Research on the cultivation mechanism of young scientific and technological innovation talents in Shanghai for 2035[1]

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Abstract. In order to stimulate the innovation vitality of young scientific and technological innovation talents in China, Application of PEST Analysis for Systematic Analysis of Youth Science and Technology Innovation Talent Cultivation in Shanghai: Construction of Cultivation Index Model. Empirical Study Using CRITIC-TOPSIS Model in the Computer Software SPSSau to Obtain Key Factors for Science and Technology Innovation Talent Cultivation. The study reveals that: (1) The CRITIC-TOPSIS entropy weighting method in the computer software SPSSau minimizes the impact of universal exceptional information on index weighting. (2) Policy, economy, society, and technology have a strong positive correlation with youth science and technology innovation talent, with the number of regular higher education institutions, technological achievements, and new employment positions being the core factors for the development of youth science and technology innovation talent cultivation in Shanghai. (3) From 2010 to 2020, the cultivation of youth science and technology innovation talent in Shanghai has continuously strengthened, and the development level of youth science and technology innovation talent has shown an integrated growth trend.

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1 Introduction

According to the data of China Science and Technology Human Resources Development Research Report (2020), by the end of 2020, China's total science and technology human resources reached 112,341,000, continuing to maintain the world's largest number of talent scale, but at the same time there are also problems such as uneven regional distribution of science and technology talent training resources, low efficiency of innovation output and insufficient staff density[1] . In the new era of rapid development of science and technology, continuous adjustment and upgrading of industrial and economic structures, the level of national development, comprehensive strength and core competitiveness enhancement, and even the manifestation of its international competitiveness are also closely related to the cultivation of young scientific and technological talents. The cultivation of young scientific and technological innovation talents is influenced by many factors, among which the positive impact of economy and technology on the cultivation of scientific and technological innovation talents has been universally recognised. To achieve the 2035 vision, there is an urgent need for different levels and types of talents as a strong backing, both researchers who master the country's frontier technologies and engage in scientific and technological innovation and basic research, as well as application-oriented talents with solid theoretical foundation and strong practical skills The need for researchers who have a good grasp of the country's cutting-edge technologies and are engaged in scientific and technological innovation and basic research, as well as applied talents with a solid theoretical foundation and strong practical skills. Therefore, to engage in the cultivation of young scientific and technological innovation talents with "social needs" as the basic orientation and "competence-based" as the value orientation is not only the requirement for talent cultivation in the new era, but also the premise and foundation for the scientific, standardized and socialized cultivation of young scientific and technological innovation talents. The foundation The key to the cultivation of young talents in science and technology innovation in Shanghai is the adjustment of the direction of talent cultivation and the reconstruction of the process and mode of talent cultivation, rather than the differentiation of higher education levels and hierarchies, which deviates from the basic laws and requirements of higher education. Therefore, the training of young scientific and technological innovation talents in Shanghai should have clear objectives, accurate positioning, emphasis on practice and application, so as to lay the foundation for Shanghai to highlight its own development and improve the quality of talent training. On this basis, using the PEST analysis method of strategic management, combined with the current development trend and needs of the Yangtze River Delta region, we analyse in depth the advantages and disadvantages faced by the cultivation of young scientific and technological innovation talents in Shanghai, combine with relevant literature, summarize the key indicators of information, propose corresponding development strategies, strive to turn disadvantages into advantages, provide protection for the cultivation of young scientific and technological innovation talents in Shanghai, and create a good development environment. Continuously improve the internal construction.

