STEM Education Review

EDITORIAL

Accelerating STEM education: The key to building a high-quality education system

Dingming Wang*, Yuzhu Lin, Yan Yang

School of Humanities and Social Sciences, Beijing Institute of Technology, Beijing 100081, China

INTRODUCTION

"To accelerate the train of professionals that we are short of in the fields of science, technology, engineering, and mathematics (STEM)", emphasized in both the *14th Five-Year Plan Proposal*[1] and *14th Five-Year Plan Outline*[2] of Central Committee of the Communist Party of China (CCCPC), is the key to better management and improvement of higher education, as well as quality education for all. The issues that we are facing now are threefold: (1) Why China pays close attention to the significance of STEM education in this period? (2) What is the core of STEM talent cultivation? (3) What are the methods to accelerate and optimize STEM education?

WHY CHINA PAYS CLOSE ATTENTION TO THE SIGNIFICANCE OF STEM EDUCATION IN THIS PERIOD?

In the face of the situation and challenges in and outside China, accelerating STEM education is an internal requirement to understand the New Era as well as to create a New Development Paradigm. This is also a major task of developing a high-quality higher education system now and in the near future.

Global trends

Today's world is experiencing a great change that has not happened in a century. The new round of technological revolution and industrial transformation is gaining momentum, and China has taken a new and big stride towards the great rejuvenation of the Chinese nation. Nowadays talented professionals are key factors of competition between countries. The enhancement of comprehensive national strength and international competitiveness is increasingly dependent on qualified personnel, particularly in cutting-edge technology, in which they are irreplaceable. In recent years, especially since the outbreak of coronavirus disease 2019 (COVID-19) pandemic, the Sino-US economic and trade frictions have exerted great influences on the international cooperation among disciplines like integrated circuit, information and communication engineering, cyberspace security, biomedical engineering, and plant genetic engineering. To break through the bottleneck of technologies in core areas, it is urgent to enhance crisis awareness, to achieve great self-reliance and strength in science and technology, and to speed up efforts to cultivate STEM workforce.

China's development

The period between the start of the *14th Five-Year Plan* and the year 2035 will be a new stage, during which China begins its march towards the second centenary goal of building a modern socialist country in an all-round way. China is pushing the "dual circulation", a new development paradigm with the domestic market as the mainstay and domestic and overseas markets reinforcing each other, indicating abandonment of the old national economical circle strategy of "Two Ends Outside" (large-scale imports and exports with two ends of the economic process [markets and resources] being located abroad). The new "dual circulation" and the focus on quality improvement imply that the transformation and upgrading of the development paradigm in higher education, which consists of large-scale overseas migration and high proportion of returnees bound tied for a long time. This also means actively integrating into the national development, unswervingly taking the road of independent cultivation

***Corresponding Author:**
Dingming Wang, School of Humanities and Social Sciences, Beijing Institute of Technology, No.5, Zhongguancun South Street, Haidian District, Beijing 100081, China.
Email: wdmedu@bit.edu.cn; https://orcid.org/0000-0003-2038-4673
Received: 25 November 2022; Revised: 26 December 2022; Accepted: 19 January 2023; Published: 3 February 2023
https://doi.org/10.54844/stemer.2022.0323

of STEM talents that are in short supply, and enhancing the competitiveness of human resources.

China's strategy

Chinese President Xi Jinping called for accelerated efforts to build China into a major world hub of science, professional talent and innovation in his speech at the central conference on talent-related work[3] as well as the joint session of the 19th Meeting of the Members of the Chinese Academy of Sciences and the 14th Meeting of the Members of the Chinese Academy of Engineering.[4] The strategy of putting forward new challenges and requirements for China's higher education implies that the CCCPC with President Xi Jinping at the core has fully understood and scientifically evaluated the complicated international environment and global competition. "Never in history has China been closer to the goal of national rejuvenation and never in history has it been in greater need of talented people."[3] In order to play central roles in researching basic science and making major breakthroughs in core technologies, colleges and universities need to take advantage of the Double First-Class initiative to improve the independent education of STEM personnel that is in short supply.

