platform sharing (jointly building key laboratories, engineering technology centers, training bases, and industry-university collaborative colleges), faculty sharing (mutual appointment of “dual-qualified” teachers), project sharing (real-world R&D projects from enterprises becoming teaching cases, and priority given to the commercialization of university research results by partner companies), and data sharing (opening up anonymized production and operation data under compliant conditions). These four types of sharing collectively aim to transform heterogeneous resources into public resources that can be accessed across organizations, thereby reducing the marginal cost of collaboration.

The evaluation feedback mechanism is the key to the formation of a closed loop. It is advocated to establish a multi-dimensional evaluation system involving multiple stakeholders such as the government, third-party evaluation agencies, enterprises, universities, and students. Quantifiable indicators should be set, such as the matching degree between disciplines and industry needs, graduate employment rate and salary level, enterprise satisfaction, and scientific research achievement transformation rate. In terms of measurement, the coupling coordination degree model can be used as a reference, and attention should be paid to avoiding common pitfalls in standardization and weight setting ^[8-9]. The evaluation results should be regularly fed back to the system layer and each subsystem as a basis for adjusting the professional settings and optimizing the cooperation model.

6.3. Dynamic adjustment based on signal early warning

Supported by three major mechanisms, the adjustment of disciplines and majors should shift from “periodic approval” to “normalized early warning”: green signals correspond to additions or expansions, and the establishment of demonstration projects or expansion of enrollment should be initiated for emerging interdisciplinary fields with strong demand; yellow signals correspond to adjustments or transformations, and the curriculum of majors with saturated demand or knowledge systems that deviate from industrial development should be updated, and new technologies should be integrated; red signals correspond to early warnings or withdrawals, and the closure or merger of majors with persistently low employment rates and insufficient social demand should be initiated. This design echoes the national deployment of “early warnings and rectification requirements for disciplines and majors with insufficient social demand, declining training quality, and inadequate school conditions,” and technically relies on the continuous supply of platform data

and the dynamic updating of evaluation indicators ^[1]. The supporting process can refer to the three-stage management of “demand analysis—resource allocation—process monitoring.”

7. Pathways for collaborative optimization

At the government level, top-level design and platform supply should be strengthened (**Table 5**). First, a special plan for regional industry-education integration should be formulated and incorporated into the “15th Five-Year Plan” system, giving priority to key areas such as artificial intelligence, biotechnology, new materials, and energy conservation and environmental protection, and providing supporting fiscal and tax incentives and financial support policies to reduce the institutional transaction costs of school-enterprise cooperation; Guangxi has already clarified the key industrial directions through the document Guizhengbanfa [2025] No. 21, and the key to the future is to transmit the strength of industrial policies to the talent side ^[7]. Second, a high-level collaborative platform should be built to implement the requirements of the “Notice on Carrying Out the Construction of Municipal Industry-Education Consortia,” and consortia with talent training, innovation and entrepreneurship, and industrial service functions should be built based on industrial parks, opening up the whole chain of scientific research and development, technological innovation and achievement transfer ^[17]. Third, an evaluation and certification system should be established, and a third party should be commissioned to regularly evaluate the matching degree between disciplines and industry needs, and the results should be linked to resource allocation and performance-based funding.

At the university level, a dynamic adjustment mechanism and talent cultivation system should be restructured. First, institutional and mechanism reforms should be deepened, granting secondary colleges and program leaders greater autonomy in program design and curriculum reform, while remaining vigilant against blindly following trends in program adjustments, and ensuring that disciplinary and program planning is aligned with the university’s overall development plan. Second, the structure of disciplines and programs should be optimized, emerging disciplines and programs should be established, and the transformation and upgrading of traditional disciplines and multidisciplinary integration should be promoted; at the curriculum level, a modular system should be constructed, project-based teaching should be implemented, and a dynamic content update mechanism should be established. Third, universities should actively integrate into regional development, participate in the construction of city-level industry-education consortia and industry education communities, and jointly build modern industry colleges and joint postgraduate training ^{bases [18]}.

