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Cultivating Multi-disciplinary Talents of Medicine-Engineering in the Context of Science and Education Integration

ZHAO Jie, YUE Xuezheng, GAO Wu, CUI Guomin
University of Shanghai for Science and Technology, Shanghai, China

Owing to the growing demand for interdisciplinary professionals in high-tech medical equipment, Medicine-Engineering Co-education has become crucial to train the demanded talents in China. How to cultivate inter-disciplinary talents with the theoretical foundation of medicine-engineering as well as research an ability has become an urgent problem for higher education. In the context of promoting a Healthy China, this article analyzes the current situation and challenges for cultivating talents of medicine-engineering. Also, it explores solutions for training interdisciplinary professionals through medicine-engineering integration by constructing an integrated platform optimizing the team of "dual tutor" and establishing an all-around talent cultivation mode.

Keywords: integration of science and education, medicine-engineering co-education, talent cultivation

Introduction

The *Outline of the Healthy China 2030 Plan* commits to enhancing the cutting-edge medical equipment and fostering innovation in the field, promoting construction of high-tech medical devices as well as high-performance medical devices. Furthermore, China plans to accelerate upgrading medical devices while simultaneously increasing available medical diagnostic and treatment equipment. By means of competitive medical diagnostic and treatment equipment and medical materials of Chinese intellectual property rights, the quality and efficacy of healthcare services will be improved (Outline of Healthy China 2030). "Made in China 2025" issued by the State Council highlights high-performance medical devices as a crucial area for national development so as to accelerate the medical industry and to promote the social well-being.

With the rapid development of China's medical industry, medicine-engineering coeducation has become the key to breakthroughs in the medical field. Especially, the combination of medicine and engineering technology will lead the trend in manufacture of medical devices, development of engineering technology and upgrading of instruments and equipment will continue to promote the development of medicine (Lei, Ye, & Yi, 2021). Therefore, through medicine-engineering coeducation, the development of high-performance medical devices

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ZHAO Jie, M.A., Graduate School, University of Shanghai for Science and Technology, Shanghai, China.
YUE Xuezheng, Ph.D., Lecturer, School of Materials and Chemistry, University of Shanghai for Science and Technology, Shanghai, China.
GAO Wu, M.A., Lecturer, School of Health Science and Engineering, University of Shanghai for Science and Technology, Shanghai, China.
CUI Guomin (corresponding author), Ph.D., Professor, Graduate School, University of Shanghai for Science and Technology, Shanghai, China.

with China's own intellectual property rights has become one of the important tasks in the construction of a healthy China. However, medicine-engineering cooperation is limited to research, and lacks substantive progress in talent cultivation. As a result, contradiction between the demand of the rapidly developing medical industry and the insufficient supply of inter-disciplinary talents is becoming more and more serious.

To meet the challenge, integration of science and education calls for full integration of scientific research and personnel training in higher education, combining scientific research with teaching and training postgraduates to accelerate scientific and technological progress (Ding, Cha, & Shu, 2022). As stated in the *Report of the 20th National Congress of the Communist Party of China*, "Implement the strategy of invigorating China through science and education, and strengthen the support of modernization and construction of talents." Now the strategy of invigorating China through science and education is a major national strategy that will be adhered to for a long time, which is a key issue for high-quality development of modernization. The National Conference on Graduate Education in 2020 also emphasized the importance of integrating science and education in cultivating high-level talents. The conference also emphasized science and education in top talent training, urging to deepen the reform of postgraduate training mode, promote integration of science and education, and enhance the practical and innovative ability of postgraduates. Integration of science and education is not only the core concept of a world-class university, but also the only choice for China's higher education of high-quality in the new stage.

However, most of the universities still follow the teaching-centered training model, and the teaching contents hardly match the rapid development of the medical device. Thus, it is imperative to innovate the talent training mechanism of universities with the concept of science and education integration, to build a compound multidisciplinary talent training system of high-level and high-quality, and to cultivate innovative top-notch talents for the modern medical industry.

Dilemmas in Training Medicine-Engineering Interdisciplinary Talent

Though top universities at home and abroad have taken various ways to break the disciplinary barriers in medicine-engineering intersection, there are some problems common to the multiple modes (Li et al., 2015; Zhu, Zhang, Chen, Shen, Zheng, & Guo, 2022).