WHAT IS THE CORE OF STEM TALENT CULTIVATION?

According to China's strategic mission in cutting-edge technologies and key areas, accelerating STEM education indicates a boost of much-needed high-level talents, technical personnel, and excellent engineers.

STEM talent

President Xi Jinping refers to building a contingent of high-caliber personnel on many occasions. Xi made an instruction at national conference on graduate education in 2020, saying that "to aim at cutting edge technologies and key areas, efforts should be made to adjust academic disciplines and programs, to improve standards/levels of tutors, to optimize education system, and to accelerate the cultivation of urgently-needed high-caliber personnel".[5] In 2021, it is stressed for vocational education "to build a number of high-level vocational colleges and programs for the construction of a modern vocational education system through the adaptability enhancement and integration with general education, so as to cultivate more highly-skilled technicians and master craftsmen".[6] During Xi's investigation in Tsinghua University, he stressed "to aim at cutting edge technologies and key areas, we should step up the development of new engineering, new medical, new agricultural and new liberal arts so as to boost cultivation of talent urgently needed by the country".[7] At central conference on talent-related work,[3] Xi stressed that "we need to cultivate excellent engineers in great numbers…and expand STEM education scale". Therefore, accelerating STEM education, from the perspective of the CCCPC, means speeding up cultivating high-level talent urgently needed by the country, well-educated technical personnel, and large quantities of excellent engineers.

Urgently-needed

The lack of personnel could refer to its small scale, structural gaps as well as short supply of human resources in certain industries and core areas. Take the engineer as an example, despite China is the only country in the world that has all the industrial categories, its industrial system generally stays at the lower middle end of the global value chain and production chain. Furthermore, the demand for excellent engineers, catering the industrial transformation in the new era, is exceeding supply. Consequently, three cases should be considered in the analysis of the STEM personnel shortage: (1) Existing personnel is inadequate for country's needs which means insufficient quality and quantity of human resources. (2) There may be no obvious demand for such talents at present, but there are potential needs predicted from the industry trends. (3) Compared with developed countries, there is still a significant gap in talents supply in some categories. In each above case, once there is a personnel gap or imbalance, it will have a serious impact on the economic and social development. All in all, urgently-needed personnel is a relative, dynamic and developing policy concept or epoch theme.

National policies

With strategic goals of joining the ranks of the world's most innovative countries and building China into a leading country in talent by 2035, China has been working hard to strengthen confidence in personnel training and to enhance independent capacity of China's education. It sets sights on the global frontiers of science and technology, national economic development, the major needs of the country, and the health and safety of the people. As for higher education, China should deliberate on the strategic needs of STEM workforce for nation's economy and people's livelihood, frontiers of science and technology, and key areas, meanwhile, put efforts into building a system for training STEM personnel in short supply.

WHAT ARE THE METHODS TO ACCELERATE AND OPTIMIZE STEM EDUCATION?

The multiple relationships of supply-demand, scale, structure, and quality should be balanced dynamically so that much-needed STEM personnel education could be accelerated.

Expanding scale or adjusting disciplines?

Generally, accelerating training of much-needed talents in specific fields, can be realized through scale expansion. In practice, it is often manifested as an increase in the number of graduate enrollments, disciplines, degree

awarding bodies, and colleges or departments. For example, China's graduate admission updated with "project for high-level talent training in national key areas that require urgent attention", universities have gained an extra enrollment in some fields of engineering, like artificial intelligence, clinical medicine, public health and preventive medicine, biomedical engineering, cyberspace security, integrated circuit, *etc.* China also took steps in adding interdisciplinary of cyberspace security and integrated circuit into top level disciplines and professions, raising the number of doctoral degree awarding bodies of mathematics, physics, chemistry, biology, and engineering in 2021, as well as setting up secondary schools and colleges of future technology in artificial intelligence, integrated circuit, and engines. Accordingly, should the cultivation of much-needed STEM talents depend on expanding scale substantially, adjusting academic disciplines and programs, or carrying on a reform of high-level talent training mode with comprehensive improvement in relevant academic disciplines.

