

Research on the Cultivation Mechanism of Scientific and Technological Innovation Talents in Colleges and Universities under the Vision of Collaborative Innovation Network*

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Abstract—As one of the core nodes of collaborative innovation network, colleges and universities play a key role in the cultivation of scientific and technological innovation talents. The cultivation of scientific and technological innovation talents must be systematically built in the logical framework of collaborative innovation network. The collaborative innovation network consists of the core innovation layer and the external innovation platform layer, which achieve collaborative innovation through the collaborative interaction with the external environment in the close connection of each node. Under the vision of collaborative innovation network, the collaborative cultivation mechanism of scientific and technological innovation talents in colleges and universities is composed of four parts: the internal self-cultivation mechanism of colleges, the collaborative cultivation mechanism of industry and education, the collaborative cultivation mechanism of schools and institutes, and the collaborative cultivation mechanism of colleges and innovation platforms. The design and implementation of the collaborative cultivation policy of scientific and technological innovation talents in colleges and universities shall be systematically carried forward from the perspectives such as improving the system of self-cultivation of scientific and technological talents guided by innovation, establishing a model of collaborative talent cultivation of school-enterprise collaborative school running, promoting the school's substantive cooperation with the institutes and strengthening institutional environment protection for platform service institutions.

Keywords—*collaborative innovation network; scientific and technological innovation talents; collaborative cultivation mechanism*

*Fund program:

1. "Driving Mechanism and Countermeasures of Scientific and Technological Talent Innovation: From the Perspective of Self-Determination Theory" (J17RA134) of the humanities and social sciences program project of colleges and universities in Shandong province;
2. "Research on the Cultivation Mechanism of Scientific and Technological Innovation Talents in Colleges and Universities under the Vision of Collaborative Innovation Network" (YBKT201714) of research topics on higher education in 2017 of Qilu University of Technology.

I. INTRODUCTION

It is clearly pointed out in the "Reports of the 19th National Congress of the CPC" of Communist Party of China that, in the past five years of work and historic change, "the innovation-driven development strategy has been vigorously implemented and the innovative country construction has achieved fruitful results", by looking forward to the future, on the journey of realizing "two centenary goals" and realizing the Chinese dream of the great rejuvenation of the Chinese nation, we shall "foster a large number of strategic science and technology talents with international level, technological leading talents, young science and technology talents and high level innovation teams". On May 30, 2016, president Xi Jinping pointed out in his speech at the "national science and technology innovation conference", "To build a world scientific and technological power, the key is to build a team of innovative talents with a large scale, reasonable structure and excellent quality, which will stimulate the innovation vitality and potential of all kinds of talents". The construction of high-level scientific and technological innovation talent team is the driving force for the realization of "dual-wheel driving" of scientific and technological innovation and institutional mechanism innovation.

Colleges and universities have the teachers and scientific researchers group with the most abundant knowledge capital and the most dynamic and innovative college students group. As an important gathering place for scientific and technological innovation talents, colleges and universities have been carrying the important mission of science and technology innovation and are the main force of leading the innovation of science and technology. In the strategic plan of "double first-class" construction in domestic universities, the important construction tasks of building first-class teaching staff, cultivating outstanding innovative talents and improving the level of scientific research have been also clearly put forward. The cultivation mechanism of scientific and technological innovation talents in colleges and universities determines the quality and quantity of scientific and technological innovation talents in colleges and universities, which directly affects the

overall strength and level of China's scientific and technological innovation. Scientific and technological innovation is difficult to move forward by itself, in the open interaction of "industry-university-research" collaborative innovation network, it is the inevitable choice of scientific and technological innovation to realize multi-subject resource sharing and innovation cooperation. The research on the cultivation mechanism of scientific and technological innovation talents shall be carried out in the framework of collaborative innovation network.

II. REVIEW OF RELATED STUDIES

The basic theoretical research on the cultivation of scientific and technological innovation talents abroad is relatively mature and their practical results are outstanding. In terms of practice, the developed countries attach great importance to the cultivation of scientific and technological innovation talents and formed a relatively systematic three-in-one cultivation model of "industry-university-research". Under the guidance of the principle of "intelligent and innovative country", Japan has gradually formed the cultivation mode of "industry-government-university combining" which is characterized by government dominance. The theoretical research abroad provides us with the basic theory and research perspective reference mainly from the perspectives of psychology and behavior, for example, the theory of self-determination (SDT) proposed by the American psychologists Deci Edward L. and Ryan Richard M. et al. in the 1980s discusses the great driving effect of independent environmental support on motivation from a positive personality perspective, which provides an important basis for the cultivation of innovation ability. Matson and Patiath et al. have conducted a research on the cultivation, evaluation and influence on economic development of innovative scientific and technological talents and other relevant contents. Swanson and Holton set forth the framework for the development of innovative abilities of the scientific and technological talents, which demands to carry out a comprehensive cultivation from the supply and demand balance system of human resources, configuration system, quality improvement system, capacity utilization system and other subsystems.

