



Research on the Cultivation of Technical and Skilled Talents Driven by Dual Subject Synergy under the Perspective of Industry-Education Integration

Yong Wen^{1,*}

¹ School of Economics and Management, Lu'an Vocational Technical College, Lu'an, Anhui, 237000, China

SUMMARY: *Dual-principle cooperative parenting functions as a pivotal driving force in promoting an innovative advancement of education, which can effectively deepen the practice of merging education with industry. Based on the evolution game theory, this paper establishes the evolution game framework for vocational industry-education integration education, and divides the synergistic mechanism of school education organization to carry out industry-education fusion into the motivation mechanism of synergistic education and the quality guarantee mechanism. Through simulation, we explain how the school's collaborative parenting education action evolves and analyze the key determinants shaping the choice of school-enterprise proactive partnership strategies. It is found that the subjects are affected by the benefit/cost structure of school education development at different stages, while the governing authorities, universities and enterprises constitute the principal actors within the collaborative educational cultivation mechanism. Drawing upon the findings of this research, the implementation path of joint cultivation between two subjects in school and enterprise for the fusion of industry and education is presented, which provides theoretical support for advancing the integration of industry and education while optimizing technically proficient talent.*

KEYWORDS: *integration of industry and education; evolutionary game; collaborative education; school-enterprise cooperation*

1 Introduction

With the escalating demand for technically skilled personnel in the society, the conventional educational paradigm has been increasingly inadequate to match the alignment between industrial requirements and economic development. As a pivotal orientation for higher education reform, the industry-education integration endeavors to improve the caliber of talent training and bolster students' hands-on capabilities and innovative spirit through the deep industry-education fusion [1, 2]. The importance of the convergence between academia and industry lies in breaking the traditional contradiction between the industrial sector and academia, promoting the win-win development within education as well as industry, providing learners with enhanced employment opportunities along with career development space, and providing an effective path toward nurturing technically proficient talent driven by the collaborative efforts of the dual stakeholders encompassing enterprises and academic institutions.

Cultivation of technically skilled talents requires schools to make efforts from practical

*wenyongjeff1981@163.com

<https://doi.org/10.65102/is2026021>

teaching, curriculum, faculty construction, internship and employment support and other aspects [3]. Industry-teaching integration practice teaching stresses the close integration of theoretical knowledge with hands-on application, allowing learners to learn within a real work environment, focusing on skills training and innovation ability stimulation, while strengthening the training of vocational literacy, ensuring that instructional material is docked against the industry benchmark, promoting the overall growth of learners, while accurately docking societal demand [4-6]. In the curriculum needs to be closely attuned to industrial requirements, so as to ensure that course content and industry standards are synchronized and updated, to strengthen the practical teaching links, to enhance learners' applied competencies; simultaneously pay attention toward the integration of interdisciplinary, to cultivate the comprehensive application of the ability in responding to the needs within the enterprise's diversified advancement, and to realize a smooth convergence across the educational and commercial sectors [7, 8]. With regard to faculty development, it is essential to strengthen the training of the "dual-teacher" teachers, i.e. educators possessing both a robust academic grounding and extensive real-world expertise; to promote the exchange between teachers and industry, and keep up with the industry dynamics; to provide regular training to improve teachers' professional ability and industrial service ability; to build joint teachers' teams of schools and enterprises, and to undertake the teaching tasks together to ensure that the quality of teaching is highly compatible with the industrial demand. Teaching quality is highly compatible with industrial demand [9, 10]. In addition, it is necessary to actively build robust collaborative mechanisms alongside the industry, provide diversified practical placement opportunities to guarantee that learners get practical training [11]; strengthen the management throughout the internship process so as to safeguard the legitimate rights and wellbeing of learners and safety; and build a platform for school-enterprise collaborative engagement to advance the accurate employment among students and enhance their employment competitiveness [12, 13].

Regarding the related investigation into the development of technical-skilled talent driven by two-body synergy within the framework of industry-education convergence, Yu and Tsao analyzed the obstacles encountered by vocational colleges and tertiary institutions in the realm of industry-education integration such as insufficient participation of enterprises, examined the paths of strengthening the guidance of enterprises and the construction of faculty members, and emphasized the key roles of these measures in improving the standard of technically-skilled talent development and adapting to the market demand [14]. Wang and Zhang analyzed the nurturing of technical-skilled innovative talents through the lens of the integration of the commercial sector and academic institutions, by exploring its connotation, the interplay between the academic framework and the sectoral configuration, pointing out the approaches encompassing course refinement and the broadening of cross-disciplinary competence, and emphasizing the importance of the core driving role of such talents in fostering the long-term growth of the regional economy alongside the in-depth coupling mechanism [15]. Liu et al. analyzed the trend of global metallurgy upgrading to intelligence and greening in the context of Industry 4.0, studied the technological breakthroughs in the U.S., Japan, and other countries and the transformation within China's industry, while emphasized the need for China's undergraduate metallurgy education to refine the course structure and reinforce applied learning so as to cultivate high-skilled talents through industry-academia collaboration [16]. Based on the convergence of industry and education, Zhao discussed the talent cultivation model within higher learning institutions, pointed out the pivotal function of university-industry partnership in enhancing the practicality within the curriculum as well as the employability among students through case and empirical analyses, and emphasized the significance of groundbreaking initiatives including the joint development of course programs and commercial sector

internships in narrowing the divide separating the educational outcomes from the commercial sector's needs [17].

Li analyzed the shortcomings of the traditional education paradigm within the realm of finance and economics disciplines amid the digital economy within the context of industry-education convergence, studied the key design pertaining to the curriculum, practice platform and dual-teacher structure by constructing an ability-driven cooperative instructional architecture, and emphasized the systematic role of the model in promoting the profound amalgamation of theoretical knowledge, practical skills and professional competencies of technically skilled talents [18]. Wang analyzed the practical teaching system of information industry talent development within the industry-education integration paradigm, selected Chongqing C Vocational College as a case study, explored its correlation with students' satisfaction through questionnaire survey and regression analysis, and underscored the key function of refining the system so as to align with industrial requirements and improve the quality of technical and skilled talent training [19]. Li and Wang studied the deficiencies encountered in technical-skilled talent nurturing in the city construction within the framework of industry-education integration, pointed out the phenomena of vague cultivation objectives and insufficient synergy, and analyzed the relevant improvement suggestions based on the national situation, emphasizing its significance in promoting industrial upgrading and educational innovation [20].

In addition, Yangyang and Lisha analyzed the problem of disconnection from practice caused by over-reliance on personal interest throughout the development of practically-oriented technical talent across China, by explaining the basic principles and implementation methods of the industry-academia fusion while emphasized its pivotal contribution toward docking the market demand and enhancing the holistic competency of learners so as to foster excellent technically proficient talent [21]. Fang and Shi explored the prevailing conditions alongside the enhancement path of core competencies of agricultural undergraduates, pointed out the problems of insufficient practice of students and lack of industry experience of teachers through investigation and analysis, emphasized the role of deepening industry-academia integration while strengthening the comprehensive training in addressing the competency gaps, thereby constructed a competency model highlighting the growth competencies in order to support the talent demand of agricultural modernization [22]. Zhu analyzed the problems encountered in talent development within tertiary vocational digital media majors, pointed out the key role of joint cultivation involving academic institutions and commercial enterprises toward improving the practical ability of students through the adoption of the "three-introduction and three-output" model and the modern apprenticeship system, and emphasized that this method optimizes the cultivation system of technical skills talents [23]. Wang studied the application of this new form pertaining to industry-academia integration within vocational institutions, namely the industrial college, in the development of technically proficient and practically skilled talent. Taking "TCL Eagle Industrial College" as an example, he analyzed its innovative cooperation model, pointed out the significance of exploring practical talent training paths beyond tertiary vocational education alongside applied baccalaureate programs, and emphasized the academic and applied value of this model in advancing the establishment and progression of industrial colleges [24]. Ye et al. explored the top talent cultivation path of product design within the framework of industry-education fusion, and proposed reform programs including the refinement of course content and reinforcing practice by analyzing its problems such as weak practical teaching, emphasizing its reference value to the educational reform of related professions [25]. With a symbiotic theory lens, Ling analyzed the mutually beneficial relationship of each participant within the realm of industry-academia convergence, studied its evolutionary path, while emphasized the necessity of this model in nurturing

technical-skilled talent across vocational institutions [26]. Wanqi analyzed the key role played by vocational education industry-teaching integration service bodies in the cultivation of technical and skilled talents, pointed out that they can effectively match supply and demand and provide resource support, and emphasized the need for the government, enterprises and other parties to collaborate to optimize their policies, professions and cooperation functions [27]. Peng addresses the challenge of misalignment in talent development of navigation majors against industrial requirements by constructing a cultivation scheme anchored in the paradigm of profound industry-academia fusion, analyzes its practical paths in terms of clarifying the standards and hierarchical guidance, and emphasizes its reference value in enhancing the standard of talent development so as to docking with the industry's demand [28].

