

Research on the Emergence Mechanism of High-Skilled Talent Cluster Cultivation from the Perspective of Complex Adaptive System Theory

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Abstract

In response to the demand for industrial upgrading, the cultivation of high skilled talent clusters has become a key path for vocational education reform. Based on the theory of Complex Adaptive Systems (CAS), this article defines the cultivation of high skilled talent clusters as a complex adaptive system with harmonious coexistence of multiple agents. It analyzes its core characteristics such as aggregation, nonlinearity, flow, and diversity, and constructs an "environment subject process emergence" analysis model. Based on the case of the new energy vehicle industry cluster, compare the differences in training modes in different regions, and draw on the experience of national teaching achievement awards to extract key elements of incentive mechanisms. The study proposes a three-tier incentive system and practical path, aiming to break through the barriers of industry education integration through multi-party collaboration, rule optimization, and resource coupling, promote the emergence of high skilled talents at the individual, collective, and system levels, and provide support for the high-quality development of vocational education and the supply of industrial talents.

Keywords

high skilled talents; Cluster cultivation; Complex adaptive systems; Emergence mechanism

Introduction

As of September 2025, the total number of skilled workers in China has exceeded 220 million, accounting for more than 27% of the employed population, and the number of high skilled talents has exceeded 72 million. Accounting for 32.7% of skilled workers, providing support for Chinese path to modernization. Compared with developed countries and neighboring countries in East Asia, there is a significant gap: firstly, the proportion of high skilled talents is relatively low. China's 32.7% proportion is far lower than the nearly 50% level in Germany and Japan, and

the population proportion is only 5%, which is less than one seventh of the 40% in developed countries; Secondly, the talent structure is poorly adapted to the industry, and a reasonable structure of "senior leadership and intermediate subjects" has not been formed, resulting in insufficient supply of high skilled talents in emerging fields.

The cultivation of high skilled talents undoubtedly requires education based on production, education guided by production, education transformed from production, and education promoted by production. However, currently, talent cultivation lags behind market demand. There is flexibility in policies and regulations, as well as inconsistency in standards. Standards play a fundamental role in improving the quality of vocational education and require the establishment of a linkage mechanism. There are also short-sighted reasons for interest games, and at the same time, there is a lack of integration methods and unclear cooperation subjects. There is a lack of macro level guarantees such as systems, mechanisms, and platforms, as well as operational measures such as methods, norms, and evaluations. How to build an effective collaborative mechanism of "benefit sharing and responsibility sharing".

Vocational education bears the important mission of cultivating high skilled talents for the construction of a modern industrial system. Cluster training, as a systematic and collaborative new model, is gradually becoming a key path to explore the intrinsic value of cultivating high skilled talents in vocational education. The connotation of cluster cultivation lies in upgrading the paradigm of industry education integration through system reconstruction. Its core is based on system theory and human capital theory, promoting the collaboration of multiple subjects, deep coupling of resources, and linkage of element systems, transforming traditional scattered school enterprise cooperation into a sustainable ecological education system. To maximize the efficiency of cluster cultivation, it is necessary to establish a scientific mechanism, identify common and compatible interests between schools and enterprises, systematically reconstruct the underlying logic of education and teaching, and promote a pattern change in vocational education and teaching.

1. The cultivation of high skilled talents is a complex adaptive system

Neil John proposed, "Two are companions, and three is complexity." As long as a group of people gather together, they will influence and compete with each other in complex ways, forming a complex system. The theory of Complex Adaptive Systems (CAS), as an important branch of complexity science, is a sublimation and crystallization of complex system theory. Since its proposal by Holland in 1994, it has attracted widespread attention in the academic community and has been widely applied in fields such as economics, ecology, and social systems. Holland

summarized 7 basic characteristics of complex adaptive systems, including 4 features (aggregation, nonlinearity, flow, diversity) and 3 mechanisms (identification, internal model, building blocks). These 7 basic characteristics are necessary and sufficient conditions for complex adaptive systems. Every complex adaptive system possesses these 7 basic points, and a system that possesses these 7 basic characteristics must also be a complex adaptive system.