The cultivation of scientific and technological innovation talents is also a hot issue in domestic research. Domestic scholars have analyzed the construction issues of the incentive and guarantee mechanism of scientific and technological innovation talents from multiple perspectives, Zhou Xuejun (2013) conducted an empirical study on the correlation between science and technology investment, talent flow and the composite efficiency of science and technology talents (1); Jin Zhenxin (2011) constructed the GERT network model of regional innovative scientific talent cultivation and policy design based on the theory of "life cycle"(2); Gao Shuyu (2013) put forward the idea that the framework of the training mechanism of the entrepreneurial ability of the engineering scientific and technological talents shall be established from the driving mechanism construction at the individual level (3); Wang Rui (2014) found that the learn ability, self-control and dominance of the personality traits of scientific and technological talents have significant influence on their

innovation behaviors (4). Many achievements have provided rich theoretical results for the research of talent cultivation mechanism, but they are mostly emphasized on the role of talent cultivation in a single mechanism, and not much attention was paid to the research of collaborative cultivation.

The research on the field of scientific and technological innovation talent cultivation in colleges and universities is also not sufficient. Huang Xiaoping (2017) used qualitative research and quantitative research to establish a five-factor quality structure model based on "innovative scientific and technological talents", which has enlightenment and reference significance to the cultivation of innovative scientific and technological talents in our country (5); Li Jun et al. (2017) emphasize that we shall pay close attention to the collaborative development of scientific research, teaching resource allocation and knowledge coding ability on the talent cultivation in colleges and universities based on the Logistic model of the knowledge triangle (6); Zhu Deyou (2010) systematically discussed the incentive mechanism of university teachers from the perspectives of architecture, system, function and regulation. The research on the cultivation mechanism of the scientific and technological innovation talents in colleges and universities in China is mostly confined to the scope of university system (7). A few research attempts on collaborative innovation of universities are also limited to the studies among colleges and universities (Zhang Baoge, 2015) (8) or on the two-way connection between universities and research institutes (Wu Zhi, Sun Xia, 2010) (9), but the research on multi-agent collaborative network mechanism which is compatible with the open collaborative innovation law is rare.

It can be seen from the review of the present situation of domestic and foreign researches that, the research on the cultivation of scientific and technological innovation talents has become a hot research issue, however, the research on the cultivation mechanism of scientific and technological innovation talents in colleges and universities is still not sufficient which is far from meeting the actual needs of the development of innovative talents, and the targeted research conforming to the development law of collaborative innovation is still insufficient.

III. CONSTRUCTION OF COLLABORATIVE INNOVATION NETWORK

The nature of collaborative innovation is an innovative organization model of large span integration carried out by the enterprises, government, knowledge production institutions (universities & research institutions), intermediary organizations and users, etc in order to achieve major scientific and technological innovation. The key is to form a multi-subject collaborative interactive network innovation model (10), of which the core elements are universities, enterprises and research institutions and the auxiliary elements are government, financial institutions, intermediary organizations, innovation platforms, non-profit organizations, etc. Through the collaborative innovation network formed by the integration of multiple innovative subjects, the collaborative innovation can realize the continuous generation of innovation and the amplification effect of the achievements.

Freeman (1991) was the first official proposer of the concept of innovative network, he believes that the innovation network is a basic institutional arrangement to deal with systemic innovation and the main binding mechanism of network architecture is the innovation cooperation between enterprises. Innovation network is not a simple concept of innovation cooperation, according to the definition specified by Freeman, its meaning includes the all kinds of formal and informal cooperative relations formed in the process of innovation of the enterprises; therefore, enterprises are at the center of innovation network. The cooperative relationship among enterprises and universities and research institutions is a pattern of manifestation of innovation network, in addition, there are various other types of formal and informal cooperation 11. Therefore, the innovation network in a region refers to the sum of each node and its connection, which is an informal organizational form and a cooperative group 12. The participants of innovative jointly participate in the formation,

development, production and marketing of new products, which establishes direct and indirect, reciprocal and flexible relationships among science, technology and market through interaction. From the regional perspective, the innovation network is a relatively stable system formed on the basis of long-term formal or informal cooperation and communication among the local adaptive agents¹³.

