

The Guangdong Mode of Integration of Science-Education and Industry-Education for Postgraduates in Engineering

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Abstract: Based on the theory of collaborative innovation and the triple helix theory combined with the needs for innovative development in the modern manufacturing industry in Guangdong Province, the construction of open bases as education carriers by the governments was explored in terms of implement joint training for postgraduates in engineering through the integration of science-education and industry-education, to improve the practical innovation ability of postgraduates in engineering. The integration training mode has significantly improved the effectiveness of collaborative education and innovation, and it has become an important talent and intellectual support for Guangdong's modern manufacturing industry. It has further advanced the theory and practice of joint training conducted by governments, industries, universities, and scientific research institutes.

Keywords: Postgraduates in engineering; Scientific research and education; Industry and education; Guangdong Province

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1. Background

1.1. Open bases for joint training of postgraduates

In order to meet society's demand for high-level application-oriented talents, China made professional degrees available for full-time postgraduates in 2009. Followed by the industry's needs, it highlights practical ability training through the integration of science-education and industry-education, therefore joint training by both universities and enterprises are encouraged. The aim is to establish a training mode with Chinese characteristics, which is adaptable to economic and social development for postgraduates studying for professional degrees. In 2017, the 19th National Congress of the Communist Party of China proposed to strengthen the integration of industry and education, as well the college-enterprise cooperation. Accordingly, relevant state departments successively issued several related documents such as "Several Opinions on Deepening the Integration of Industry and Education and A Plan on Advancing a National Pilot Program for the Integration of Industry and Education," where the importance of implementing the integration of industry and education to postgraduate education was further emphasized. In addition, in these documents, it has also been stipulated that a specific platform which serves as a carrier for implementing of the integration of industry and education should be built, to promote vigorously the joint training of postgraduates studying for professional degrees. A document with title "A Development Plan for Professional Degree Postgraduate Education (2020-2025)" was issued in 2020, where a national program was proposed to construct postgraduate joint training bases, to implement the integration of

industry and education by encouraging enterprises and industries to build open postgraduate joint training bases^[1]. Therefore, the urgent task of the current reform of engineering postgraduate training is to construct joint training bases for graduate students, and at the same time to make the training mode of postgraduates in engineering more innovative, thereby graduates can be adopted into the modern high-quality engineering talents. Accordantly, in 2015 open bases for joint training of postgraduates were successively established in the central manufacturing cities such as, Foshan, Dongguan, and Zhongshan by the local governments of Guangdong Province to implement a joint training mode between science-education and industry-education. Further, under the coordination and guidance of the government, the joint training was aimed to solve the problem of the disconnection between training of postgraduates in engineering and fulfill the needs of the industry by establishing a joint training guarantee, communication, and coordination mechanism. Due to the government's exploration to build, an integration of scientific research, education, and industry, this has enriched the mode of engineering postgraduate training. Additionally, the integration mode has provided first-class engineering talents to the development of the modern manufacturing industry in Guangdong. The colleges, universities, and scientific research institutes have provided solutions to key technical issues, serving as an important talent and intellectual support for the innovation-driven development strategy of Guangdong. Therefore, it is theoretically and practically essential to analyze the integration mode in Guangdong Province to improve the mode of engineering postgraduate training, and subsequently facilitate its replication and application in other regional cities.

At present, China's economic development has shifted from a stage of high-speed growth to another level of high-quality development with innovation serving as the main driving force to achieve the country's economic transformation and development. As talents represent the first element and resource of innovation, the issue on how to encourage people to be talents, especially to be high-level innovative talents through education system has become an important subject in the postgraduate education^[2]. Therefore, postgraduate education system directly affects the transformation and development of China's economy and society, it serves as the driving force for the sustainable development of the country's economy. At present, due to the domestic and international double circulation, and domestic circulation of the country's economic development, and the lack of innovative talents and technology, this will contribute to the talent and technology shortage in the country, especially in industrial development. During the training, students should be application-oriented and inter-disciplinary high-level talents for industry, the current engineering postgraduate education should make it clear on how to build a training mechanism for innovative talents, and a new education carrier should be introduced to meet the urgent needs of China's major strategies for high-end talents and key technologies in the new situation^[3].