Existing scholarly attention remains comparatively limited regarding the cost-benefit of enterprises and vocational institutions for technical and skilled talents within the context pertaining to industry-teaching integration at present. This paper applies the thinking of evolutionary game principles to construct the replicated iterative equations governing both parties, explore the robustness of the equilibrium position, and build the power mechanism and quality assurance framework underpinning collaborative cultivation for industry-academia integration. It also analyzes the benefits and losses involving enterprises alongside tertiary vocational institutions and their dynamic promotional relationship through case study experiments, with the aim of addressing the challenges stemming from low motivation of commercial entities to participate, low degree of participation, and lack of promotional efforts of vocational colleges and universities.

2 Evolutionary game of technical and skilled personnel training in the perspective of industry-teaching integration

2.1 The game model of the evolution of industry-teaching integration and human education

Evolutionary game theory is one of the most important frontier research fields in management, economics and game theory, which does not rely on any rationality assumptions and is more realistic by reaching game equilibrium through trial-and-error methods. The interrelationships of multiple individuals are described mathematically, a dynamic evolutionary game model is constructed, the framework is resolved through the application of replication dynamic equations and Jacobi matrices, and its stability is analyzed to derive an evolutionary stable strategy.

2.1.1 Evolutionary game modeling

Two distinct participating actors exist within this model, specifically enterprises and vocational tertiary institutions, while the strategies that enterprises can choose are to participate or not to participate in the fusion of industry and academia, whereas the strategies that tertiary vocational institutions can choose are to promote or not to promote the policy of industry-academia integration. The relevant parameter settings are shown in Table 1.

Table 1: Main parameters and their meanings

Parameter	Meaning	Parameter	Meaning
C	Cost pertaining to Corporate Engagement in Industry-Academia Convergence	R	Cost of Vocational Colleges Promotion

C_1	The Benefit of Enterprise Engagement within the Industry-Academia Integration Framework	R_0	The Benefit of Vocational College Promotion
C_2	The Loss incurred by Commercial Entities Not Engaging in the Fusion of Industry and Education	R_1	Costs not promoted by vocational colleges
M	Loss of vocational college not promoting	R_2	Loss of vocational college not promoting

The general situation is that the integration of enterprises into the convergence of industry-academia collaboration and school-enterprise partnership constitutes its intrinsic need and inherent function, therefore, the value of C will not be very large, i.e., $C < C_1$, $C < C_2$; the forward benefits show that the gains accrued by vocational colleges when advancing the integration of industry and academia shall certainly be much higher than the cost savings from not advancing the industry-academia fusion, i.e., $R_0 > R_1$, $R_2 > R$. The matrix of the benefits is presented in Table 2.

Table 2: Revenue Matrix

Enterprise \ Vocational college	Push on	Do not advance
Partake	$(C_1 - C, -R + R_0)$	$(C_1 - C, R_1 - R_2)$
Drop out of	$(-C_2, -R + R_0)$	$(-C_2 - M, R_1)$

2.1.2 Evolutionary Game Modeling

Designate the likelihood that a corporation selects the engagement strategy as x and the likelihood that it adopts the non-engagement strategy as $1 - x$. The probability that a vocational college adopts the progression strategy is y , and the probability that it embraces the non-progression strategy is $1 - y$.

The anticipated and collective mean payoffs corresponding to the two strategic options (engagement and non-engagement) accessible to the enterprise are U_{1Y} , U_{1N} , and \bar{U}_1 , respectively:

$$U_{1Y} = y(C_1 - C) + (1 - y)(C_1 - C) \quad (1)$$

$$U_{1N} = -yC_2 - (1 - y)(C_2 + M) \quad (2)$$

$$U_{1N} = -yC_2 - (1 - y)(C_2 + M) \quad (3)$$

The anticipated and collective mean payoffs for the two strategic options (advancing and refraining from advancing) accessible to vocational institutions are U_{2Y} , U_{2N} , and \bar{U}_2 , respectively:

$$U_{2Y} = x(-R + R_0) + (1 - x)(-R + R_0) \quad (4)$$

$$U_{2N} = x(R_1 - R_2) + (1 - x)R_1 \quad (5)$$

$$\bar{U}_2 = y(R_0 - R) + (1 - y)(R_1 - xR_2) \quad (6)$$

(1) Constructing the replication dynamic equation for a company

Formulate the replication dynamic equation:

$$F(x) = \frac{dx}{dt} = x(U_{1Y} - \bar{U}_1) = x(1 - x)(C_1 + C_2 + M - C - yM) \quad (7)$$

Thus, when $x=0,1$ or $y = \frac{C_1 + C_2 + M - C}{M}$, $\frac{dx}{dt} = 0$, the proportion of the corporate sector embracing the engagement strategy remains stable. When $y = \frac{C_1 + C_2 + M - C}{M}$, the condition within the range $0 \leq x \leq 1$ is stable, and the likelihood of a vocational institution opting for active promotion under this state is y . When $y \neq \frac{C_1 + C_2 + M - C}{M}$, then $x_1 = 0$ or $x_2 = 1$ represent the two plausible steady states. When $y < \frac{C_1 + C_2 + M - C}{M}$, then $x = 1$ denotes the equilibrium position; when $y > \frac{C_1 + C_2 + M - C}{M}$, then $x = 0$ is the equilibrium point. Figure 1 shows the corresponding phase diagram of the replicated dynamic equations.

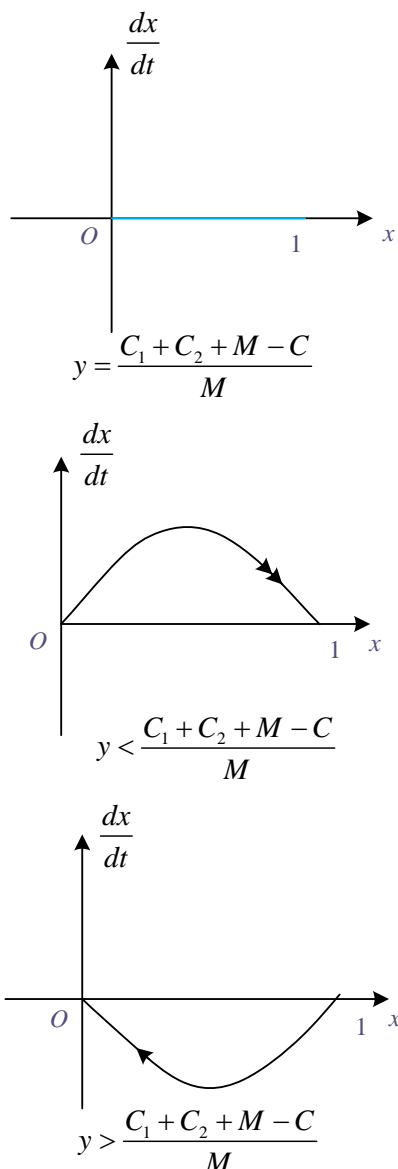


Figure 1: Phase Diagram of Dynamic Relationship in Enterprise Replication

(2) Formulating Replication Dynamic Equations applicable to Vocational Institutions
 Develop the replication dynamic equation:

$$F(y) = \frac{dy}{dt} = y(U_{2y} - \bar{U}_2) = -y(1-y)(R + R_1 - R_0 - xR_2) \tag{8}$$

Therefore, when $y = 0, 1$ or $x = \frac{R + R_1 - R_0}{R_2}$, $\frac{dy}{dt} = 0$, the share of tertiary vocational institutions embracing the advancement strategy pertaining to promoting the industry-academia fusion remains steady, and upon $x = \frac{R + R_1 - R_0}{R_2}$, for any $0 \leq y \leq 1$ all of them are stable states, at which time the probability of enterprises choosing to engage in the convergence of industry and academia is x , which may equally be interpreted as an indicator of the degree of

enterprises' participation. When $x \neq \frac{R+R_1-R_0}{R_2}$, then $y_1=0$ and $y_2=1$ each represent two distinct plausible steady states; when $x < \frac{R+R_1-R_0}{R_2}$, then $y=0$ serves as the equilibrium position; when $x > \frac{R+R_1-R_0}{R_2}$, then $y=1$ constitutes the equilibrium position. Figure 2 is the phase diagram of its corresponding replicated dynamic equations.