At the enterprise level, the focus should shift from “talent users” to “talent participants.” First, enterprises should change their role positioning, viewing participation in talent development as a means to acquire core competitiveness. Second, they should deeply participate in the entire development process, including developing training programs, curriculum development, and textbook writing, placing hiring standards and technical requirements at the forefront of the training chain. Third, they should open up and share resources, opening their R&D platforms, production facilities, and real project data to partner universities, jointly building technology transfer centers and pilot-scale verification platforms, and conducting joint innovation around key technical challenges.

Table 5. Supporting measures for curriculum reform, industry-education integration, and teacher development

Dimension	Specific measures	Expected results
Curriculum Reform	Modular curriculum system and interdisciplinary electives; teaching driven by real-world enterprise projects; regular updates of textbooks and course content; development of loose-leaf and digitally integrated textbooks.	Enhance the adaptability, practicality, and cutting-edge nature of the curriculum to cultivate the ability to solve complex problems.
Industry-Education Integration	Industry-university collaborative colleges are established to integrate production, education, research, and application; modern apprenticeship and dual-mentor systems are promoted; an innovation community with coordinated planning, governance, talent cultivation, and synergistic effects is built; and research and development platforms are jointly constructed, and research projects are jointly applied for.	Break down barriers between schools and enterprises to create an industry-education ecosystem characterized by resource sharing, shared responsibility, and shared benefits.
Teacher development	Establish a standard and certification system for “dual-qualified” teachers; implement enterprise practice and on-the-job training for teachers; set up special appointment positions for industry mentors; and incorporate the achievements of industry-education integration into professional title evaluation and performance appraisal.	Building a high-level teaching staff with solid theoretical foundations and rich practical experience

8. Conclusion and discussion

This study, based on the integration of systems theory, synergy theory, and control theory, constructs a synergistic optimization model of “hierarchical architecture—three major mechanisms—signal early warning,” and conducts empirical testing based on 197 questionnaires and three university case studies. The main conclusions are threefold:

First, the real problem of regional collaboration lies in the superposition of three types of obstacles. The overall level of collaboration among the sampled regions is low, with only 24.9% of respondents giving a positive evaluation; the perceived talent supply and demand gap reached 61.4%, and the combined percentage of respondents who reported “few transformations” and “almost no transformations” of research results reached 56.8%. These four core obstacles do not exist in isolation, but rather reinforce each other through mechanisms such as “information gaps increasing transaction costs, unclear property rights weakening the willingness to cooperate, and insufficient resources limiting the depth of organization,” forming a low-level equilibrium in deepening collaboration.

Second, the essence of collaborative optimization lies in constructing an institutionalized intermediary that can transmit industry demand signals to the discipline and major setting process in real time. Although the three university cases have different starting points, they share a closed-loop mechanism of “focusing on discipline direction—jointly building research platforms—outputting key achievements—industry supporting disciplines,” in which joint platform construction provides organizational carriers and talent circulation provides flow channels. This finding connects macro-structural measurement with meso- and micro-mechanism analysis, providing an operational analytical unit for “how to collaborate.”

Third, collaborative optimization requires a restructuring of the responsibilities of the three parties: the government is the rule-maker and platform provider, universities are the responders and organizational innovators, and enterprises need to shift from “talent users” to “talent participants.” The key lies in the substantive operation of the three mechanisms and the routine operation of the dynamic adjustment mechanism characterized by traffic light warnings.

This study has three limitations: the questionnaire sample size is mainly composed of university

teachers, and the external validity needs to be tested by stratified sampling on a larger scale; the coupling coordination model is only proposed as a method suggestion for evaluating the feedback mechanism in this paper, and the calculation has not yet been completed using regional panel data. Quantitative verification can be carried out in combination with data on the structure of graduates from disciplines and industrial output value in the future^[19]; the three case universities are all first-class disciplines in Guangxi, and the extent to which their experience can be transferred to local universities with relatively weak educational foundations still needs to be tested by more comparative cases.

The “15th Five-Year Plan” period will be a crucial five years marked by the overlapping of reshaping the regional industrial competitive landscape and profound adjustments to the structure of higher education. How to upgrade project-based and point-to-point cooperation into a long-term collaborative mechanism that is institutionalized and platform-based is a long-term issue that both theoretical research and policy practice are facing.

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Disclosure statement

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