2 Literature Review

In today's globalized and knowledge-based economy, the competition between countries is focused on young scientific and technological innovators, who combine knowledge, information and technology, and the cultivation of young scientific and technological innovators has never been more prominent.[2] Since the founding of the University of Berlin by Hum- boldt, which revolutionised the form of talent training, foreign scholars have begun to pay attention to the study of the cultivation of young scientific and innovative talents[3] . In terms of training models, the most representative models include Dew- ey[4] 's problem-based teaching method, Kilpatrick[5] 's design-based teaching method and Kevin Hovland[6] 's RTTP teaching method. In terms of researching the factors influencing the training of young innovative talents in science and technology, foreign scholars believe that the teaching methods of schools, simulation training, practical training, policy protection, talent evaluation, etc. can Factors influencing talent cultivation[6] . In addition, Yayun Yang[7] has designed a robotics-assisted talent training model and has shown through his research that robotics-assisted talent training is a feasible way to improve the efficiency of talent training. Command Sgt (2022)[8], Gen. Ed Daly (2022)[9], and Pocztowski Aleksy, Pauli Urban (2022)[10] all highlight the importance of cultivating young science and technology innovation talents from different perspectives. In recent years, with the transformation of China's industrial structure, the importance of training young scientific and technological innovators has been highlighted. In recent years, with the transformation and upgrading of China's industrial structure and the acceleration of business integration, the cultivation of young scientific and technological innovation talents has received increasing attention from enterprises, government and scholars, and relevant research has yielded fruitful results. In terms of theories on the cultivation of young scientific and technological innovation talents, scholars such as Zhang Xiaohong[11] and Li Weiguo[12] have made a more comprehensive analysis of the model, characteristics, influencing factors, motives and cultivation mechanism of young scientific and technological innovation talents cultivation from different perspectives and positions.

In summary, domestic research has made breakthroughs by creatively applying relevant Western theories to the practice of cultivating young science and technology innovation talents, and there is still room for major research enhancements: firstly, most scholars are more ambiguous in their research paradigms in studying the impact of talent cultivation, most of them focus on research talents, and there is less research on young talents who have not yet been cultivated; secondly, Shanghai's young science and technology innovation talent cultivation system is less studied in terms of internal and external interaction; thirdly, there is a greater lack of systematic comparative reference studies, and the operability of the research needs to be strengthened. In the future, through further in-depth research on the interaction, evaluation, control and coordination of the cultivation of young science and technology innovation talents in Shanghai and its Yangtze River Delta region, it is important to promote the development of talents and innovation clustering in Shanghai and its Yangtze River Delta region, and to enhance the effectiveness of Shanghai's radiation role of talents to the Yangtze River Delta region.

3 Model construction

3.1 Constructing a system of indicators

Based on the principles of scientificity, comparability, usability and the combination of absolute and relative numbers, this paper composes and draws on the research results of existing scholars, deeply analyses the spirit of the documents of the Party Central Committee and national ministries and commissions on cultivating young scientific and technological talents, and constructs a system for cultivating young scientific and technological innovation talents from four dimensions: political, economic, socio-cultural and technological, with a total of 20 indicators. The specific indicators are shown in Table 1.

Table 1. Shanghai Youth Science and Technology Innovation Talent Cultivation Index System

Measurement factors	Indicators	Indicator content	Unit	Documentary sources
Policy P	P1	Internal expenditure on R&D funding	billion	Li Kang, Huang Chen, Deng Dasheng and others[13]
	P2	R&D expenditure as a proportion of Shanghai's GDP	%	
	P3	Local financial expenditure on science and technology	billion	
	P4	Expenditure on science and technology as a proportion of local fiscal expenditure	%	
	P5	Shanghai Utility Investment	billion	
Economy E	E1	Household disposable income per capita	Yuan	Li Xuhui, Zhu Qigui, Hu Jiayuan and others[14]
	E2	Shanghai Gross Domestic Product	billion	
	E3	Share of tertiary sector in Shanghai's GDP	%	
	E4	General public budget revenue	billion	
	E5	Investment in fixed assets	billion	
Social S	S1	General higher education	the	Luo Xingpeng, Zhang Qianqiang and others[15]
	S2	Number of health institutions	individual	
	S3	Mass art museums, cultural centres (stations)	individual	