Complexity and adaptability are the basic characteristics and inherent requirements of vocational education industry education integration. The cultivation of high skilled talent clusters is a complex adaptive system that harmoniously coexists with industry systems, industry systems, and education systems. It has openness, relative independence, and adaptability, and contains complex characteristics such as complex fields, complex attributes, complex subjects, and complex content.

The concept of high skilled talents has undergone a historical evolution from "craftsmen", "technicians" to "knowledge workers", possessing exquisite skills that general skilled talents do not possess, as well as the ability to solve complex, critical, and unconventional practical problems. Drawing on the definition of Holland, the founder of complex systems theory, this article defines "the emergence of high skilled talents" as: new abilities, patterns, and achievements that systematically emerge in a cluster training system through nonlinear interactions between multiple subjects, surpassing the simple sum of individuals (such as collective technological research capabilities, self-organizing industry skill standards, and super linear growth of talent groups) (Holland, 1998). This process is closer to the category of "weak emergence" elaborated by Mitchell, that is, its mechanism of generation can be understood in principle by analyzing the elements and their interactions at various levels of the system (Mitchell, 2009). At the same time, drawing on the critical realism perspective of sociology, this article regards talent cultivation clusters as a social structure with emergent attributes. It is constructed by the actions of various participating entities and, as a relatively autonomous whole, continuously shapes individual behavior and opportunities (Archer, 1995). This integrated perspective provides a meta theoretical basis for constructing an analytical model of "environment subject process emergence" in this study.

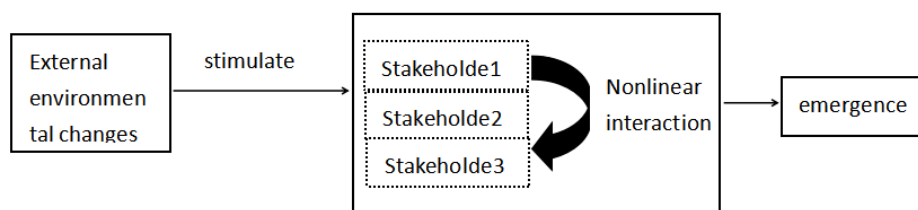


Figure 1. The emergence model of high skilled talent cluster cultivation: a multi-layer dynamic framework

Model interpretation: This model depicts a multi-level dynamic system aimed at revealing the internal mechanism (black box) of how "cluster cultivation" leads to

"talent emergence", in order to explain how high skilled talents achieve "emergence" through cluster cultivation. The macro context layer sets the initial parameters of the system. The actor and interaction layer is the core explanatory layer, and heterogeneous actors (government G, enterprise F, university U, etc.) engage in repeated games through multi loop collaborative processes under the constraints of formal and informal interaction rules. This process dynamically shapes the social network structure among actors (density, centrality, structural holes, subgroups), which in turn determines the flow patterns of knowledge, resources, and opportunities, thereby affecting the effectiveness of collaborative processes. The platform and carrier of the regulatory layer provide infrastructure for interaction. When a virtuous cycle of interaction causes system parameters (such as network density and structural hole richness) to exceed critical thresholds, the overall properties of the system undergo a phase transition, resulting in emergent properties at the individual, collective, and system levels in the outcome layer.

2. Investigation on the main structure and collaborative process of high skilled talent cultivation based on the new energy vehicle industry cluster

As a typical complex adaptive system, industrial clusters are deeply bound to the local context in terms of their "emergence effect" and success path. The formation and development of high skilled talent clusters is itself a complex evolutionary process of a "talent ecosystem". Its structure and efficiency, like industrial systems, are deeply rooted in the local context and exhibit distinct situational dependence and path creation characteristics.

The differentiation logic of local industrial development. Local governments in China play a core role in industrial development, but their behavior patterns vary significantly. One is the "market innovation" model represented by Hefei, where the government builds emerging industrial clusters from scratch through strategic venture capital. Another type is the "institutional transformation" model represented by old industrial bases such as Tianjin, which is deeply constrained by the industrial path and institutional heritage formed by history. The transformation process is manifested as the activation and reconstruction of existing resources.