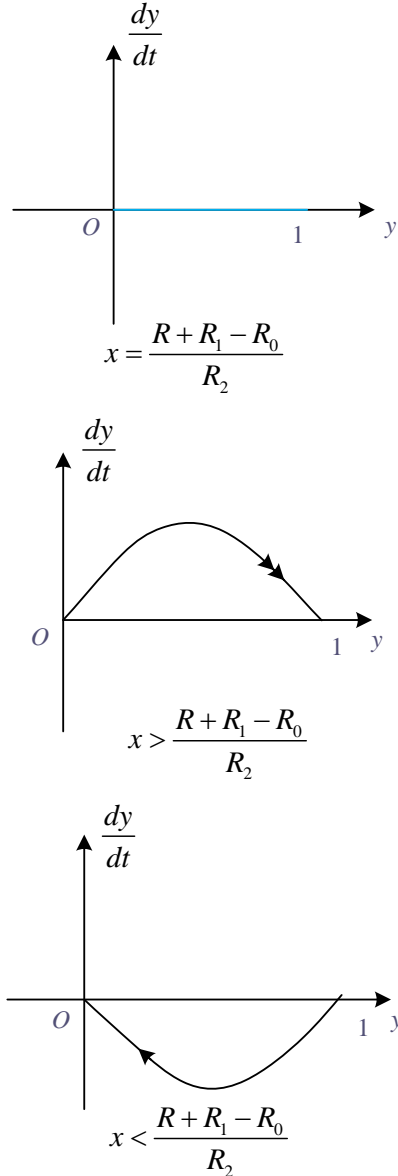


Figure 2: Copy dynamic relationship phase diagram

2.1.3 Stability analysis of evolutionary games

Let $F(x)=0$ and $F(y)=0$, we can find 5 equilibrium points of the system, which are $O(0,0)$, $A(0,1)$, $B(1,0)$, $C(1,1)$ and $D\left(\frac{(1-\beta)C+T}{(1-\alpha)S+W_2}, \frac{\beta C+T}{\alpha S+W_1+F}\right)$.

The system of replicated dynamic equations (9) is analyzed using the local stability of the Jacobi matrices, and the Jacobi matrix J is obtained by taking partial derivatives for x and y .

$$J = \begin{bmatrix} (1-2x)(y\alpha S + yW_1 - \beta C - T + yF) & \\ & y(1-y)[(1-\alpha)S + W_2] \end{bmatrix} \quad (9)$$

Then the determinant of the matrix is:

$$\begin{aligned} \det J &= (1-2x)(y\alpha S + yW_1 - \beta C - T + yF)(1-2y) \\ &\quad [(1-\alpha)xS + xW_2 - (1-\beta)C - T] \\ &\quad -x(1-x)(\alpha S + W_1 + F)y(1-y)[(1-\alpha)S + W_2] \end{aligned} \quad (10)$$

The trace of the matrix is:

$$\begin{aligned} trJ &= (1-2x)(y\alpha S + yW_1 - \beta C - T + yF) \\ &\quad + (1-2y)[(1-\alpha)xS + xW_2 - (1-\beta)C - T] \end{aligned} \quad (11)$$

The five equilibrium points of the system are brought into the determinant pertaining to the matrix alongside the trace pertaining to the matrix for equilibrium stability examination, and the stability evolution results are shown in Table 3.

Table 3: Stability Examination of the Evolutionary Game in School-Enterprise Cooperation

Break-event point	$\det J$	trJ	Stability
$O(0,0)$	+	-	ESS
$A(0,1)$	+	+	Instability
$B(1,0)$	+	+	Instability
$C(1,1)$	+	-	ESS
$D\left(\frac{(1-\beta)C+T}{(1-\alpha)S+W_2}, \frac{\beta C+T}{\alpha S+W_1+F}\right)$	+	0	Saddle point

Drawing upon the stability principles of the evolutionary game system, the equilibrium positions $O(0,0)$ and $C(1,1)$ satisfy $\det J > 0$ and $trJ < 0$, which constitute the results of the system's evolutionary stability points. Among them, A and B are unstable points, and D represents the saddle point, namely the pivotal threshold of the game. Therefore, in the process involving school-enterprise partnership within vocational education, (negative collaboration, negative collaboration) and (positive cooperation, positive cooperation) are the stabilizing strategy choices for both schools and enterprises. The saddle point D to which stable point converges is influenced by the benefits of positive cooperation S , benefit sharing coefficient α , costs of positive cooperation C , cost sharing coefficient β , free-riding T , financial support W_1 , incentive policy W_2 , performance evaluation F and other factors.

2.2 Model construction of the power mechanism of industry-teaching integration and collaborative educator training

According to the relevant theories of organizational behavior, this study mainly analyzes the reasons affecting their collaborative parenting from the three dimensions of the driving force dominated by the interest drive, the driving force dominated by government incentives, and the sustaining force dominated by technological potentials.

(1) Driving force: interest-driven

Benefit drive can be mainly divided into the reduction of transaction costs and the increase of cooperative profits. The fundamental transaction cost theory shows that the significance of the existence of the system or organization is to replace the higher cost with the lower cost system regulations or organizational model, and school-enterprise collaborative mechanisms is essentially a system paradigm under the transaction contract, whereas the engineering education organization provides a place for the internalization of transaction costs for the development of industry-academia partnerships. Therefore, industry-academia partnerships can encourage vocational as well as technical schools and the industry to optimize the allocation of resources on the basis of reduced transaction costs, while school-enterprise integration can help schools in acquiring compensation with respect to the profits stemming from research and development and the economic benefits brought about by the transfer of technology, and enterprises can also obtain the excess profits brought about by the cooperative research and development.

(2) Driving force: government incentives

The driving force originates from the external environment of the organization, such as the requirements of government policies, external products and demands of service users. In the external environment, the government, as an important regulator of the macro market economy and social development, assumes a central function in redistributing social production factors as well as innovation resources within the process of industry-industry integration, which should not be ignored.

(3) Maintenance Power: Technological Potential Difference

Maintenance power is the force that can ensure the continuous operation of the organization, which is mainly originated from the technical potential difference between the industry and the school. When facing bottlenecks in the development process, the party with lower technological potential will take the initiative to seek cooperation from the party with higher potential, and the greater the technological potential difference between the two, the more pronounced the drive toward collaborative engagement and the greater the probability of joint endeavors.

A framework illustrating the coordinated educator driving mechanism pertaining to school-enterprise integration within academic institutions has been developed, as shown in Figure 3.

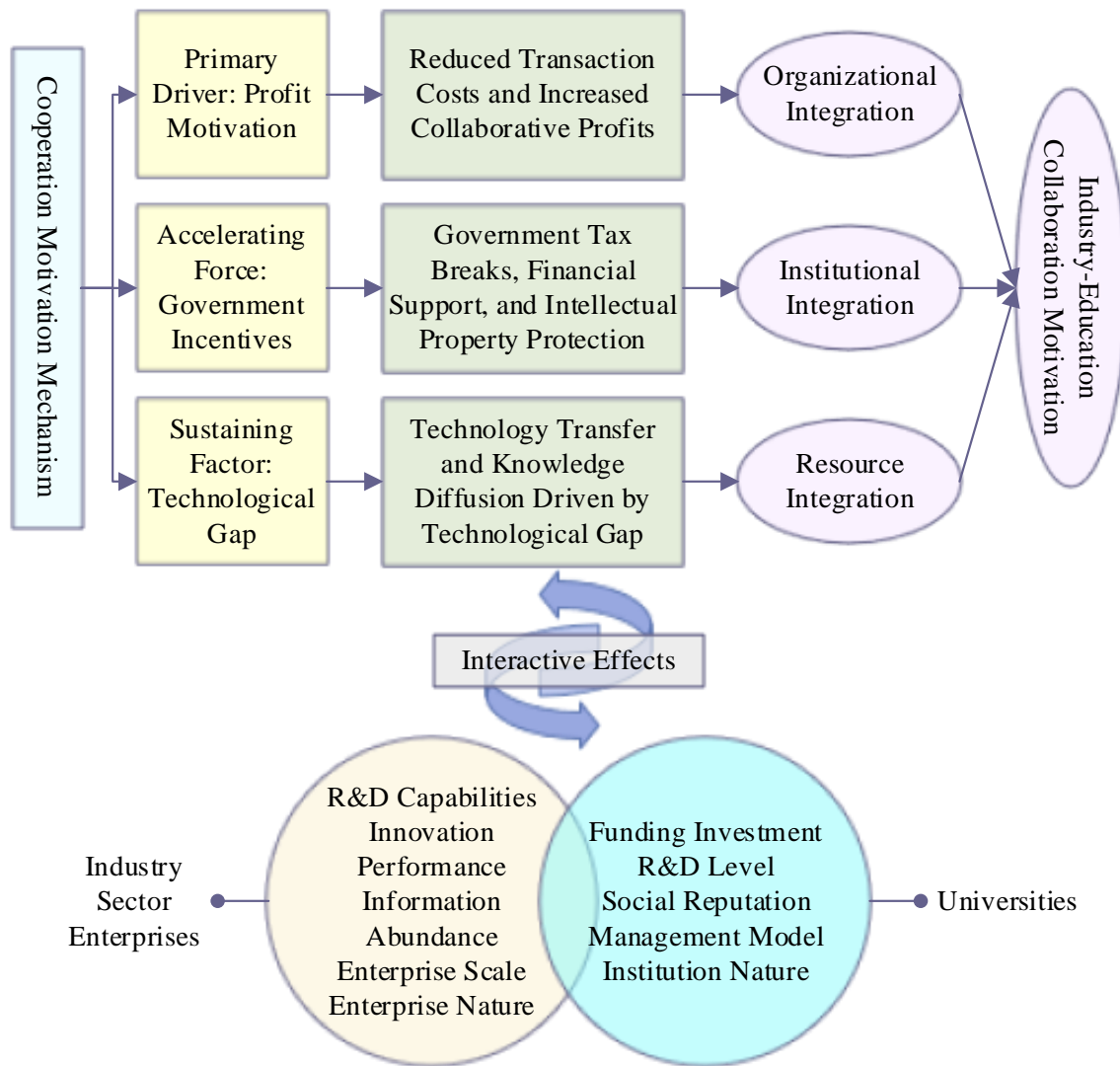


Figure 3: The Cooperative Driving Mechanism of Industry-Education Integration in Vocational Education

2.3 Quality assurance mechanism for collaborative education in industry-teaching integration

In addition to the static elements, the construction of quality assurance mechanism cannot be separated from the supporting implementation of dynamic operation mechanism, so as to link the organization, quality standards and regulations into an organic whole, and to empower the advancement and strengthening of school-enterprise collaborative engagement within the engineering education organizations of first-class universities. Among them, evaluation feedback and supervision constraints, as the core links, are crucial for improving the participation and integration of industrial enterprises throughout university-school-enterprise cooperation alongside quality assurance. From a perspective examining the components constituting the quality assurance system for industry-industry integration, it mainly consists of quality standards, rules and regulations, and organizational institutions.