	S4	New jobs	million	
	S5	Total labour productivity	RMB/person	
Technology T	T1	Number of scientific and technological achievements	Item	Liu Hui, Li Xinxian, Li Huiling and others[16]
	T2	Number of scientific papers published	Part	
	T3	Technology transfer projects	Item	
	T4	Technology development projects	Item	
	T5	Number of patents granted	Pieces	

3.2 Model selection

3.2.1 CRITIC-entropy method combined weighting model.

Diakoulaki et al. in 1995 proposed an objective weighting method, the CRITIC Model in the Computer Software SPSSau method, which measures the objective weight of an indicator primarily by evaluating the comparative strength and conflict of the indicator[17] . The correlation coefficient and contrast intensity are expressed in terms of conflict and standard deviation, respectively. The correlation coefficient in this method may be negative, but in fact, the conflict is only related to the absolute magnitude of the correlation coefficient, not to the positive or negative[18] . Therefore, this paper improves the CRITIC Model in the Computer Software SPSSau method by (1) using the standard deviation coefficient instead of the standard deviation to eliminate the influence of the magnitude, and (2) taking the absolute value of the correlation coefficient to eliminate the influence of the positive and negative signs.

The CRITIC Model in the Computer Software SPSSau method provides a comprehensive measure of the strength of contrast and conflict between indicators, but does not measure the degree of dispersion between indicators. The entropy method is based on the dispersion between indicators to determine the weight of indicators. Therefore, the combined use of CRITIC Model in the Computer Software SPSSau method and entropy method can reflect the weight of indicators more objectively and clearly[19] .

Therefore, this paper chooses to use the comprehensive CRITIC-entropy weighting method to calculate the weights of the indicators for the cultivation of young scientific and technological innovation talents in Shanghai. There are m evaluation objects and n evaluation indicators. The original data is X_{ij} , i=1,..., m; J=1,..., n. Firstly, the normalisation process is carried out as follows:

$$\chi_{ij}=\frac{Xij-Xmin}{Xmax-Xmin} \text{ (}X_{ij}\text{ is an effector-type indicator)} \quad (1)$$

$$\chi_{ij}=\frac{Xmax-Xij}{Xmax-Xmin} \text{ (}X_{ij}\text{ is a cost-based indicator)} \quad (2)$$

Note: X_{max} indicates the maximum value of the jth indicator and X_{min} is the minimum value. x_{ij} indicates the normalised result.

The CRITIC method is used to derive the final weights and to calculate the information content of the jth indicator.

$$c_j = \frac{\sigma j}{\overline{\chi j}} \sum_{j=1}^{m} (1 - |rij|) \tag{3}$$

Notes:σ denotes the standard deviation of the jth indicator, the $\overline{xj}$ denotes the mean of the jth indicator, and the correlation coefficient between the i-th and j-th indicators is expressed by r_{ij} .

Calculate the final weight of the jth indicator.

$$\omega_1 = \frac{cj}{\sum_{j=1}^{m} cj} \tag{4}$$

The entropy weighting method is used to derive the final weights and to calculate the probability of the jth indicator for the ith evaluation object.

$$p_{ij} = \frac{xij}{\sum_{i=1}^{m} xij} \tag{5}$$

Calculate the information entropy of the jth indicator.

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^{m} \text{pij} \ln \text{pij} \tag{6}$$

Calculate the final weight of the jth indicator.

$$\omega_2 = \frac{1-ej}{\sum_{j=1}^{n} 1-ej} \tag{7}$$

The final weight of the jth indicator is obtained using the CRITIC-entropy combination weighting method.

$$\omega_j = \beta\omega_1 + (1-\beta)\,\omega_2 \tag{8}$$

Note: As both assignment methods are objective, the paper considers them to be of equal importance and assigns a value of 0.5 to β.