Expanding scale

Accelerating STEM education means adjustment of education scale, disciplines, types, and programs other than expanding scale of all the disciplines in STEM while decreasing the number of humanities and social science students. Taking medical science as an example, at present in China, the annual number of graduates of clinical medicine in higher vocational colleges and rural medicine in technical secondary schools exceeds 70,000, only about 10,000 less than the number of bachelors of clinical medicine awarded. However, only 1/4 of them could pass the National Medical Licensing Examination at their first attempt. Such large-scale, high-proportion, but poor-quality clinical medicine enrollment in higher vocational colleges should be controlled strictly. There are other medical colleges whose annual enrollment of clinical medicine exceeds 1500. But they cannot guarantee clinical teaching and internship allocation. Therefore, the enrollment of such medical colleges with excessive education scale should also be strictly controlled. Through international comparison, it is found that the ratio of doctors to nurses in developed countries is generally 1:2–1:4,[8] while for China is 1:1.17.[9] The proportion of general practitioners in European and American countries is generally 30%–50%,[10,11] for China is only 10%.[12] The serious shortage of nurses and general practitioners indicates that it is urgent to optimize the distribution and enrollment of clinical medicine, nursing, and general medicine in China.

Adjusting disciplines

Accelerating STEM education requires special attention to avoid hierarchical isomorphism. For a long time, it has been the internal logic of China's higher education management that the number and proportion of academic disciplines and majors determine the number and proportion of degree awarding bodies, and further determine the scale and proportion of enrollment. For example, in *China Graduate Discipline Catalog*,[13] the number of first-level disciplines in engineering accounts for 34%; the number of doctoral programs in engineering accounts for 37%; the number of doctoral degrees in engineering awarded annually accounts for 37%; the number of master programs in engineering accounts for 34%; and the number of master's degrees in engineering awarded annually accounts for 34%. As for engineering in *Undergraduate Discipline Catalog*, the number of majors accounts for 34%; the number of bachelor's programs accounts for 35%; the bachelor's degrees awarded annually accounts for 32%. The above eight "one-third" or so reflect a high degree of isomorphism in the number of engineering subjects, degree awarding bodies, and enrollments at different levels. While in developed countries, there are obvious differences in the scale and structure of tertiary (bachelor's, master's and doctoral) education in different disciplines. According to the statistics, in developed countries, like the UK and the USA, the number of doctoral degrees in science awarded annually accounts for about 30% and the number of master's degrees is usually less than 10%. The number of doctoral degrees awarded in business is generally less than 10% and the number of master's degrees in business is about 30% yearly. This differentiated cultivation scale by degree and discipline reflects the diverse needs of the economy and society for various talents, and also reflects the rational allocation of disciplines and enrollment of colleges and universities.

CONCLUSION

It is a systematic project to establish the cultivation system for much-needed STEM talents, which requires (1) joint efforts and initiatives of all sides including education management, higher education institutions, industrial enterprises, and other aspects; (2) precise analysis and scientific prediction of the demand for talents in key areas of the industry at present and in the future; (3) improvement of the cultivation mode of STEM personnel; (4) sensitivity and recognition of relevant policies to social needs; (5) supportability and adaptability of STEM personnel cultivation to satisfy demands of social development. All in all, accelerating STEM education is definitely an important content and key initiative of building a high-quality education system.

DECLARATIONS

Source of funding

The key project of philosophy and social science research of the Ministry of Education of the PRC (21JZD060).