1.2. Development of joint training of postgraduates

The joint training of postgraduates was firstly introduced into the field of education in the 1980s, which means "exploring to build and improve integration of teaching, scientific research, and production through joint college" to train engineering technical talents who can engage not only in scientific and technological research, but also in the research and development (R&D), design, and debugging of new products^[4]. Since the introduction the training of full-time engineering postgraduates in 2009, the integration of industry and education has become a hot yet difficult issue to achieve. The new technology revolution and education are under rapid development, however, the insufficient implementation of the integration of industry and education in engineering education in China has restricted the collaborative education through the integration of industry and education to a certain extent^[5].

In 2019, Zhao CH mentioned that the integration of industry and education in engineering education in the new era faced three challenges: (1) the adaptability of discipline construction to industrial transformation and upgrading; (2) the integration of the dual subjects of enterprise and university education;

and (3) the effectiveness of the government's macro-control and the supervision of industry associations ^[6]. Subsequently, in 2012 Li CF argued that the joint training base of graduate students in engineering should be the main platform for the joint training of engineering postgraduates through the integration of industry and education, and as the same time it should be a platform for training high-level application-oriented talents, which should be built by the colleges with the support of the industry, enterprises, and coordinated by the government ^[7]. Further, in 2016, Dong ZC et al., proposed three modes for the construction of joint training bases for engineering postgraduates studying for a professional degree, including a college-industrial mode, a college-enterprise mode, and a college-government mode, with the college-enterprise mode serving as the first principle ^[8]. He pointed out that there were some issues in the joint training bases for engineering postgraduates studying for a professional degree, including unclear principles of base construction and selection criteria ^[9], low openness of base construction, insufficient mode and scale of base construction ^[10], unsatisfactory guarantee, and ambiguous authority and responsibility for base construction ^[11], and the lack of standardization in the college-enterprise interaction platform ^[12]. For a long time, the joint training through the integration of scientific research and education is mainly provided for graduate students who are studying for academic degrees, which is realized through cooperation between universities or between universities and research institutes. In addition, in 2018, Jiang WJ divided the current stage of collaborative education through the integration of scientific research and education in China into a joint postgraduate training mode, a science and technology elite class mode, and a mode of joint college running through the integration of scientific research and education. The joint postgraduate training mode of the integration of scientific research and education was first implemented for the joint training of doctoral students by institutions of higher learning and engineering institutes in 2009, and then it was expanded to master students, aiming to promote the training of high-level top innovative talents by taking advantage of the educational functions and scientific research resources of institutions of higher learning and scientific research institutes. At the same time, the author also pointed out the existing problems in the joint training of graduate students through the integration of scientific research and education, where the joint training of doctoral students was a pilot program with certain limitations in the scope of influence and demonstration, the participating institutions of higher learning were basically comprehensive research universities while those with industry characteristics were rarely involved, and lastly, and there was still a lot more work to do in terms of the cooperation mechanism and affairs related to the operation of joint training ^[13].

At present, the root of existing problems in joint postgraduate training bases either through the integration of industry and education or the integration of scientific research and education lies in the inconsistency of the interests of universities and enterprises, resulting in low enthusiasm for joint training by the two parties. It is essential to innovate collaborative organizational to form a bridge to close the gap of interests between both parties, to increase their enthusiasm for joint training ^[14-16]. In short, joint training is an inevitable requirement for the gathering of innovative elements in the era of the knowledge economy, in which the integration of multiple innovative elements can be achieved, and the carrier of joint training is as a professional practice base. Therefore, on should solve the existing problems in the current postgraduate professional practice bases, and seek for a new development mode.

2. The integration mode

2.1. Construction of open bases

2.1.1. The theoretical basis

Scholars in China put forward the feasibility of government participation in join training base construction based on the triple helix theory. According to this structure theory, the government as an important factor in promoting industry-university-research cooperation in the era of the knowledge economy. In addition,

the triple helix structure concept is much superior to the double helix structures, example of double helix structures is government-university, government-industry, and university-industry, therefore, the triple helix structure can avoid the defects of the industry-university cooperation mode and the industry-university-research cooperation mode due to the neglect of the government role in innovation^[17]. Based on the 28 and 108 demonstration bases survey for the joint training of engineering postgraduates in China respectively, Ma Y H and Zhang SL, respectively, pointed out that the proportion of the construction of the bases, in which the government has participated was less than 8%, thereby they proposed the necessity and urgency for the government to participate in the construction of postgraduate practice bases with the integration of government, industry, university, research, and application^[18,19], with the core idea of the collaborative innovation theory is integration and interaction. In 2015, Li JL, et al., proposed a strategic, organizational, and knowledge collaboration mode for the joint training of postgraduates based on the collaborative innovation and triple helix theory^[20] (**Figure 1**), further emphasizing the importance of government participation in the joint training of graduate students in the era of the knowledge economy.