3.2.2 TOPSIS model.

The TOPSIS method was first proposed by Hwang and Yoon in 1981.The ranking is based on the proximity of the evaluated objects to the ideal targets, achieved by actively measuring the distance between the evaluated objects and the best and worst solutions [20].The combined application of the improved CRITIC method, entropy weighting method and TOPSIS method can effectively overcome the shortcomings of the traditional TOPSIS method which cannot reflect the relevance and importance of variables, and the problem of inverse order can also be effectively avoided through normalisation.

Construction of the weighting matrix .

$$V = \begin{bmatrix} v_{11} & \cdots & v_{1n} \\ \vdots & \ddots & \vdots \\ v_{m1} & \cdots & v_{mn} \end{bmatrix} \tag{9}$$

Notes. $v_{ij} = x_{ij} * w_j$, w_j indicates the weight of the jth indicator.

Calculation of positive and negative ideals:

V^{+}=(v_1^+ ,v_2^+ ,..., v_n^+)=$\{maxv_{ij}|j=j_1, minv_{ij}|j\in J_2\}$

V^{-}=(v_1^- ,v_2^- ,..., v_n^-)=$\{minv_{ij}|j=j_1, maxv_{ij}|j\in J_2\}$

J_1denotes the set of benefit-based indicators, andJ_2 denotes the set of cost-based indicators.

Determine the distance between the evaluation object and the positive or negative ideal solution.

$$S_i^+=\sqrt{\sum_{j=1}^{n}(v_{ij}-v_j^+)^2} \quad (10)$$

$$S_i^-=\sqrt{\sum_{j=1}^{n}(v_{ij}-v_j^-)^2} \quad (11)$$

$$\delta_i=\frac{S_I^-}{S_I^+-S_i^-} \quad (12)$$

Calculate the relative closeness of the i-th evaluation object to the ideal solution:

Notes:$0 \le \delta \le 1$, ranks the results calculated from δ_i , with larger values indicating closer to the optimal level.

3.2.3 Empirical analysis.

In order to gain an in-depth understanding of the basic situation of the cultivation of young scientific and technological innovation talents in Shanghai, and to accurately grasp the bottlenecks, difficulties and "pain points" of the cultivation of young scientific and technological innovation talents, the data related to the indicators were collected according to the basic principles of scientificity, systematization, representativeness and accessibility, spanning the period from 2010 to 2020. The data were mainly obtained from the Shanghai Statistical Yearbook and the China Science and Technology Statistical Yearbook. After normalizing the data according to equations (1) to (8), the weights of the indicators were calculated as shown in Table 2; then the evaluation of the development of young scientific and technological innovation talents cultivation in Shanghai from 2010 to 2020 was carried out according to equations (9) to (12), and the evaluation results are shown in Figure 1.

Table 2. Shanghai Young Science and Technology Innovation Talent Cultivation Index Weights

Guideline level	Indicator layer	CRITIC Method Empowermentw_1	Entropy method of assignmentw_2	CRITIC-entropy method of combining weights	Total
Policy P	P1	0.0349	0.0477	0.0413	0.2338
	P2	0.0314	0.0307	0.0311	
	P3	0.0412	0.0537	0.0475	
	P4	0.0749	0.0334	0.0542	

	P5	0.0343	0.0853	0.0598	
	E1	0.0352	0.0436	0.0394	
	E2	0.0380	0.0491	0.0436	
Economy E	E3	0.0439	0.0451	0.0445	0.2208
	E4	0.0441	0.0446	0.0444	
	E5	0.0351	0.0629	0.0490	
	S1	0.0980	0.0479	0.0730	
	S2	0.0423	0.0471	0.0447	
Social S	S3	0.0548	0.0576	0.0562	0.2815
	S4	0.0838	0.0458	0.0648	
	S5	0.0338	0.0519	0.0429	
	T1	0.1045	0.0324	0.0685	
	T2	0.0377	0.0835	0.0606	
Technology T	T3	0.0390	0.0747	0.0569	0.2640
	T4	0.0638	0.0298	0.0468	
	T5	0.0294	0.0331	0.0313	