Author contributions

Dingming Wang: Writing—Original draft preparation, Conceptualization, Resources. Yuzhu Lin and Yan Yang: Writing—Reviewing and Editing.

Conflict of interest

Dingming Wang is the Editor-in-Chief of the journal. The article was subject to the journal's standard procedures.

REFERENCES

1. Xinhua. CPC Central Committee's development proposals set long-range goals through 2035. The State Council of the People's Republic of China. Accessed December 10, 2022. http://english.www.gov.cn/policies/latestreleases/202011/03/content_WS5fa159efc6d0f7257693edc1.html
2. Xinhua. [The 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of the Long-range Goals for 2035]. The State Council of the People's Republic of China. Accessed December 10, 2022. http://www.gov.cn/xinwen/2021-03/13/content_5592681.htm
3. Xinhua. Xi calls for accelerating building of the world center for talent, innovation. The State Council of the People's Republic of China. Accessed December 10, 2022. http://english.www.gov.cn/news/topnews/202109/29/content_WS6153c339c6d0df57f98e108d.html
4. Xinhua. [Xi Jinping: Speech at the 19th Meeting of the Academicians of the Chinese Academy of Sciences and the 14th Meeting of the Academicians of the Chinese Academy of Engineering]. Xinhuanet. Accessed December 10, 2022. http://www.xinhuanet.com/politics/2018-05/28/c_1122901308.htm
5. Xinhua. [Xi Jinping made important instructions on postgraduate education: To meet the needs of the development of the Party and the country and train a large number of high-level talents with both integrity and ability]. Ministry of Education of the People's Public of China. Accessed December 10, 2022. http://www.moe.gov.cn/jyb_xwfb/s6052/moe_838/202007/t20200729_475754.html
6. Xinhua. [Xi Jinping made important instructions on vocational education: To speed up the development of the modern vocational education system and cultivate more high-quality technical professionals and consummate craftsmen]. Ministry of Education of the People's Public of China. Accessed December 10, 2022. http://www.moe.gov.cn/jyb_xwfb/s6052/moe_838/202104/t20210413_526123.html
7. Xinhua. [Xi Jinping stressed during his visit to Tsinghua University: Adhering to the direction of building world-class universities with Chinese characteristics and making contributions to the prosperity of the country, the rejuvenation of the Chinese nation, and the well-being of the people]. Economic information daily. Accessed December 10, 2022. http://www.jjckb.cn/2021-04/20/c_139892123.htm
8. OECD, National Statistical Office, Helgi Analytics calculation. Nurse to Doctor Ratio. Helgilibrary. Accessed December 10, 2022. https://www.helgilibrary.com/indicators/nurse-to-doctor-ratio/
9. Xinhua. China home to over 5 million registered nurses. The State Council Information Office of the People's Republic of China. Accessed December 10, 2022. http://english.scio.gov.cn/pressroom/2022-05/11/content_78212714.htm
10. Frédéric Michas. General practitioners practicing in Europe in 2020, by country. Statista. Accessed December 10, 2022. https://www.statista.com/statistics/554951/general-practitioners-in-europe/
11. Phillips WR, Dai M, Frey JJ 3rd, Peterson LE. General practitioners in US medical practice compared with family physicians. *Ann Fam Med.* 2020;18(2):127–130.
12. China's National Health Commission. [The statistical bulletin of China's health development in 2021]. The State Council of the People's Republic of China. Accessed December 10, 2022. http://www.gov.cn/xinwen/2022-07/12/content_5700670.htm
13. The Academic Degrees Committee of the State Council, The Ministry of Education. [Notice of the Academic Degrees Committee of the State Council and the Ministry of Education on publishing the catalog of Graduate Education Disciplines (2022) and the Administrative Measures for the Catalogue of Postgraduate Education Disciplines]. Ministry of Education of the People's Republic of China. Accessed December 10, 2022. http://www.moe.gov.cn/srcsite/A22/moe_833/202209/t20220914_660828.html