The monitoring of the activities of the school engineering education organization during school-enterprise collaborative programs and the reflection of the members of the organization involved in school-enterprise cooperative initiatives on their own actions can be approached from five dimensions: the effectiveness of school-enterprise collaborative integration, the

efficiency of school-enterprise cooperative programs, the efficiency of industry-academia partnerships, the efficiency of coordinated school-enterprise mechanisms, the effectiveness of the integration between academic institutions and enterprises, and the effect of industry-academia collaborative endeavors. Effectiveness serves as a primary criterion to judge whether school-enterprise cooperative integration meets the expected goals, and is required to meet the substantive and formal requirements of industry-academia collaboration simultaneously; efficiency and effectiveness are used to monitor the human and financial resources consumed in the course of school-enterprise cooperative undertakings, which highlights the instrumental rationality of industry-academia integration; effectiveness constitutes a significant indicator in measuring the operational capacity of the schools and industries participating in industry-academia collaborative frameworks and for assessing the level of competence of the different sub-systems within the organization in terms of their ability to play the role of school-enterprise integration. Effectiveness represents a key indicator of the operational ability of schools and industrial organizations involved in school-enterprise cooperative activities, in addition to serving as a quantitative reflection of the ability of different sub-systems within the organization. Generally speaking, under the perspective of synergy theory, industry enterprises and schools have induced the behavioral motivation of industry-industry integration based on the inherent cooperation motivation mechanism, and the two parties involved in industry-industry integration have adopted the corresponding operation and management mechanism as well as the quality assurance mechanism to carry out the specific behavioral practices of industry-industry integration under the motivation of the motivation.

3 Simulation analysis of the game of the evolution of collaborative education in industry-teaching integration

3.1 Initial Parameter Settings

According to the evolutionary game enterprise-school model, the initial parameters of the enterprise-school evolutionary game parameters are configured as presented in Table 4, with computer numerical analysis being carried out with the following initial parameters and their correlations so that the saddle point is located in the center of the space.

Table 4: Initial Parameter Setting of Evolutionary Game Model between Enterprise and School

Parameter Symbol	Parameter Meaning	parameter values
R_1	Corporate profits when businesses maintain participation and schools sustain investment	11
R_2	Corporate benefits during emergency response participation or school emergency investment	8
C_1	Cost of continuous participation	7
C_2	Enterprise Cost in Emergency Participation	3
O_1	When schools maintain continuous investment and enterprises sustain active participation, the school benefits	10
O_2	School benefits during emergency funding or corporate emergency participation	7
I_1	School costs when the school continues to invest	6
I_2	School cost in emergency	2
B_e	When the enterprise continues to participate and the school continues to invest, the enterprise will gain recognition and reputation, bring commercial benefits from contact with other organizations, and accumulate goodwill towards the school.	2.3
B_u	When schools maintain sustained investment and enterprises participate continuously, the institutions can obtain higher-level performance evaluations from regulatory authorities, along with enhanced appeal to prospective students and parents, as well as greater public recognition.	4
L_e	When enterprises participate in emergency response and schools continue to invest, they face losses such as negative evaluations and missed business opportunities.	2.9
L_u	When schools invest in emergency preparedness and enterprises continue to participate, the losses include the loss of cooperative partners and damage to school recognition.	3

In the parameter settings as above, it is possible to make the saddle point D_{55} coordinate point:

$$x' = \frac{I_1 - I_2}{O_1 - O_2 + B_u + L_u} = 0.5 \tag{12}$$

$$y' = \frac{C_1 - C_2}{R_1 - R_2 + B_e + L_e} = 0.5 \tag{13}$$

That is, the saddle point is located at the center of the space in the plane space formed by the phase diagram. In this case, the four quadrants of the planar space are equal in area, and the initial probability of strategy selection of both enterprises and schools will be evenly distributed in the four quadrants, which will eventually lead to an equal probability that the final strategy selection of the enterprises and schools will be {continuously participating, continuously investing} and {contingency participation, contingency investing} after the evolution. This

initial model setting is more in line with the setting of the benefits and costs of strategy selection under realistic conditions when neither the enterprise nor the school has a priori knowledge, implying neutrality, and therefore this setting is acceptable and plausible.

The simulation results of the strategy simulation under the parameter conditions of this initial model are obtained as shown in Fig. 4. For the initial parametric model, the scheme of setting the initial probabilities of both sides of the strategy randomly for 1000 times is used in order to obtain more stable simulation results with a larger random initial sample size.

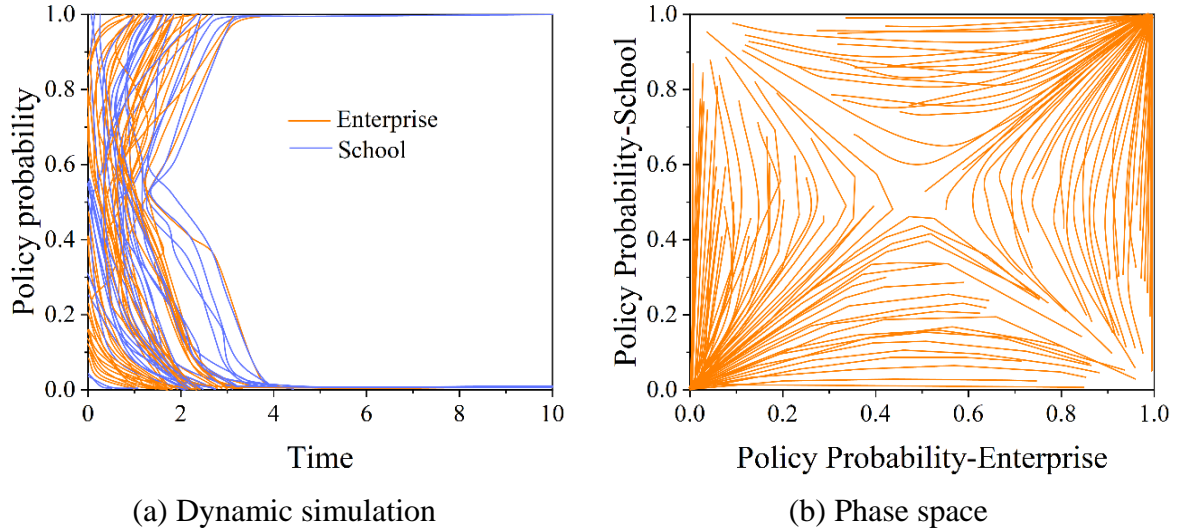


Figure 4: Simulation results of the initial parameter strategy between enterprise and school

3.2 Impact of benefit/cost parameters

The initial model parameters were adjusted according to the benefit-cost data of enterprises participating in vocational education provision as shown in Table 5.

Table 5: First adjustment of enterprise revenue/cost parameters

Parameter symbol	Parameter Meaning	Parametric variation
R_1	Corporate profits when businesses maintain participation and schools sustain investment	Initial value: $R_1 \times 3.013 = 33.143$
R_2	Corporate benefits during emergency response participation or school emergency investment	Initial value: $R_2 \div 4.3756 = 1.8283$
C_1	Cost of continuous participation	Initial value: $C_1 \times 2 = 14$
C_2	Enterprise Cost in Emergency Participation	Initial value: $C_2 \div 2.9543 = 1.0155$

Based on the parameter settings in the above table, through 1000 random settings of the initial probabilities for both parties using the computer, the simulation results are shown in Figure 5. From the phase diagram, it can be clearly seen that after adjusting the enterprise parameters, the proportion of eventually persisting in the cooperative strategy has increased, but the increase is not significant. There are still many evolutionary results tending towards non-cooperation. The enterprise-school eventually reached a cooperative state of "continuous participation" with higher vocational schools at approximately 61%, and a cooperative state of "emergency participation" at approximately 39%. This also means that regardless of the initial

probability of an enterprise choosing the "continuous participation" strategy or the "emergency participation" strategy, ultimately, about 61% reached the equilibrium state of {continuous participation, continuous investment}, and about 39% reached the equilibrium state of {emergency participation, emergency investment}. This result is very close to the data from the satisfaction survey of enterprises' participation in vocational education operation. This also indicates that the simulation results of the strategies of the enterprise and the school are relatively reliable and can be further simulated.