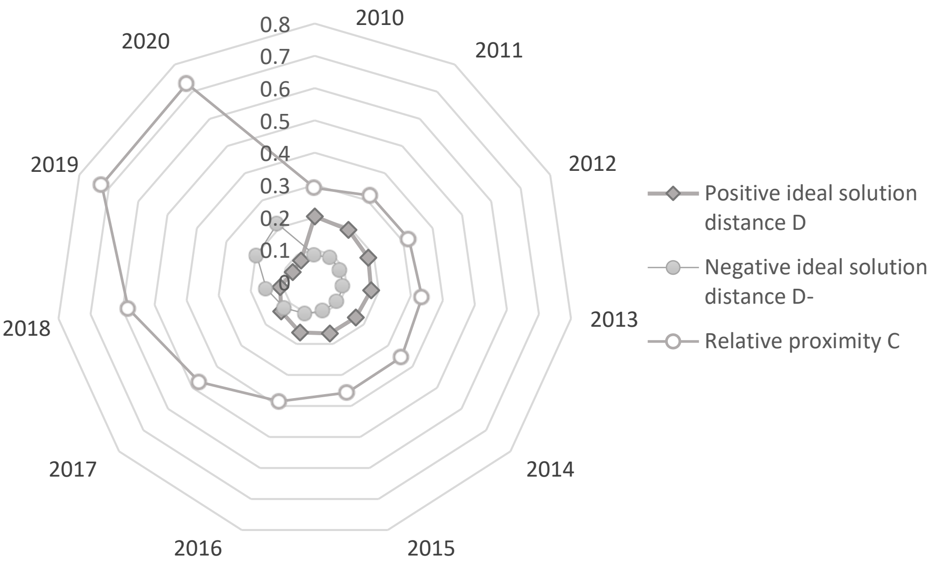

Fig. 1. Calculated results of the comprehensive evaluation of the training of young scientific and technological innovation talents in Shanghai from 2010 to 2020

3.2.4 Analysis of indicator weights.

In this paper, we use three methods to calculate the indicator weights:CRITIC Model in the Computer Software SPSSau method assignment, entropy method assignment, and CRITIC-entropy method combined weight, and the indicator weights of Shanghai young science and technology innovation talents training are shown in Table 2 as well as Figure 1. The indicator weights of the four primary indicators are 0.2338, 0.2208, 0.2815 and 0.2640 respectively, among which the indicator weight of social factors is as high as 0.2815, indicating that social factors play an important role in the cultivation of young scientific and technological innovation talents, followed by technological factors which also have a greater impact on the cultivation of young scientific and technological innovation talents; the indicator weights of the policy factors and economic factors are 0.2338, 0.2208, 0.2815 and 0.2640 respectively. The combined weight of policy and economic factors is 0.2338 and 0.2208 respectively, which indicates that the development process of policy and economic factors is a long and gradual one. In general, the difference in the weight of the four primary indicators is relatively small, and the policy, economic, social and technological factors complement each other and play an indispensable role in the cultivation of young talents in science and technology in Shanghai. Among the secondary indicators, the number of general higher education institutions, scientific and technological achievements, and new jobs rank in the top 3, with weights of 0. 0730, 0. 0680, and 0. 0648 respectively, indicating that the cultivation of young scientific and technological innovation talents in Shanghai is more dependent on the investment in scientific research in schools and the construction level of the city. The weights of the indicator combinations of per capita disposable income are relatively small, 0.0311, 0.0313 and 0.0394 respectively, and Shanghai still needs to increase investment in relevant aspects and further deepen the reform of the talent cultivation system and mechanism. 2010-2020 Shanghai young science and technology innovation talent cultivation comprehensive evaluation results are shown in Figure 2, in the time range of 2010-2020, the ideal The larger the value, the closer to the optimal level, which indicates that the development trend of Shanghai's youth science and technology innovation talent cultivation is steadily improving.