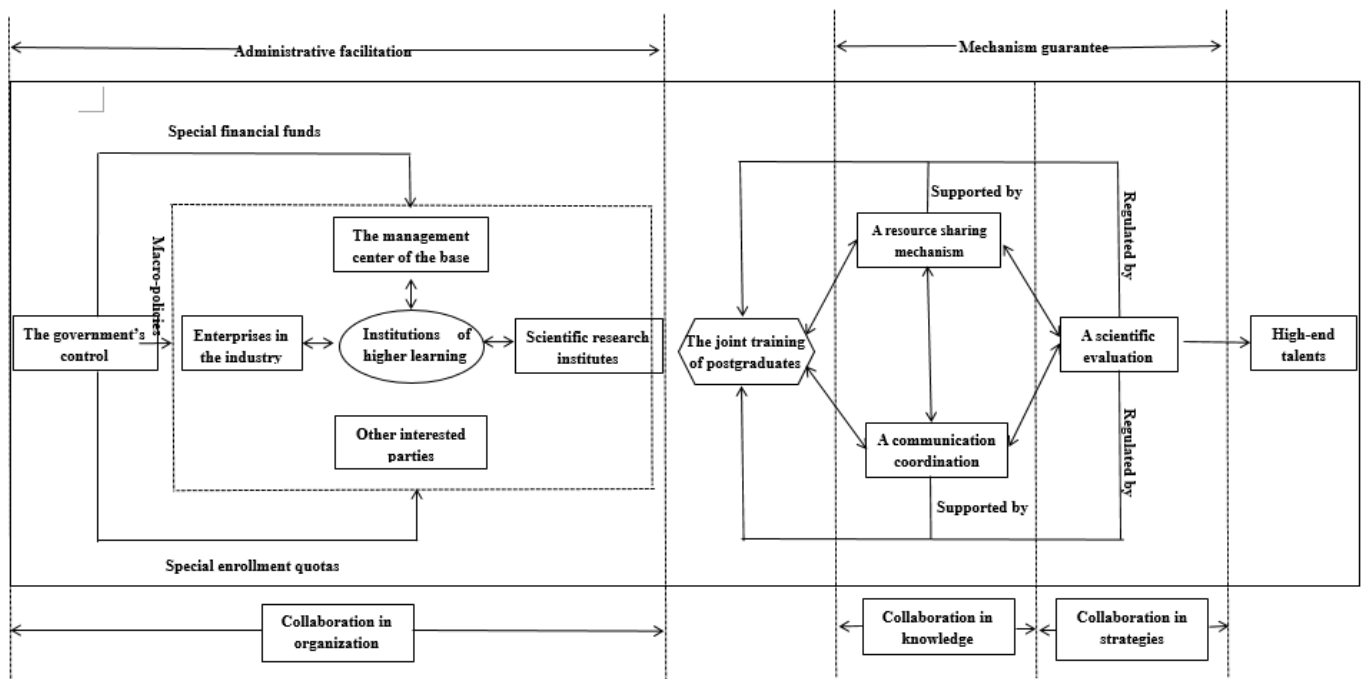


Figure 1. A joint postgraduate training mechanism in the collaboratively innovative environment

2.1.2. An open base mode

Based on the above theories, Guangdong Province has explored the construction mode of “1+N+N” as shown in **Figure 2** as the management mode for the center-university-demonstration site for open bases for the joint training of postgraduates, which was constructed by the local governments. The management center is a third-party service organization established by the government to provide daily services for the joint training of graduate students from many universities and enterprises. In addition, the joint training uses enterprise issues as the postgraduates’ dissertation topics, where under the joint guidance of university and enterprise tutors, the graduate students complete engineering practice, and their dissertation topics are related to the enterprises. The local governments have provided a guarantee for the smooth development of the joint training, and have invested a lot of resources in the construction of the open bases, including a special enrollment plan for the joint training of graduate students through the integration of industry and education in the Foshan base, which is established by the department of education in Guangdong Province,