The Multi-subject Collaborative Education Mechanism to Be Improved

Universities generally adopt a hierarchical organizational structure of "University-School-Department" which is conducive to discipline construction and standardized orderly management, enabling clear and effective allocation of limited resources within the department and facilitating cultivation of talents with disciplinary characteristics. However, with rapid development of interdisciplinary disciplines, this structure appears to be rather conservative in policies and behaviors. In the practice of cultivating medicine-engineering talents, it is disadvantageous to manage across disciplines and cooperate between on- and off-campus mentors. It is also difficult for collaboration between departments, and talent cultivation resources cannot be efficiently utilized. Therefore, this disciplinary organizational structure needs to be restructured and reestablished.

Usually universities, hospitals and enterprises play their own roles of different objectives and interests, and they are unable to form a mutually integrated community of interests nor to form a synergy of nurturing talent training. The traditional industry-university-research cooperation model can hardly to break the institutional barriers, which is the external cause of the imperfect mechanism of inter-disciplinary talents in medicine-engineering. Thus, it is urgent for universities to solve the problem by reforming their organizational structure

and establishing a management platform that can both synergize faculties and departments of universities, hospitals and enterprises.

Faculty Team to Be Further Optimized

Being unable to be fully involved in the process of medicine-engineering joint training is also a problem for the off-campus tutors. Even though the joint training mechanism is based on programs and projects of "dual tutor", insufficient academic exchange between students and dual tutors cannot meet the demand of joint talent training. The real "dual tutor" system should be established from the very beginning, clearly defining the qualifications of co-faculties at the selection and recruitment stage. For example, qualified supervising, rich teaching experience, appropriate research direction need take into consideration for tutor selection in the medical engineering program. In the "dual tutor" mentoring system, division of responsibilities, mentoring content, exchange mechanism, and assessment process need to be clearly defined. And then a mentoring team can serve the medicine-engineering joint training program.

Talent Training and Scientific Research to Be Integrated

Scientific research and talent training are the main inseparable functions of universities which should carry out reform and innovation in talent training mode and promote talent training with scientific research so that talent training and scientific research progress complementarily and synergistically. However, the gap between cultivation of medicine-engineering talents and scientific research exerts barriers to realize organic integration in universities. The status quo of "emphasizing scientific research while neglecting education" decreases importance of talent cultivation (Wang, Xu, & Tian, 2021). The main reason is the sharp contrast between the low cost but fast outputs of scientific research and the huge investment but slow and long cycle of talent training. At present, the problem of insufficient integration of science and education has frustrated medicine-engineering interdisciplinary talents. For example, the selected students fail to match with medicine-engineering research projects, the training program fails to reflect the characteristics of interdisciplinary objective and the course teaching fails to upgrade with medicine-engineering edge knowledge; students fail to participate in scientific research practice. In a word, the existing cultivation mechanism cannot meet the needs of cultivating medicine-engineering joint talents.

To sum up, all the above problems have seriously constrained cultivating medicine-engineering coeducation talents and hindered its development (Wang, Xu, & Tian, 2021; Zhao, Xu, & Chen, 2022). Therefore, universities need to solve the three problems in order for high-quality talent cultivation.

Path for Medicine-Engineering Inter-disciplinary Talents Cultivation

Building an Integrated Platform for Science and Education Integration and Innovation

Innovating university education's mechanism and system through top-level design and constructing a unified platform for integration of science and education are effective both to eliminate the disciplinary barriers among faculties and to remove institutional barriers among universities, research institutions, and industrial enterprises. The essence of the platform is to break through division of education, science and technology, and industry so as to create a strategic alliance of collaborative innovation that can integrate various resources of all parties. The synergistic mechanism will ensure the multi-win and the sustainable strategic alliance for collaborative innovation.

In terms of medicine-engineering inter-disciplinary talents cultivation, the Science and Education Integration Platform is a matrix-type organizational structure integrating the departments of interdisciplines in universities,

hospital workstations, and medical enterprises. In fact, the platform has a board of directors and an academic committee, the university president and the director of the main hospital act as the chairman of the board and the director of the academic committee respectively. Councilors and members include department heads from universities and hospitals. They are jointly responsible to study the direction of medicine-engineering scientific research cooperation and inter-disciplinary talents collaborative training mechanism, to explore the cooperative mode among universities, hospitals and enterprises, and to build a mechanism for sharing scientific research and educational resources. On the one hand, this multifaceted and synergistic integrated platform effectively integrates different faculties and departments, and promotes the sustainable development of medicine-engineering scientific research and inter-disciplinary talents cultivation. On the other hand, it cares about the interests of universities, hospitals and enterprises, fully utilizes the multiple advantageous resources, and provides the platform with multi-dimensional scientific research and talent cultivation resources, which realizes a win-win situation for all parties.