4 Research conclusions and policy recommendations

4.1 Research findings

(1) The empirical results show that the main indicator factors for the development of young scientific and technological innovation talents cultivation in Shanghai are general higher education institutions, scientific and technological achievements and new jobs, and the cultivation of young scientific and technological innovation talents in Shanghai cannot be separated from the investment in scientific research in schools and the construction of people's livelihood in the city; (2) the combination of indicators of R&D expenditure equivalent to the proportion of Shanghai's GDP, the number of patents granted and the per capita disposable income of households The weighting is relatively small, and Shanghai still needs to increase investment in relevant aspects and further deepen the reform of the talent cultivation system and mechanism; (3) the cultivation of young scientific and technological innovation talents in Shanghai from 2010 to 2020 is continuously strengthened, and the development level of young scientific and technological innovation talents shows an integrated growth trend. Among them, from 2010 to 2013, Shanghai youth science and technology innovation talent cultivation was

in the adjustment period of transformation and upgrading, and the growth rate of relative proximity level was low; from 2013 to 2016, Shanghai youth science and technology innovation talent cultivation development relative proximity level maintained rapid growth; from 2016 to 2018, Shanghai youth science and technology people innovation talent cultivation relative proximity level maintained steady growth; after 2018, Shanghai The development level of young scientific and technological innovation talents training has a further trend to improve.

4.2 Policy recommendations

Based on the influencing factors and evaluation results of the development of young scientific and technological innovation talents training in Shanghai, and in view of the reality of the conditions and level of young scientific and technological innovation talents training in Shanghai, this paper argues that the overall plan for young scientific and technological innovation talents training in Shanghai towards 2035 needs a differentiated division of labour for talents development, with the core of increasing the number of general higher education institutions, increasing investment in scientific research and increasing employment opportunities. The specific countermeasures are the integration of industry-university-research, innovation integration and industrial structure integration cooperation. This paper builds on Liu Weidong et al.[21] to construct an ecosystem for the cultivation of young science and technology innovation talents in Shanghai in 2035 as shown in Figure 2.

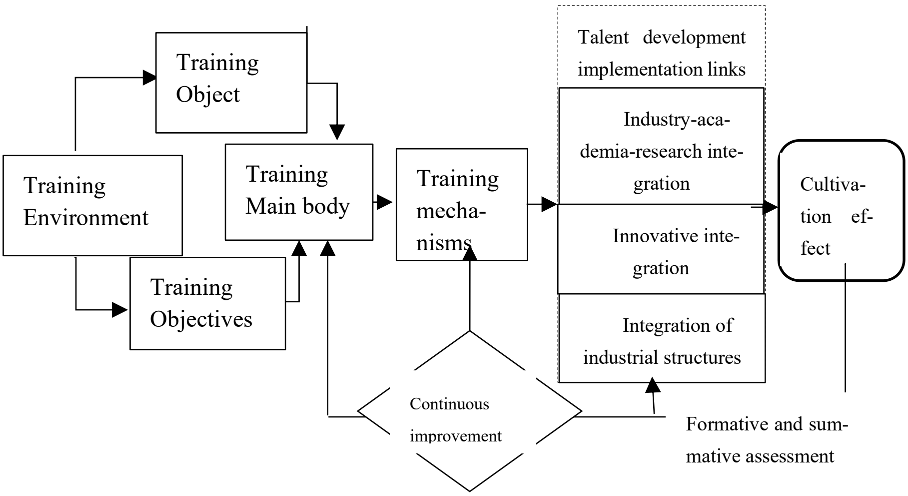

Fig. 2. The ecosystem for fostering young scientific and innovative talents in Shanghai towards 2035

4. 2. 1 Differentiated division of labour in the perspective of cultivating young scientific and innovative talents in Shanghai for 2035.