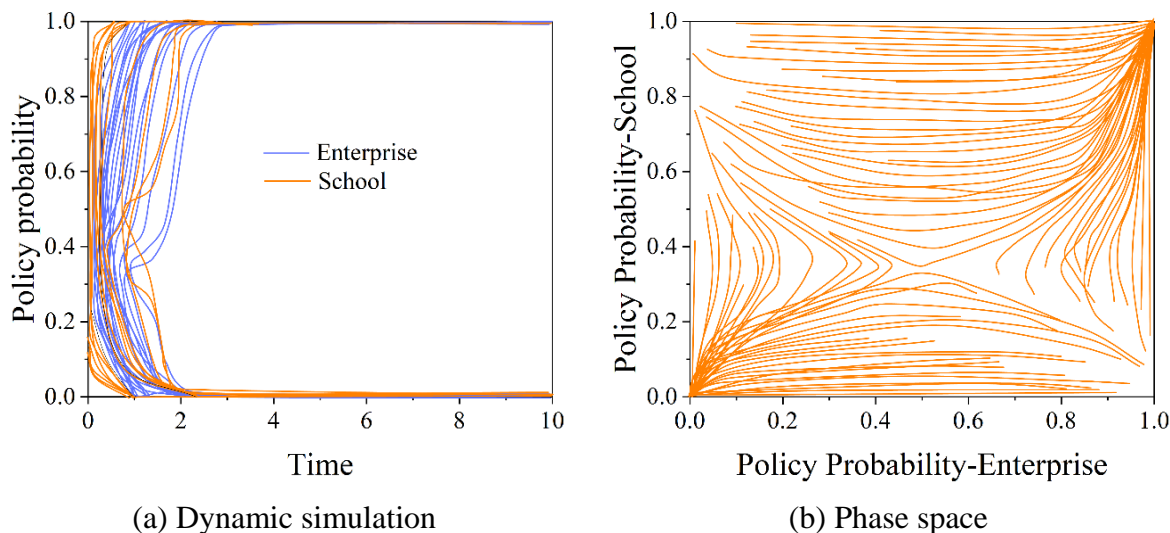


Figure 5: Simulation results after the first adjustment of enterprise profit/cost parameters

Try to further enhance the benefits of the firms under the strategy of continuous participation in schooling and reduce the corresponding costs in order to examine the change in trend of the evolutionary game as shown in Table 6.

Table 6: Second adjustment of revenue/cost parameters

Parameter symbol	Parameter Meaning	Parametric variation
R_1	Corporate profits when businesses maintain participation and schools sustain investment	$33.143 \times 1.6 = 46$
R_2	Corporate benefits during emergency response participation or school emergency investment	1.8283 invariant
C_1	Cost of continuous participation	$14 \times 0.923 = 13$
C_2	Enterprise Cost in Emergency Participation	1.0155 invariant

The simulation results after the second adjustment of the enterprise benefit/cost parameters are shown in Fig. 6. At this point, the calculated percentage of the enterprise-school parties eventually converging to the equilibrium state of {continuous participation, continuous input} is raised to about 83%.

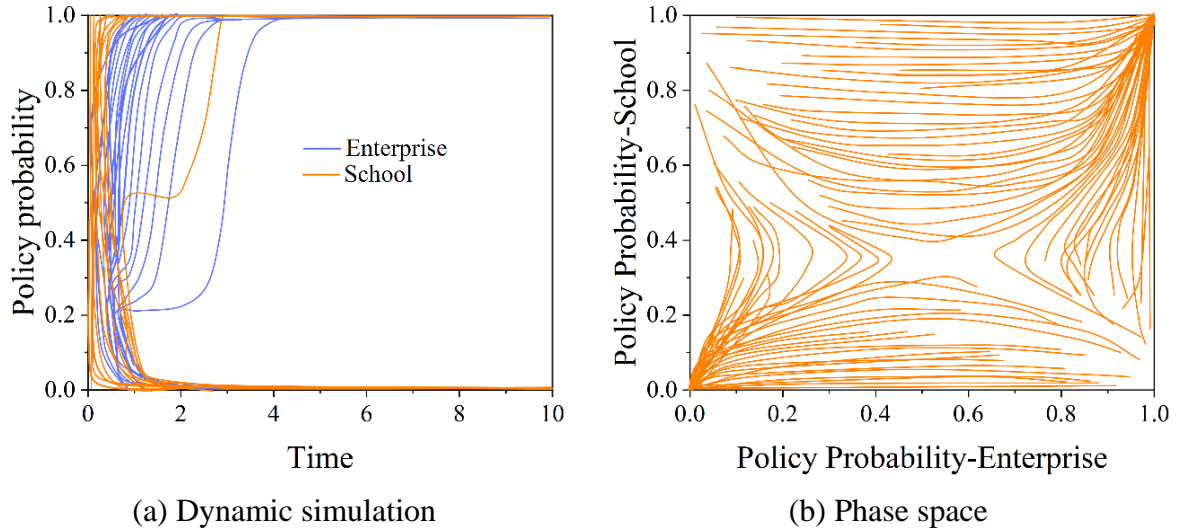


Figure 6: Simulation results of enterprise profit/cost parameters after the second adjustment

The results of the third adjustment of the enterprise parameters are shown in Table 7, at which time the enterprise's benefit-cost ratio under the continuous participation strategy has risen to 4.6 times. Therefore, if it is necessary to further increase the ratio of both parties to reach the equilibrium state of {continuous participation, continuous input}, it can be considered to increase the additional benefits brought by the enterprises when they continue to participate. B_e . In this study, the B_e in the initial parameter is increased from 2.3, to 21.

Table 7: Third adjustment of enterprise parameters

Parameter Symbol	Parameter Meaning	Parametric variation
R_1	Corporate profits when businesses maintain participation and schools sustain investment	4.6 invariant
R_2	Corporate benefits during emergency response participation or school emergency investment	1.6329 invariant
C_1	Cost of continuous participation	11 invariant
C_2	Enterprise Cost in Emergency Participation	0.7032 invariant
B_e	When the enterprise continues to participate and the school continues to invest, the enterprise will obtain the visibility and reputation, the commercial benefits brought by the contact with other organizations, and the accumulated goodwill of the school.	Initial value $B_e \times 9.23 = 21$

The simulation results after the third adjustment of the enterprise benefit/cost parameters are shown in Fig. 7. At this time, the calculated proportion of both sides of the enterprise-higher vocational school eventually converging to the equilibrium state of {continuous participation, continuous input} is raised to about 87%.

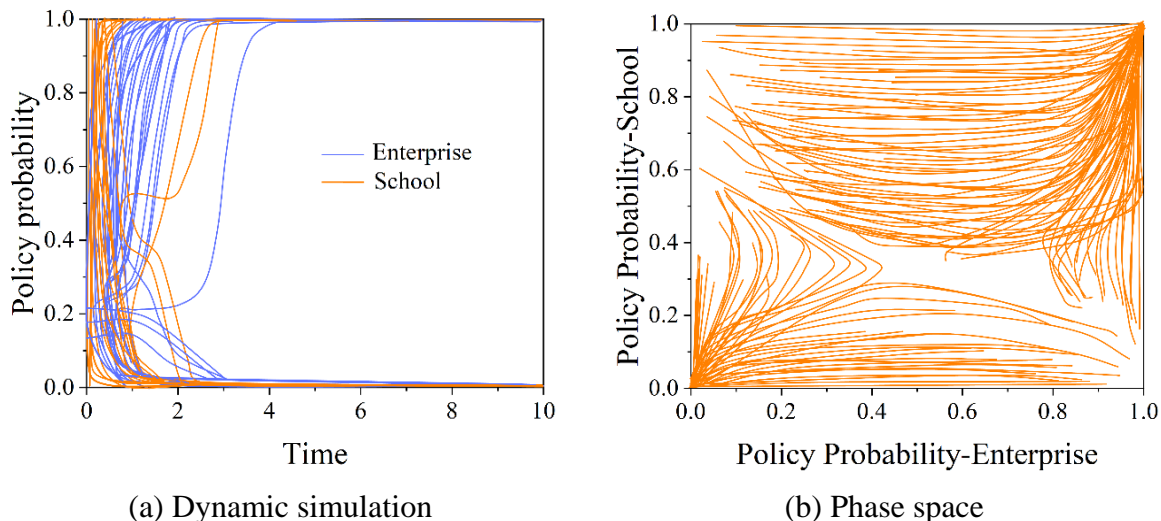


Figure 7: Simulation results of enterprise profit/cost parameters after the third adjustment

From the simulation in Figure 7, it can be seen that improving the benefit R_1 , additional benefit B_e , and reducing cost C_1 when enterprises continuously participate in cooperative education can help both enterprises and higher vocational colleges and universities to choose {continuous participation, continuous investment} strategy. However, when the proportion reaches about 85%, the changes in the enterprise's benefits and costs are larger, especially the additional benefit B_e , which is more than nine times higher, but it is not obvious to increase the proportion of the final cooperation between the two parties. In reality, it is not feasible to increase the enterprise's benefit/cost ratio and additional benefits by such a large amount. In other words, it is difficult to change the benefits and costs of the enterprises only, which can strongly promote the final {continuous participation, continuous investment} strategy of the two parties. Therefore, the direction of parameter adjustment needs to be revised. The specific data are shown in Table 8.