Therefore, collaborative innovation network is essentially a self-gain cycle innovation ecosystem, which has the characteristics of self-organization, complexity, dynamics and systematicness. Through collaboration in network relations, resource sharing, knowledge transfer and technology diffusion can be realized, and through the non-linear network relationship in the system, the innovation subjects can interact with the external environment in material, energy and information 14. The inter-node relationship and network structure of collaborative innovation network are shown in "Fig. 1".

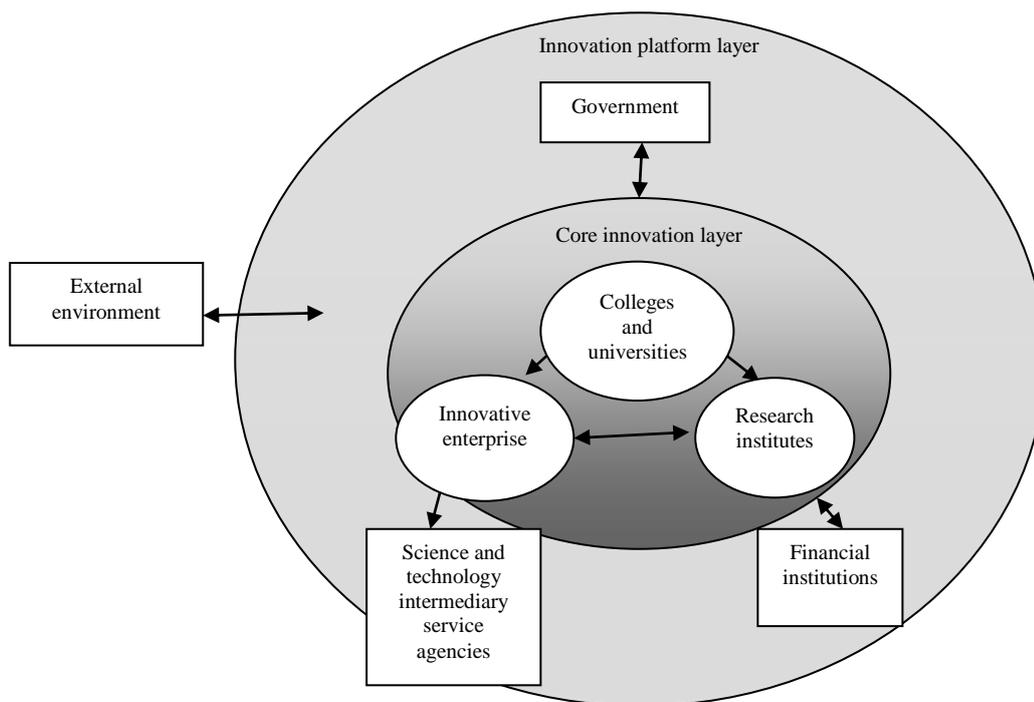


Fig. 1. Structure diagram of the collaborative innovation network.

A. Core Innovation Layer

Enterprises, universities and research institutes are the core bodies of scientific and technological innovation. Among them, enterprises are the main actors of collaborative innovation network which are in the central position in the collaborative innovation network and are the fundamental driving force of the whole innovation network operation. Universities and research institutes shall work closely with the enterprises on the innovation cooperation to enhance the vitality and capacity of innovation.

B. Innovation Platform Layer

The government, science and technology intermediaries and financial institutions and other institutions have a direct impact on the innovation ability and collaboration ability of the core subjects of science and technology innovation, it provides an important platform for the collaborative innovation of science and technology, which determines whether and to what extent the core innovation layer can make collaborative innovation.

C. Collaborative Interaction with External Environment

The external environment includes the transformation power of economic development, complexity of technical

environment, knowledge dispersion and mobility, competitive pressure and so on, which is the macro-environmental dynamic mechanism of collaborative innovation network operation and development. Therefore, the collaborative innovation network must maintain an open interaction with the external environment.

Different collaborative layers contains the strategic collaboration, organization collaboration, knowledge collaboration and industrial chain collaboration among each node as well as the system collaboration and resource collaboration among different layers, the various layers are interpenetrating and open connected, which forms a self - gain spirally ascending circular ecosystem in the process of dynamic self-organization.