Based on the above analysis, and taking into account the differences in the development of Shanghai's five new cities and other regions, the process of training young science and technology innovation talents should take into account the advantages of each region's development, and make a clear division of labour in the training of talents, taking advantage of Shanghai's "international economic, financial, science and technology innovation, trade and shipping centre" to vigorously train We should make use of Shanghai's advantages as an international economic, financial, science and technology innovation, trade and shipping centre to cultivate young science and technology innovation talents, to give full play to Shanghai's leading role in the Yangtze River Delta region, and at the same time radiate the cultivation of talents in the Yangtze River Delta region to drive the development and gathering of science and technology innovation talents in the region.

4. 2. 2 Suggestions for optimising the training of young science and technology innovators for 2035 in Shanghai.

(1) Integration of Industry, Education, and Research. The integration of industry, education, and research is a talent cultivation model that combines universities, enterprises, and research institutes. Its fundamental purpose is to enhance the innovative and creative abilities of young talent in science and technology innovation, better adapting to the requirements of economic and social development.

1) Universities need to establish practical bases on campus. The practical content should be closely related to students' professional practices. The main objective is to enhance students' innovative consciousness, creativity, and professional skills, comprehensively and systematically cultivating their understanding of theoretical knowledge through practical experiences.

2) According to the teaching requirements of scientific and technological talent, enterprises need to explicitly stipulate that young talent in science and technology innovation should be assigned to at least one year of practical experience. They should have sufficient understanding of the corporate culture and work environment, participate in the research and innovation activities organized by the company, and cultivate their innovation consciousness and abilities, thereby improving the comprehensive qualities of the talent.

3) Research institutes should fully leverage the geographical advantages of Shanghai as a "science and innovation center." Through organizing lectures by senior experts, forums, and other activities, they can cultivate and enhance the innovation awareness of young talent.

(2) Integration of Innovation. Mastering cutting-edge technology and harnessing innovative capabilities are the core of cultivating young talent in science and technology.

1) In terms of key technologies, Shanghai should leverage its resources as a "science and innovation center" to promote the construction of national research and development centers, key laboratories, and top-tier universities as innovation hubs for talent in research institutions.

2) In the corporate sector, Shanghai should encourage the establishment of research and development institutions in various regional areas, establish collaborative research centers for small and medium-sized enterprises, and enhance the synergy between research and development investment and talent's collaborative innovation capabilities.

3) Regarding university-industry cooperation, universities and enterprises should engage in diversified and in-depth collaborations, accurately identify changes in talent development needs, and improve the conversion rate of talent innovation achievements.

4) In terms of talent mobility, Shanghai should leverage its economic strength, geographical location, and other factors to create a talent magnet. It can promote talent sharing through various forms such as talent alliances and the "Sunday Engineer" program, facilitating talent exchange among different regions in Shanghai.

(3) Integration of Industrial Structure. The cultivation of young talent in science and technology in Shanghai needs to adhere to the concept of sustainable development. Shanghai should actively adjust its industrial structure by promoting employment, expanding job opportunities, and improving the employment structure.

1) Emphasize the development of the tertiary industry. On one hand, traditional service industries such as retail, food, clothing, housing, transportation, and lifestyle services should continue to be developed. On the other hand, there should be active development of emerging scientific and technological industries, including new energy, civil aviation manufacturing, advanced major equipment, biopharmaceuticals, electronic information manufacturing, new energy vehicles, marine engineering equipment, new materials, software, and information services, to increase job opportunities for young talent in science and technology in Shanghai.

2) Foster more diversified forms of employment. Encourage unemployed individuals to engage in flexible and diverse forms of employment, such as temporary, seasonal, and flexible work arrangements.

3) Promote entrepreneurship and self-employment. Drive employment through entrepreneurship, as it not only provides self-employment opportunities but also creates more job opportunities for others. By developing diverse entrepreneurial entities and various forms of entrepreneurship, it can promote the construction of an entrepreneurial city and expand employment capacity.

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