while the base operating funds are provided by the municipal people’s government, and a management center was constructed to manage the daily work of the base. In short, the local government participation in the postgraduate engineering practice by providing guarantees to bring together innovative elements, collaborative education by multiple parties has been achieved, and the problem of the disconnection between theory and practice and between research and application in the process of engineering postgraduate training was solved, thereby improving the quality of engineering practice education in China. Furthermore, the joint training of postgraduates can be used as a bridge to promote the cooperation between university tutors and enterprises, thus forming a new collaborative innovation by helping the enterprises to solve the existing technical problems.

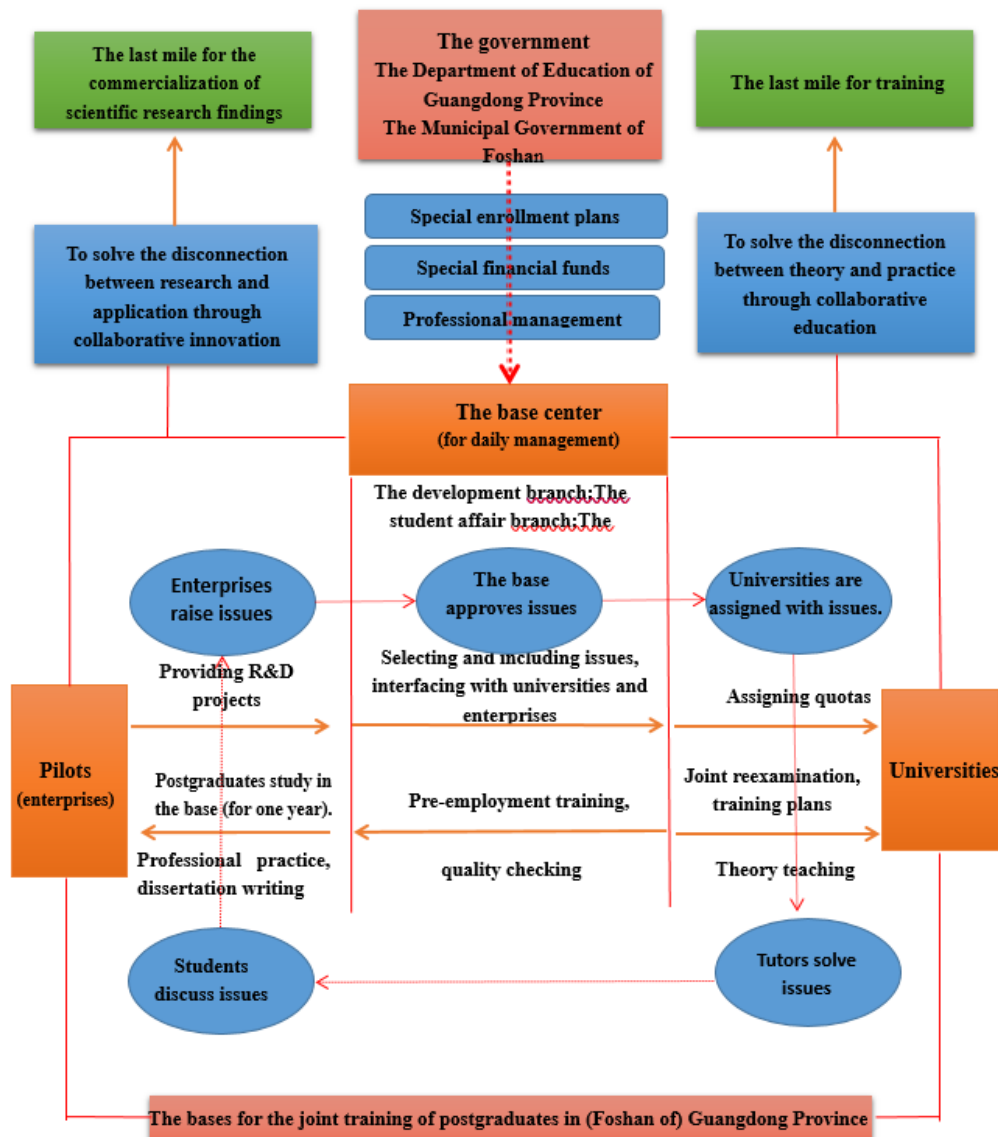


Figure 2. Running mode “1+N+N” in the open base construction

2.2. The joint training mode

2.2.1. The integration mode of industry and education

Guangdong Province is a major manufacturing province, and an innovation hub in the Guangdong-Hong Kong-Macao Greater Bay Area. It boasts not only such manufacturing central cities as Foshan, Dongguan and Zhongshan, but also a Guangzhou-Shenzhen Science and Technology Innovation Corridor, 10 core