IV. CONSTRUCTION OF COLLABORATIVE CULTIVATION MECHANISM OF SCIENTIFIC AND TECHNOLOGICAL INNOVATION TALENTS IN COLLEGES AND UNIVERSITIES

The cultivation of science and technology innovation talents in universities and colleges shall include both the internal cultivation investment in colleges and universities and the collaborative cultivation among the various nodes of the open innovation platform, and effectively guarantee the continuous growth and sustainable innovation of scientific and technological talents by encouraging the shaping of the external atmosphere of innovation. Its cultivation system mainly includes: internal self-cultivation mechanism in universities, collaborative cultivation mechanism of industry and education, collaborative cultivation mechanism of research institute and university and the collaborative cultivation mechanism of universities and innovation platforms.

A. *Internal Self-cultivation of Colleges and Universities*

The universities have the teachers and researchers group with abundant knowledge capital and the creative students group. The universities constantly inspire the innovation and learning ability of the teachers and scientific researchers through the researcher management plan, the scientific research project funding plan, the scientific research achievement awarding plan, the plan of academic exchanges and advanced studies and encouraging the shaping of research atmosphere of the quest for innovation, etc; and systematically cultivate the students' values, cognitive ability, thinking ability and professional knowledge Through teaching, so as to make college students become the New force for scientific and technological innovation.

B. *Collaborative Cultivation Mechanism of Industry and Education*

It is an important strategy for the systematic cultivation and all-round development of scientific and technological innovation talents to combine the supply of talents in universities with the needs of the society for talents, and integrate industry with education and introduce enterprises into education to promote scientific and technological innovation to produce more fruitful results through promoting the integration of industry and higher education.

C. *Collaborative Cultivation Mechanism of Research Institute and University*

Colleges and universities shoulder the basic functions of talent cultivation, and have systematic student cultivation mechanism and campus culture atmosphere, and it is an important responsibility of colleges and universities to train and cultivate students' practice and innovation ability, and ultimately to train high-level scientific and technological innovation talents. Research institutes are important research institutions, whose responsibilities are more focused on the pursuit of scientific research results and the maximization of result profits. Both of them shoulder important technological innovation missions. Therefore, it is an important mechanism for the growth and cultivation of university researchers to carry out the integration and collaboration of the universities and the research institutes and play the whole effect, at the same time, it is an important mechanism for the cultivation and development of postgraduates that the two sides gather superior resources to jointly train the students.

D. *Collaborative Cultivation Mechanism of Universities and Innovation Platforms*

Government, science and technology intermediary service agencies and financial institutions are not direct participants in innovation, but they provide important institutional environment and lubricant for scientific and technological innovation. Colleges and universities shall rely on innovative platforms created by government, financial institutions and technology intermediaries to seek opportunities to promote the rapid growth of scientific and technological talents, so as to effectively promote the large-scale production of practical scientific and technological innovation achievements.

V. CONCLUSION

The cultivation of teachers of domestic colleges and universities is facing the change period of diversification exploration. Teaching skills and scientific research innovation ability increasingly becomes the key to competition and cultivation; we shall continuously intensify the management mechanism of scientific research talent, training and education investment and practice base construction and so on. The cultivation programs and teaching modes of college students are also in constant reform and innovation, and the talent cultivation mode is gradually specialized and scientific. Under the tide of "mass entrepreneurship and innovation", the teachers and students in colleges and universities have become an important force to integrate into the innovation and entrepreneurship wave. However, there are still some problems such as: the talent contribution rate is low, the talent management mechanism is not flexible, the systematicness and effectiveness of cultivation is insufficient, scientific research and application practice are not matched and the conversion rate of scientific and technological achievements is low. Based on the collaborative innovation network theory, the following policy suggestions are proposed for the cultivation of scientific and technological innovation talents in colleges and universities within the logical framework of collaborative cultivation mechanism:

A. Improve the Self-cultivation System of Scientific and Technological Talents with Innovation as Guidance

It is an important goal of university science and technology innovation talent cultivation to cultivate the potential innovation ability of college students and to promote the output of knowledge achievements from various angles. We shall constantly improve the cultivation mode of innovative talents, vigorously promote the inquiry-based teaching, and focus more on the cultivation of innovation ability than the knowledge transfer; we shall vigorously reform the curriculum system based on the ability of scientific and technological practice and technological innovation; we shall explore the innovative talents - oriented scientific research training and practice to improve students' innovative consciousness and ability and arouse students' enthusiasm for in-depth research and innovation; we shall stimulate the innovation enthusiasm of students from multiple perspectives and cultivate and stimulate the innovation ability of university teachers by multi-measures through setting up the innovation projects and awards for students at all levels. We shall perfect the system of research and study inside and outside the school for university teachers and employ the leading talents in the fields of scientific research or industry to give full play to their roles of teaching, assisting and guidance. We shall build a new system of long-acting evaluation for teachers' development based on quality and innovation, and standardize the construction of scientific research management system to ensure reasonable appropriation of funds. We shall create an academic environment that is liberal, encourages innovations and tolerates difference so as to encourage research and development group members to innovate.

B. Construct An Industry-education Collaborative Talent Cultivation Model of School-enterprise Collaborative School Running

In December 2017, the General Office of the State Council issued A Number of Opinions on Deepening the Integration of Industry and Education, which emphasizes that "we shall deepen the integration of industry and education, closely combine the construction of first-class universities and first-class disciplines with the promotion of economic and social development, and strive to increase the contribution of universities to industrial transformation and upgrading", and let the industry-education integration become the basic institutional arrangement of national education reform and exploration of intellectual resources. It is an important measure to solve the problem of mismatch of talent supply and demand and stimulate the innovative and practical vitality of higher education that we manage to enhance the participation of enterprises in higher education and promote the integration and benign interaction of education and industry.

Colleges and universities shall focus on the construction of cooperation mechanism of win-win cooperation, joint cultivation and collaborative innovation with the enterprises and set up a school-enterprise joint meeting system to discuss the institutional measures and development plans and other issues of school-enterprise cooperation; universities shall strengthen the right of the enterprise to have a say in running the university, and jointly formulate the profession

construction plan and jointly study the course construction plan with the enterprises to constantly innovate the cultivation mode of talents. The two sides will be able to form a harmonious culture of school-enterprise cooperation which integrates campus culture with the corporate culture and promotes the school-enterprise integration and innovation with cultural atmosphere. It is also recommended the two sides establish an industry-education joint research and development platform for cooperation and sharing to seek new growth points and innovation points of scientific research in the process of integration and collision of universities and enterprises.

C. Promote the Substantive Cooperation Between the Universities and Research Institutes to Inject New Vitality into the Construction of Talent Team in Universities

The collaborative school-running mode of universities and research institutes is a new model that focuses on the cultivation and collaboration of innovative talents and aims at the reform of China's higher education talent cultivation model, and it intends to break down barriers between research and teaching and jointly explore the innovative talent cultivation mode suitable for China's current economic and social development requirements with the help of resources inside and outside the universities. 15 The cooperation between research institutes and universities in running schools can promote in-depth cooperation between the two sides in scientific research through complementary advantages and mutual resources sharing. Therefore, the two sides shall actively explore the excellent student recruitment and selection system that meets the requirements of cooperative development to guide excellent students to participate in scientific research. The performance management system of the research staff participating in teaching can be improved by deepening the reform of the personnel management system, and the cultivation of scientific and technological innovation talents can be promoted through the two-way flow of scientific research resources and perfect scientific research cooperation system of the two sides.

D. Build A Favorable Institutional Environment for Scientific and Technological Innovation with the Platform Service Institutions As the Guarantee

Colleges and universities shall strengthen cooperation and communication with government, science and technology intermediary service agencies, financial institutions and other departments to strive for resources for scientific and technological innovation and provide institutional guarantee for the development of scientific and technological talents. The government shall provide necessary policy support and institutional guarantee for collaborative innovation. The science and technology intermediary service agencies shall be developed in an orderly manner to provide professional services for the spread of technology, transformation of achievements and resource allocation. We shall strengthen the financial system's support for scientific and technological innovation, and guide Banks and other financial enterprises to transform their risk preferences for technology-based

enterprises, and adopt various ways to increase support for innovative enterprises.

“Achievements are made by talents and industries are expanded by talents”, as the main gathering place of science and technology innovation talents, colleges and universities should open their doors and take the responsibilities to play their core-node role in collaborative innovation network, so as to let more outstanding talents and scientists with outstanding contributions come forth in the implementation of the innovation-driven strategy and give full play to the role of the vast number of scientific and technological talents and let the science develop prosperously.

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