In addition, the integrated platform sets up an Innovation Research Institute which is dedicated to scientific research, and the Graduate School serves to cultivate talents. The Innovation Research Institute is responsible for matching, following up and managing the whole process of medical-industrial projects, promoting more medical experts and engineering experts to work together at "consultation" on clinical problems in order to solve the "cutthroat" problems in clinical medical research. The Graduate School is responsible for medicine-engineering graduate education and management. The medicine-engineering inter-disciplinary talents cultivation system includes supervisors and postgraduate students of the medicine-engineering program, who co-work in inter-disciplinary talents cultivation model under the Graduate School. The Institute and the Graduate School also organize regular forums, salons, and other academic activities to promote cross-fertilization of scientific research and talent cultivation. Students not only improve their ability to scientific research and problem-solving, but continuously desire inquiry and conscious innovation (Cao, Zhao, & Yu, 2022). The integrated platform provides organizational guarantee for the effective integration of medicine-engineering "science" and "education".

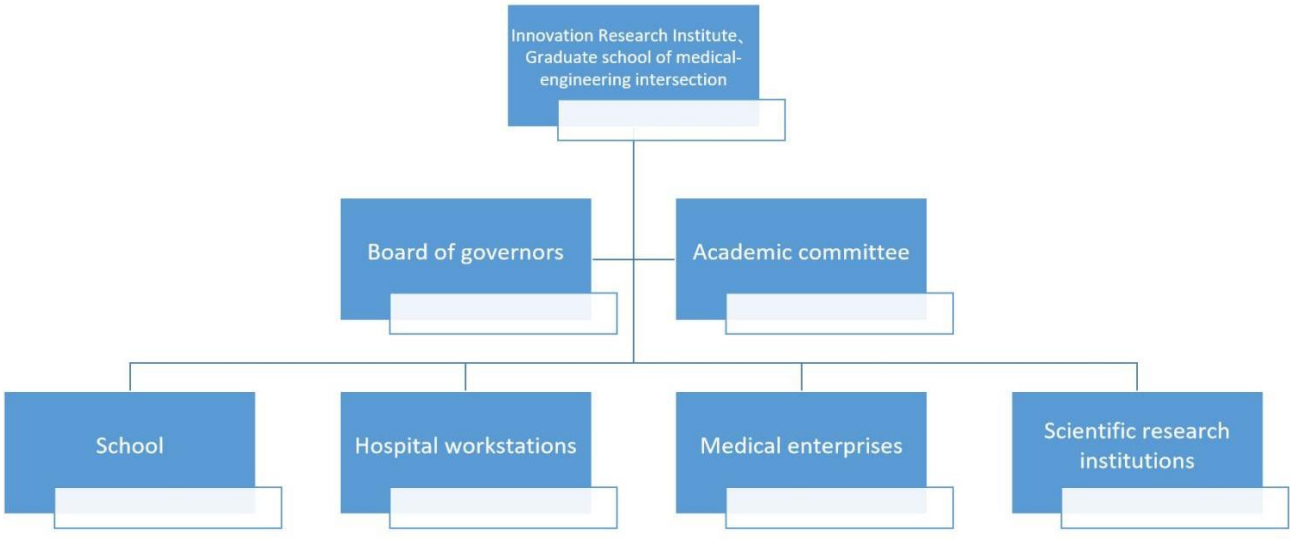

Figure 1. Organizational structure of the integrated platform for science and education integration and innovation.

Constructing a "Dual-tutor" Team for Talent Cultivation of Science and Education Integration

A high-quality and stable "dual tutor" team can effectively make up for the shortcomings of the on-campus

tutor team and provide an efficient and effective tutor team for cultivation of medicine-engineering interdisciplinary talents.