innovation platforms and many innovation branches. Therefore, the manufacturing central cities need new talents and intellectual support, as they are facing technological transformation and industrial upgrading. Additionally, the development of strategic pillar industries and many newly emerging industries required high-end engineering talents and high-level scientific and technological support, as well as major technological breakthroughs. To meet the demands and goals of different types of innovation, Guangdong, relies on the education carrier of the open bases, and has implemented a joint postgraduates training mode through the integration of science-education and industry-education as shown in **Table 1**.

Table 1. Comparison of the joint training in the open bases through the integration of scientific research and education through the integration of industry and education

The joint training mode	Governments	Universities	Enterprises	Scientific research institutes	Goals
The integration of industry and education	Constructed by the governments, led by the municipal education bureaus	Universities for training engineering postgraduates in the province	Fast-growing national high-tech enterprises	None	To train first-class engineers To solve engineering practice problems
The integration of scientific research and education	Constructed by the governments, led by the municipal science and technology Bureaus	Key science and engineering universities in the province, some famous universities in Hong Kong and Macao	Leading backbone enterprises	Academy of Sciences, provincial key laboratories	To train high-end engineering talents To solve major scientific and technological problems

The integration of industry and education is aimed to train first-class engineers as reserve talents for the Guangdong's modern manufacturing industry and solve existing technical problems in the enterprises. The construction of the open bases for the joint training of graduate students through the integration of industry and education was led by the local municipal education bureau, and Guangdong Province issued a special enrollment plan for joint training, meanwhile the local cities invest funds and formulate policies, and finally, the management centers are responsible for the daily management of the bases. With the support of the governments, 25 engineering postgraduate training universities in the province and national high-tech enterprises from various regions conducting joint training on corporate engineering practice issues to provide first-class engineers for Guangdong's modern manufacturing industry to alleviate the talent shortage. In addition, the joint training enterprises are the fast-growing high-tech enterprises in China, which urgently need the support of talents and intellectual resources from colleges and universities as they are in the rising stage of technological innovation. Further, the joint training in the open bases has introduced tutors and innovation resources from colleges and universities to enterprises. The joint training has met the needs of fast-growing national high-tech enterprises for talents and intelligence, and simultaneously trained application-oriented and inter-disciplinary high-level talents, which has greatly improved the effect of collaborative education and innovation. The Foshan Base, Dongguan Base, and Zhongshan Base jointly built by Guangdong Province and the local governments, which all the bases are for the joint training of postgraduates in engineering. Through the formation of a joint training mode of integration of industry and education, the relevant arising issues collected by the governments, raised by enterprises, approved by the bases, assigned to the universities, discussed by students, and solved by tutors.

2.2.2. The mode of the integration of research and education

The integration of research and education can promote breakthroughs in key core technologies when it responds to major national strategic needs. Focusing on the world's cutting-edge technologies and new battlefields of the national economy, it can tackle the key strangling of the core technologies. The industry, universities, and scientific research institutes have collaboratively built a high-end innovative application platform for the integration of research, education, and industry. Thereby, both parties can give full play to their basic research capabilities and scientific research platform advantages to jointly carry out cutting-edge theoretical exploration and key technology research and development applications, to solve the problem of technology shortage ^[21]. The construction of the open bases for the joint training of graduate students through the integration of scientific research and education was led by the local municipal science and technology bureaus or scientific research institutes who is responsible for their daily management. Meanwhile, the joint training universities are key science and engineering universities in the province and some famous universities in Hong Kong and Macao that master the cutting-edge scientific and technological knowledge in the world, laying a foundation for the training of innovative high-end engineering talents. In addition, the scientific research institutes who is participating in the joint training are high-end scientific research institutions focusing on strategic pillar industries and emerging industries in Guangdong Province. They have a group of academician teams, as well as experimental conditions and major scientific research projects, which are not available in universities, thereby providing good conditions for high-end engineering talents to carry out innovative practices. The joint training enterprises are a local leading and the backbone, with major scientific and technological projects supported by core technology, providing practical education platforms for the training of high-end engineering talents. Focusing on major scientific and technological projects of leading enterprises, universities, scientific research institutes, and leading enterprises have formed an innovation chain to jointly train high-end engineering talents through the integration of research and education, and at the same time tackle major scientific and technological problems and issues. Further, Guangdong Province has established open bases for the joint training of engineering postgraduates through the integration of research and education, such as the open base of Guangdong Academy of Sciences for the joint training of engineering postgraduates, in which a multiparty collaborative system was formed, with a platform built by the government, issues raised by enterprises, universities, and research institutes which are involved.