Table 8: Dual Subject Parameter Adjustment

Parameter Symbol	Parameter Meaning	Parametric variation
R_1	Corporate profits when businesses maintain participation and schools sustain investment	46
C_1	Cost of continuous participation	11
B_e	When the enterprise continues to participate and the school continues to invest, the enterprise will obtain the visibility and reputation, the commercial benefits brought by the contact with other organizations, and the accumulation of school goodwill.	2.3→4.6
O_1	When schools maintain continuous investment and enterprises sustain active participation, the school benefits	10→15
I_1	School costs when the school continues to invest	6→4.6
B_u	When schools maintain continuous investment and enterprises sustain active participation, higher vocational institutions can receive superior performance evaluations from regulatory authorities, while also enhancing their appeal to prospective students and parents, as well as public recognition.	4→6

The simulation results after the two-subject parameter adjustment are shown in Figure 8. The proportion of enterprises and higher vocational schools choosing {continuous participation, continuous input} strategy is about 95%. At this time, the additional benefits of enterprises and higher vocational schools do not need to be greatly increased, and the two sides will each improve their benefits and reduce costs will greatly increase the proportion of reaching the {continuous participation, continuous input} strategy.

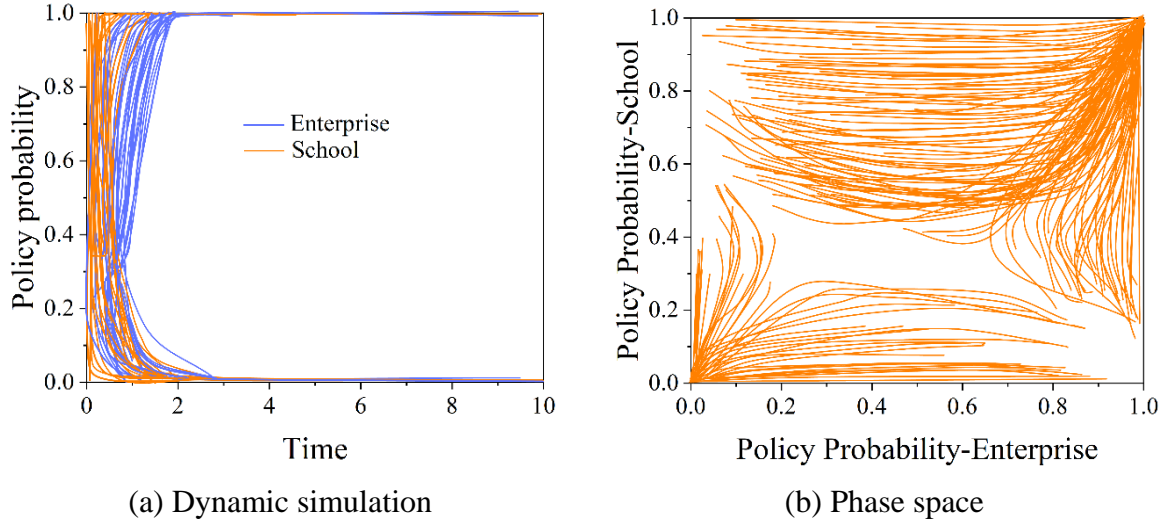


Figure 8: Simulation results after adjustment of two main parameters

3.3 Impact of Strategy Selection Probability

Within this section, representative parameters are chosen to examine and elaborate on the evolutionary trajectory of strategy selection via numerical illustrations to validate the system equilibrium outcomes. The baseline values assigned to each parameter within the game model are designated as presented below: $\lambda_1=0.4$, $C_3=8$, $C_5=6$, $K_1=1$, $R_3=1$, $\lambda_2=0.6$, $C_4=6$, $C_6=5$, $K_2=1$, $G=1$, $C=1$, $R=20$.

(1) The effect arising from varying degrees of initial willingness (x, y) among school-enterprise stakeholders on the strategic evolutionary trajectory

The baseline values pertaining to the strategies of school and enterprise (x, y) take the values of $(0.2, 0.2)$, $(0.5, 0.5)$, $(0.8, 0.8)$, and the evolution process of the system is shown in Figure 9. As evidenced by the figure, whether the contemporary vocational college can be effectively established is substantially influenced by the initial willingness of both parties, and a diminished initial willingness of the two parties will exhibit an unfavorable disposition toward joint development and allocate fewer resources in the joint endeavor, and the need for the procurement of their own resources can not be fulfilled, ultimately resulting in the breakdown of the collaborative initiative. On the contrary, a more robust initial willingness on the part of both parties will encourage them to channel greater advantageous resources and establish a productive reciprocal relationship, thereby facilitating the effective functioning of the co-construction framework in the early phase.

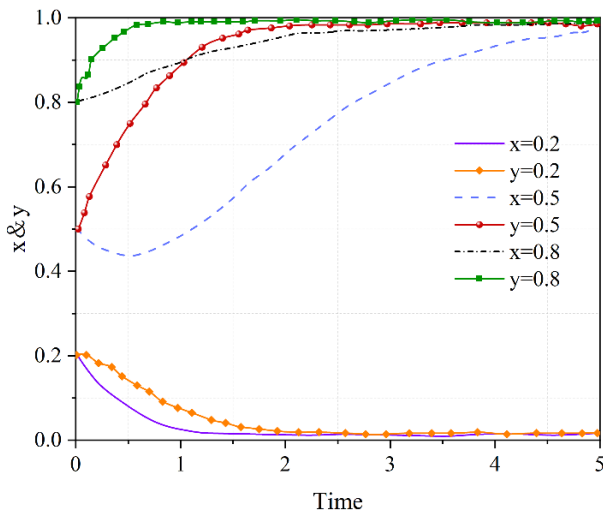


Figure 9: The Influence of x y Changes on Evolution Results

(2) Subsidies provided by the government side to incentivize the co-construction G Impact upon the strategic developmental trajectory

Given that the government subsidy G takes values of 1.5, 2, 2.5, and drawing from prior industry-university-research collaborative experience, it is observable that during the starting stage of the actual construction, the principal stakeholders' participation enthusiasm falls short of expectations, and most of them are guided by governmental policy directives toward achieving collaboration, consequently both sides of the initial willingness to (x, y) take $(0.4, 0.4)$, and the developmental trajectory of the system is shown in Fig. 10. As G increases, the ultimate evolutionary outcome reaches $(1, 1)$, the input cost of both sides of the construction is partially shared by the government, both for the enterprise and the school, a decrease in the quantity of required resource contributions implies that more resource interaction benefits can be gained through the cooperation, thereby generating an inclination toward proactive engagement in order to generate greater economic and societal worth.

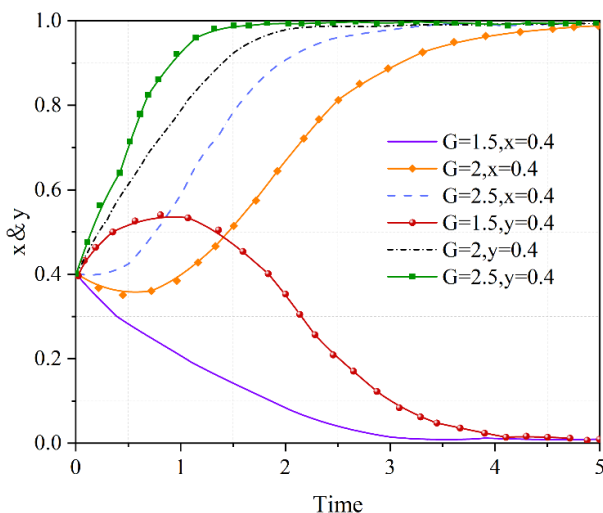


Figure 10: The Influence of G Changes on Evolution Results

(3) Influence of collaborative gain R upon the strategic developmental trajectory under active strategy

Given that the cooperative gain R is 25, 35, 45, the system evolution process is shown in

Fig. 11, and the trajectory of the evolution system progressively transitions from the equilibrium point (0,0) toward (1,1). The more substantial the benefit of active cooperation between the two parties, the faster the two parties choose the active cooperation strategy. Under these circumstances, through co-construction both parties are able to acquire greater external resources to fulfill their respective developmental requirements. Simultaneously, active collaboration can also secure governmental incentives to retain resources. With the aim of continuously securing greater co-build benefits, both parties tend to engage proactively and dedicate construction resources toward benefit maximization.