Construction of the "dual tutor" team requires an innovative mechanism, including such elements as team member selection, team equipment, the tutor's duties, and evaluation and renewal of employment. As for the team member selection, it is necessary to select from the physicians cooperating in the medicine-engineering programs, those with the background of interdisciplinary research and experience in postgraduate supervision. A joint group of experts from the hospital and university will then review the academic background, innovation capacity and potential of the candidates through material review, interview and recommendation. The employed medical tutors should match their research needs with the tutors of engineering discipline from universities, thus wo-work within the "dual tutor" system. The university will guarantee the demand-driven mentors with a certain number of postgraduate students. To be specific, on-campus supervisors are mainly responsible for students engineering training, course learning, mid-term project development, and degree application, etc.; off-campus supervisors are responsible for students' medical research projects including medical basics necessary for the research thesis writing. In order to build a high-quality "dual tutor" team, the university should also formulate a reasonable and effective appraisal and reappointment mechanism. In other words, the university should not only ensure enough tutors in the tutor pool and a stable student-teacher ratio, but also conduct regular assessment and dynamic adjustment of tutors according to the specific scientific research projects. The "dual tutor" team focuses on the depth of scientific research and the breadth of knowledge and has the characteristics of collaborative innovation in nurturing people. Based on the concept of science and education integration, through classroom teaching, scientific research training, team guidance, the "dual tutor" team can complement mutually in talent cultivation, providing high-quality inter-disciplinary knowledge in medicine-engineering and guaranteeing that the quality of talents cultivation in practice.

Establishing an All-round Talent Training Model Integrating Science and Education

All-round talent training model of medicine-engineering attaches importance to adequate students. The enrollment plan should be adjusted to medicine-engineering inter-disciplines, and the postgraduate entrance examination should evaluate the students' disciplinary background and theoretical knowledge, interdisciplinary innovation ability and future research interest. With these initiatives, the medicine-engineering interdisciplinary program can organically integrate scientific research with talent cultivation.

Furthermore, universities, hospitals, and enterprises jointly formulate the cultivation program for medicine-engineering students so that the talent cultivation goals fully meet the needs of the medical industry. Tutors will adapt systematic training programs for medicine-engineering students according to the clinical needs and research projects, and comprehensively build a curriculum in line with the interdisciplinary talent cultivation. A "practice-oriented" cultivation program will be established to include medical practice courses and cutting-edge lectures on medicine-engineering disciplines, increase the proportion of practical medical courses in the curriculum. The extra-added medical courses can enable engineering students to learn medical knowledge, and the medical lectures can broaden the students' horizon and vision of the medical research frontiers, thus increasing their knowledge reserve and practical ability required for research.

Teaching methods also need enriching. First, "bringing-in" from top to bottom, which introduces the development plan and annual report by the dean, creates an atmosphere of interdisciplinary medicine-engineering

talent cultivation with lectures by experts from different hospitals. Second, “going-out” into hospitals, which set up practical training classrooms and encourage off-campus instructors to guide students into hospital workplaces and medical enterprises for on-site teaching and visiting internships. Finally, universities and hospitals co-build practice bases, and “dual tutors” participate in writing teaching materials, course teaching, and defining research topics.

Talent training integrates with scientific research projects. To solve the urgent and difficult problems in the medical field, doctors and professors co-work on scientific research projects, leading medicine-engineering inter-disciplinary postgraduates into accumulating theoretical knowledge and engaging in research project. This mode of training focuses on goal-oriented talent training.