2.3. Implementation effects

2.3.1 The quality of engineering practice education has been significantly improved

All parties have gathered innovative resources to actively participate in the joint training of postgraduates, thereby, forming a new mechanism for multiparty collaborative education. The joint training for engineering graduate students is an issue-oriented and project-driven training, where during the training the students' dissertation topics are related to products, and the research is conducted based on the products, and the research findings are implemented in the actual enterprises, in return this can significantly improve the graduate students' engineering practice innovation ability. Taking the 2021 graduates with a master's degree in electronic information engineering of Foshan University as an example, when students who have taken the joint training are compared with those who have taken on-campus training, they have 3.4 patents per capita and the 0.9 patents per capita, respectively. Meanwhile, in terms of the initial employment rate and employment salary, the initial employment rate of postgraduates has taken the joint training is 100%, with more than 3.7% of job opportunities per capita, while it is 95.28% for postgraduates have the on-campus training, with 1.4% of job opportunities per capita. According to the post-graduation tracking data, 57.3% of the 2021 graduates who have been trained in the open base have become the technical backbone of enterprises, while only 21.9% of the graduates have been trained on-campus have achieved this.

2.3.2. A new system of independent innovation in science and technology has been initially established

Every year, more than 800 university tutors and more than 2,000 graduate students have solved more than 1,200 technical problems for enterprises, which has relieved the pressure of the technological transformation of enterprises in industrial upgrading to a certain extent. The joint training has helped 17 enterprises to grow into national high-tech enterprises, and also has assisted 79 enterprises to increase their Gross domestic product (GDP) more than 710 million yuan. The integration of industry and education has become a catalyst for enterprise transformation and upgrading. In addition, the Foshan Xianhu Hydrogen Energy Laboratory and many universities have jointly trained graduate students through the integration of scientific research and education. The two parties have gathered innovative elements for collaborative innovation, gradually breaking through the strangling problem in major scientific and technological research fields, and actively developing new energy such as hydrogen energy as the new energy industry. Thus, the integration of scientific research and education has become an energy-gathering ring for regional scientific and technological innovation.

3. Conclusion

The lack of engineering innovation practice ability is the main problem in the training of engineering postgraduates, in which the professional practice base can serve as an important carrier for training the engineering practice ability. The construction of the open base by the local governments in Guangdong Province is the reform and an exploration of the construction of the professional practice base for engineering postgraduates. The government is currently as an important factor in the construction of professional practice bases for engineering graduate students. The open bases have improved the enthusiasm of universities and enterprises, which are involved in joint training. According to the regional industry positioning and development goals, the mode of the integration of industry and education should focus on the issue of engineering practice to train first-class engineers, meanwhile the mode of the integration of scientific research and education should focus on major scientific and technological problems to train high-end engineering talents by building integration of scientific research, education, and industry. The practice has proved that the open base built by the government is an important guarantee for the effectiveness of engineering postgraduates in engineering practice. By implementing the double joint training mode through the integration of science-education and industry-education, the targeted classified postgraduate training is achieved. Thus, the role of engineering postgraduate education in supporting the development of the regional modern industry is given a full play, however, the open bases built by the governments are still in the exploratory stage, therefore the theoretical foundations, and macro and micro governance systems should be improved over time. In summary, the integration mode needs to be further clarified, and the open base construction standards should be summarized and formulated as soon as possible, to lay a foundation for its replication and promotion in other regions, in China.

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Disclosure statement

The authors declare no conflict of interest.

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