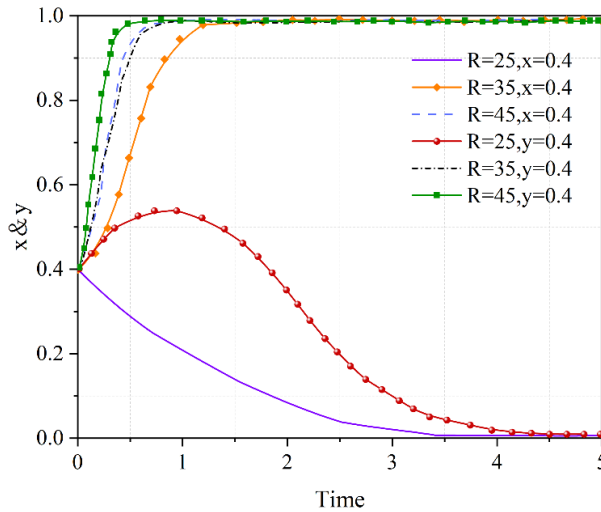


Figure 11: The Influence of R Changes on Evolution Results

(4) The additional resource cost C_3 invested by the school side affects the strategy evolution process

Given that the supplementary expenditure C_3 on the school side is 7, 7.5, and 8, the developmental trajectory of the system is illustrated in Fig. 12, and the state of the system progressively shifts from the equilibrium point (1,1) toward (0,0). From the school side, the supplementary resource cost invested cannot get enough return, and the pace of adopting passive collaboration accelerates in order to minimize further losses. When schools opt for passive cooperation, a diminished contribution of supplementary resources renders the enterprise unable to secure sufficient resources, and further prompts the enterprise to likewise opt to cooperate negatively so as to safeguard their vested interests from being compromised, which eventually results in the collapse of the co-construction mechanism. Therefore, it is evident that the stable functioning of the modern school co-construction framework is susceptible to adverse impacts stemming from the cost of additional resources.

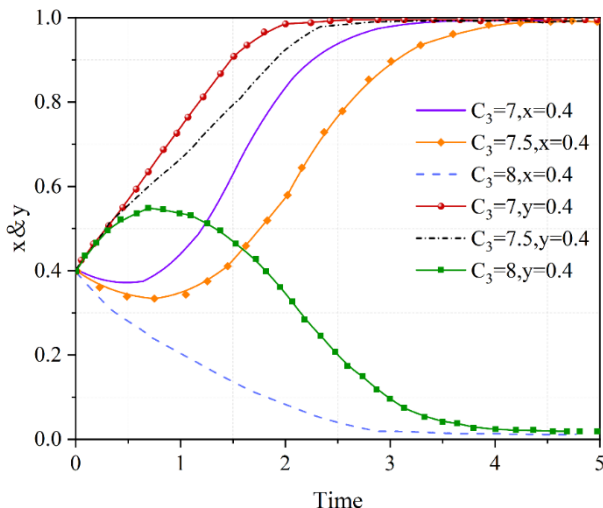


Figure 12: The Influence of C_3 Changes on Evolution Results

(5) Effect exerted by the gain R_3 obtained under the active strategy of the school side upon the strategic developmental trajectory

Given that the gains R_3 from active cooperation of the university side are 7, 7.5, and 8, the evolutionary trajectory of the system is depicted in Fig. 13, wherein the state of the system progressively transitions from the equilibrium point (0,0) toward (1,1). As R_3 incrementally rises, the collaborative returns acquired by the school side through co-construction surpass the expenditure of additional resources that need to be invested. Under such circumstances, the school behavioral approach transitions from passive engagement to active participation in pursuit of greater resources, and this proactive collaboration signal can likewise be conveyed to the enterprise side to enhance the enterprise's motivation toward joint engagement. This shows that the robustness of the organizational co-construction mechanism is favorably influenced by the magnitude of proactive cooperation benefits.

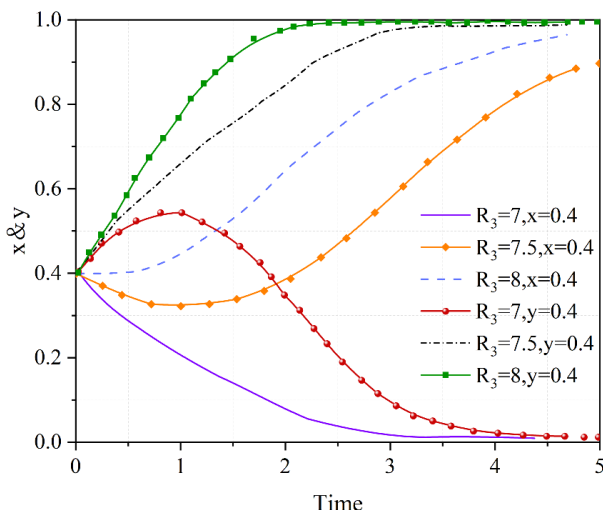


Figure 13: The Influence of R_3 Changes on Evolution Results

(6) The effect of the betrayal gain K_1 obtained under the negative strategy pertaining to the school side upon the strategic developmental trajectory

Given that the defection gains K_1 of the school side are 1, 1.5, and 2, the evolutionary

trajectory of the system is depicted in Figure 14, and the system will ultimately converge to (0,0). As K_1 incrementally rises, the school side remains capable of benefiting from the resource spillover effects from the resources invested by the business side even in the absence of additional contribution of corresponding resources. The higher this gain is, the more serious the phenomenon of free-riding will be, and the pace of adopting the passive collaborative approach will progressively accelerate. The school side adopting this passive engagement strategy will make the enterprise side of the resource input can not get enough revenue, and ultimately also choose to betray the co-construction mechanism. This shows that defection gains impose constraints upon the functioning of the joint construction framework within contemporary vocational institutions.

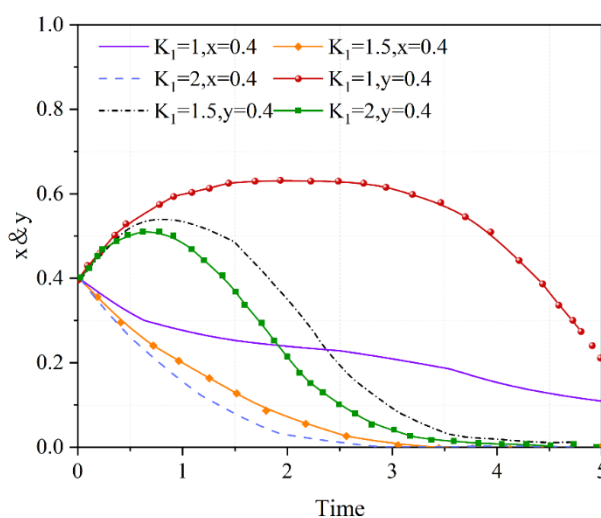


Figure 14 The Influence of K_1 Changes on Evolution Results

4 Implementation of the “two-main body” collaborative education of schools and enterprises in the integration of industry and education

(1) Institution-enterprise co-construction of vocational colleges to realize the effective docking pertaining to the alignment of workforce supply and demand.

Facing the specialized technology alongside other equipment production sectors within the region, vocational as well as technical colleges, with the goal of education-employment synergy and mutually beneficial advancement as the driving force, have established "technical colleges" and "professional classes" with enterprises in the region to coordinate the resources of both academic institutions and industry partners, and collaboratively nurture technical and proficient personnel across applied technology, automation technology and other specialties that are urgently needed by industries in the region. With the goal of cooperative education and employment-oriented and the impetus of cooperative development, the College has established "Technical College" and "Professional Classes" with enterprises in the region, coordinating the shared assets of academic institutions and industry counterparts, and collectively cultivating technical as well as skilled talents in applied technology, automation technology and other specialties urgently needed by the industries in the region, so as to effectively dock the vocational colleges in nurturing and supply of technically proficient and practically skilled personnel with the needs of enterprises in the region.

(2) Relying on the practical training base of school-enterprise collaborative frameworks,

building an infrastructure supporting joint education among schools as well as enterprises

Technical colleges and regional enterprises have jointly built industry-education fusion technology training bases integrating workforce development, technological application innovation and advancement, standard development alongside community service, and carry out the training of skillful talents in specialized technology in the form of the environment around the school. Simultaneously, vocational and technical institutions relying on other applied technology co-innovation center, artificial intelligence applied technology co-innovation center, CNC technology productive training base of teachers and equipment advantages, and regional enterprises to cooperate with the opening and realize the mass production, for enterprises to create a lot of economic benefits, and effectively promote the motivation among enterprises to engage in the development of technical and skilled personnel.

(3) Two-way penetration and mutual recruitment of teachers to carry out modern apprenticeship personnel development

With the aim of continuously strengthen the construction of "two-teacher" team, the Vocational and Technical College builds teacher training bases with enterprises in the region, and sends teachers to enterprises every year to carry out practical skills upgrading exercises. At the same time, the college employs senior engineers from enterprises in the region to guide the construction of the college's technical and other specialties, and carries out the development of technically competent and practically skilled individuals through the modality of contemporary apprenticeship programs, which effectively improves the relevance and efficacy of personnel cultivation.

(4) Strengthening the institution-enterprise collaborative framework and fostering the profound convergence of industry and academia

Taking cooperative education and collaborative development as the foundational premise, the Vocational and Technical College has established strategic partnership agreements with industry partners in the region, and continuously optimized and improved the institutional framework of institution-enterprise collaboration and collaborative training through the establishment of rules as well as regulations such as "Measures for the Management of Students' Internships", "Measures for the Management of Industry-Teaching Integration Training Bases", "Measures for the Management of the Transformation of Achievements in Applied Technology", etc., and has gradually formed the principle of "common education, common management, and common sharing of achievements". It has gradually formed a sustainable institution-enterprise collaborative framework encompassing "talent co-cultivation, process co-management and achievement sharing", which has substantially advanced the realization of profound convergence between industry and academia.