A comparative perspective based on institutional logic. The development logic of industries in different regions will shape vastly different ecosystems and pathways for the "cluster cultivation" of high skilled talents. Drawing on the theory of skill formation system (Thelen, 2004), we propose a comparative framework based on "initial conditions dominant logic collaborative process". We believe that the "market creativity" model will give rise to a goal driven and agile collaborative network, while the "institutional transformation" model will form a rule-based and deep negotiation collaborative network. These two network structures will affect the scale, speed, and quality of the emergence of high skilled talents through

different micro mechanisms. The differences in various paths are essentially different strategic choices for building local talent ecosystems and industrial resilience under different initial conditions.

3. Construction of a cluster training mechanism for high skilled talents

The National Teaching Achievement Award for Vocational Education in China is the highest award in the field of vocational education teaching in China, representing the highest level of vocational education teaching work in China. This award is reviewed every four years and is the highest level of reward in the field of education and teaching, representing the highest level of education and teaching work. Intended to strengthen the pertinence and effectiveness of vocational education teaching, promote the deepening of educational and teaching reform, and facilitate the sharing of regional vocational education resources and the exchange of teaching experience.

Based on the public information of the National Vocational Education Teaching Achievement Awards in the past decade (especially in 2017, 2018, and 2022), three types of incentive mechanisms for the integration of industry and education have been sorted out. Firstly, personnel incentives. The core is to 'make people willing to do' and solve the problem of individual motivation. Secondly, organizational incentives. The core is to "make units willing to promote" and solve the institutional motivation problem of secondary colleges and enterprise departments. Thirdly, environmental incentives. The core is to reduce system risks and promote value circulation, and to address the issue of external institutional safeguards. When it comes to cultivating high skilled talents, we must design a set of incentives that make participants (students, teachers, engineers) feel that "collaborating deeply with others and contributing unique knowledge" is a choice that maximizes their own interests, rather than going it alone or accumulating knowledge.

Merely gathering a large number of individuals together is far from sufficient to generate collective intelligence. Through a systematic analysis of the content of the teaching achievement award, the key institutional elements that promote the long-term development of school enterprise cooperation can be summarized, namely the influencing factors of multiple dimensions such as "governance interests personnel resources standards". For example, simply building a base is not enough to deepen the integration of industry and education. It must be accompanied by "benefit sharing" and "mutual recruitment of teachers". Therefore, a three-tier incentive system needs to be constructed. The first layer is the measurement and return of the "unique value" of individual contributions. The second layer, the "structural hole" reward goal of cross-border collaboration, is to motivate people to connect knowledge islands in different fields, which is the key to emergence. The third layer, the feedback goal of "co evolution" of collective achievements, is to

enable the system to learn from success and solidify the collaborative mode.

The 'boundary practitioner' is the key to connecting different communities of practice. They can understand the jargon, norms, and values of different groups, and can translate, coordinate, and mediate between them. In the process of skill formation, excellent "dual teacher" teachers and trainers who have transitioned from enterprises are precisely such boundary practitioners. We should improve the exchange mechanism between practitioners at the school enterprise boundary, establish a pool of high skilled talents, and promote the rational flow of high skilled talents.

In short, the cultivation of high skilled talent clusters requires the integration of industry, enterprise, and school forces, the establishment of reform clusters, and the overall design and systematic promotion of key teaching elements such as vocational education majors, courses, textbooks, teachers, internships, and practical training, in order to promote the transformation of talent cultivation from traditional knowledge imparting to comprehensive ability enhancement.

References

- [1] Holland J H. Hidden Order: Adaptability creates complexity Zhou Xiaomu, Han Hui, translated [M] Shanghai: Shanghai Science and Technology Education Press, 2000.
- [2] Melanie Michelle Complex [M] Hunan Science and Technology Press, 2018.
- [3] Neil Johnson, Simple Complexity [M]. CITIC Press, 2022.
- [4] John H. Holland, Emergence: From Chaos to Order. Addison-Wesley, 1998.
- [5] Pan Haisheng, Zhang Yufeng Research on the complex endowment, internal mechanism, and operational mechanism of vocational education industry education integration, 2023.
- [6] Yu Sha, Wang Jiajia The operation mechanism and construction path of urban industry education alliance: based on the perspective of complex adaptive system theory [J]. Vocational Education Communication, 2025 (3): 14-21.
- [7] Relaxation Research on Vocational Ability Cultivation of High skilled Talents, [M]. Tianjin: Tianjin Education Press, 2023, p. 84.