5 Conclusion

The present study constructs an iterative strategic interaction framework of university-enterprise partnership strategy incorporating government backing, academic institutions, and enterprise participation grounded in evolutionary game theory, and divides the synergistic mechanism of university education organization for industry-education integration into synergistic parenting motivation mechanism and quality assurance mechanism. Through iterative gaming and simulation, findings reveal that the benefit/expenditure structure of the collaborative parenting stage pertaining to industry-academia integration alongside the influence of the behavioral strategies of the government, universities, and enterprises of the three parties. Based on this, the present research proposes the actionable roadmap of university-enterprise double-body collaborative training to facilitate industrial advancement and economically sustainable high-caliber growth.

Funding

This work was supported by:

1. Provincial Quality Engineering Project of Colleges and Universities of Anhui Provincial Department of Education in 2022: Chinese-Characteristic Apprenticeship for the Major of Modern Logistics Management (Project No.: 2022tsxtz060);
2. Provincial Quality Engineering Project of Colleges and Universities of Anhui Provincial Department of Education in 2022: Teaching Innovation Team for the Major of E-Commerce (Project No.: 2022cxtz151);
3. Construction Project of the Cultivation Repository for Anhui Vocational Education Innovation and Development Pilot Zones: Research and Construction of the Talent Training System for Higher Vocational Modern Service Major Group under the "1+X Certificate" System (Project No.: WJ-ZYPX-017);
4. Excellent Top Talent Training Project for Colleges and Universities of Anhui Provincial Department of Education in 2022: Domestic Visiting and Advanced Study Program for Excellent Young Backbone Teachers in Colleges and Universities (Project No.: gxgnfx2022138);
5. Constellation Engineering Project of Lu'an Vocational and Technical College: Research and Practice on the Modern Apprenticeship Talent Training Mode for the Major of Logistics Management (Project No.: 2020QXZGC18).

About the Author

Yong Wen was born in Lu'an, Anhui, P.R. China, in 1981. He obtained a master's degree from the University of Science and Technology of China. He is currently working at the School of Economics and Management, Lu'an Vocational and Technical College. He holds the title of Associate Professor. His main research directions are economic management and higher vocational education management.

References

- [1] Wang, Y., Jiang, Y., Tian, S., Zheng, Y., Zhou, S., & Huang, H. (2023). Research on the four collaborative innovation mechanisms of industry-education integration based on the concept of community. *Journal of Educational Technology and Innovation*, 5(4).
- [2] Guan, Y., Liu, Y., Liu, J., & Sun, Y. (2025). Exploration of the Integrated Vocational and General Education Talent Cultivation Model in Higher Education from the Perspective of Industry–Education Integration. *Journal of Modern Education and Culture*, 2(4).
- [3] Chi, C., Yue, Y., Zhong, K., Zhang, Y., & Leid, V. N. L. (2022). Research on cultivation model of innovative and entrepreneurial talents with new technology applications in higher education institutions. *Journal of Educational Technology and Innovation*, 4(1).
- [4] Rakhimovna, B. N. (2024). Integration of theory and practice of the dual education system in the field of light industry education. *European International Journal of Multidisciplinary Research and Management Studies*, 4(02), 336-341.
- [5] Du, M., Abdurahman, A. Z. A., Voon, B. H., & Hamzah, M. I. (2022). Developing and leading for industry-education integration service in vocational and technical colleges.

- International Journal of Industrial Management, 13, 464-470.
- [6] Orozco, M., Gijbels, D., & Timmerman, C. (2019). Empirical conceptualisation of integrative learning. A focus on theory-practice integration in technical vocational education and training. *Vocations and Learning*, 12(3), 405-424.
- [7] Mahalingam, T. (2024). Bridging the gap between academia and industry: a case study of collaborative curriculum development. *International Journal of Business Performance Management*, 25(4), 589-603.
- [8] Song, Y. (2024). Research on the Training Path of “Dual-Qualified” Teachers in Higher Vocational Colleges under the New Vocational Education Law. *Journal of Modern Educational Theory and Practice*, 1(4).
- [9] Zhai, L., & Yang, Q. (2023). Training Mechanism of the “Double Teacher” Teaching Team in Higher Vocational Undergraduate Colleges under the Background of Integration of Industry and Education. *Advances in Vocational and Technical Education* (7).
- [10] Zhong, Y., Liu, W., Wu, S., & Li, Y. (2024). A study on the path of teacher team building for training field engineers based on symbiosis theory. In *SHS Web of Conferences* (Vol. 187, p. 03008). EDP Sciences.
- [11] Lan, C. C. (2021). Industry instructors' perspective on internship implementation strategy. *Higher Education, Skills and Work-Based Learning*, 11(3), 739-756.
- [12] Alaraj, H., Allelin, M., Amundsen Bergström, M., & Brudin Borg, C. (2019). Internship as a mean for integration. A critical study. *Journal of International Migration and Integration*, 20(2), 323-340.
- [13] Wang, B., Liang, K., & Yuan, F. (2024, November). Research on Strategies for Enhancing the Employment Competitiveness of Computer Science Graduates Under the School Enterprise Cooperation Model. In *International Conference on Computer Science and Educational Informatization* (pp. 103-110). Singapore: Springer Nature Singapore.
- [14] Yu, K., & Tsao, H. J. (2024). Research on the Challenges and Paths of Industry Education Integration in Vocational Colleges. *International Journal of Education and Humanities*, 15(3), 303-307.
- [15] Wang, Z., & Zhang, S. (2025). Research on the Cultivation of Skilled Innovative Talents and the Coordinated Development of Regional Economy from the Perspective of Industry-Education Integration. *Journal of Social Science and Cultural Development*, 2(4).
- [16] Liu, Y., Wang, C., & Chen, Z. (2024). Cultivation of Highly Skilled Talents at the Bachelor degree of Vocational Education in Major Iron and Steel Metallurgy--Exploration Under the Background of New-Quality Productive Forces From the Perspective of Industry-Education Integration and School. *International Journal of Educational Teaching and Research*, 1(3).
- [17] Zhao, W. (2024). Innovation and practice of talent cultivation models in higher education from the perspective of industry-education integration. *Higher Education Practice*, 10,

h241515.

- [18] Li, T. (2025). Research on the Construction of an Integrated Education Model for "Technical and Skilled Talents" in Finance and Economics Majors under the School-Enterprise Cooperation Model. *Journal of Modern Education and Culture*, 2(7).
- [19] Wang, L. (2023). Research on Practical Teaching System of Information Industry Talent Training in Higher Vocational Colleges Under the Background of Industry Education Integration: The Case of Chongqing C Vocational College. *Journal of Education and Educational Research*, 4(1), 75-81.
- [20] Li, J., & Wang, H. (2023). The explore of college talent training mode under the city of production-education integration. *Adult and Higher Education*, 5(3), 94-101.
- [21] Yangyang, L., & Lisha, M. (2019, October). Study on the Cultivation of Applied Talents and the Reform of Curriculum System in Universities Based on the Integration of Production, Teaching and Research. In *2019 International Conference on Advanced Education, Service and Management (Vol. 3, pp. 155-160)*. The Academy of Engineering and Education.
- [22] Fang, Y., & Shi, Y. (2025). CULTIVATING CORE COMPETENCIES FOR AGRICULTURAL HUMAN CAPITAL: THE ROLE OF INDUSTRY-EDUCATION INTEGRATION IN CHINA. *Journal of economic Education*, 14(1), 30-47.
- [23] Zhu, M. (2024). Research on Talent Cultivation in Digital Media Technology at Vocational Colleges Under the Modern Apprenticeship System. *Journal of Humanities, Arts and Social Science*, 8(8).
- [24] Wang, K. (2024). Research on Talent Cultivation Mode Based on Industrial Colleges: Taking TCL Ace Industry College of Huizhou Technician Institute as an Example. *Journal of Higher Vocational Education (ISSN: 3005-5784)*, 1(3), 25.
- [25] Ye, D., Tan, Y., & Wang, S. (2024). Reform and Practice of Cultivation Mode of Top Talents in Product Design Specialty under the Background of Industry-Teaching Integration. *Advances in Humanities and Modern Education Research*, 1(1), 98-104.
- [26] Ling, L. (2024). Research on the path of integration of industry and education in vocational education from the perspective of " symbiosis" theory. *Frontiers in Educational Research*, 7(8), 166-170.
- [27] Wanqi, Z. (2024). Analysis of the Functions and Optimization Strategies of Vocational Education Industry-Teaching Integration Service Organizations. *International Journal of New Developments in Education*, 6(6).
- [28] Peng, C. (2019). Research on the construction of the training plan of the compound navigation technical talents under the mode of the deep integration of industry and education. *Frontiers in Educational Research*, 2(10).