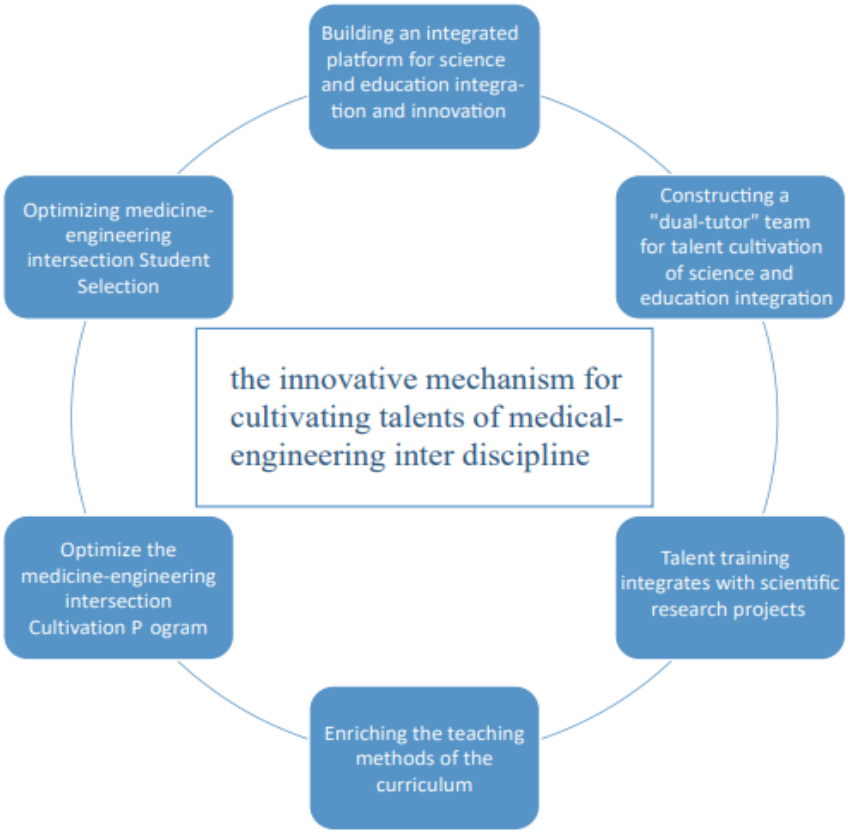

Figure 2. The innovative mechanism for cultivating talents of medical-engineering inter discipline.

Effective Interdisciplinary Talent Training in University S

After four years of exploration, University S has successfully shifted the focus of medicine-engineering interdisciplinary program from scientific research to cultivation of interdisciplinary talents, initiated a new mechanism for cultivating high-level interdisciplinary talents, and established a brand-new management organization and supporting management system. The university has innovatively integrated medical-engineering and talent cultivation organically, and has built a graduate school of medical-engineering inter-disciplines with the medical school of University J, University H and its affiliated hospitals, and docked more than 30 workstations in the hospitals, forming a general pattern and management style of “one hospital connected to three schools, and one nucleus platform to many stations”. This mechanism, with talent cultivation as its core,

has realized the two-way integration of university innovation and medical technological needs and established the core position of high-level interdisciplinary talent cultivation in medicine-engineering.

Under the concept of integration of science and education, University S has built a new platform for collaborative education and a new model of joint training in medicine-engineering inter-disciplines, which has been well practiced in the four major disciplines of Science, Engineering, Biology and Medicine (as shown in Figure 1). A total 368 off-campus supervisors of medicine-engineering have been selected into the "dual tutor" system together with on-campus supervisors, which efficiently promotes the scientific research of medicine-engineering inter-disciplinary projects. University S has established an all-round talent cultivation model, completed more than 300 high-tech medicine-engineering research projects, and successfully cultivated more than 1,000 medicine-engineering inter-disciplinary postgraduates; and won provincial and ministerial awards in major competitions. The university has won dozens of provincial and ministerial awards in major national competitions, the proportion of students participating in the competitions is above the average level, and the proportion of experimental research has increased from 25% to 50%. The scientific research team with medicine-engineering interdisciplnary graduate students has accomplished a series of research achievements, such as successfully developed the engineering prototype in the field of naked-eye 3D, high-frequency scalpel, among which a number of research have been industrialized. The quality of talent cultivation is satisfying because the medicine-engineering inter-disciplinary talents can reduce the training cost of enterprises by 45%, compared with graduates of a single discipline, and their inter-disciplinary research provides important technical support for the technological research and development of enterprises. Since the implementation of the cultivation mechanism of medicine-engineering interdisciplanry talents, the university has further enhanced its social influence.

Conclusion

Under the background of Healthy China, science and technology in medical field develop rapidly, which results in the shortage of medicine-engineering interdisciplinary talents. Based on the concept of science-education integration, constructing an innovative mechanism for cultivating medicine-engineering interdisciplinary talents is an important solution to the talent shortage; it is also the direction to realize high-quality talent cultivation in the period of China's "14th Five-Year Plan". University S has explored the innovative mechanism for cultivating talents of medical-engineering interdisciplines under the concept of science-education integration: (1) Building an integrated platform for integrating science and education to provide organizational guarantee for cultivating talents of medical-engineering; (2) Constructing a "dual-tutor" team to guarantee medicine-engineering interdisciplinary talent cultivation; (3) Establishing an all-round talent cultivation mode with adequate management system for medicine-engineering talents cultivation. This institutional innovation has proved to be effective. On the one hand, it promotes the wide application of advanced engineering technology in the medical field, realizes the joint research goal of key scientific research projects, and solves the cutthroat problem of clinical medicine. On the other hand, it promotes the joint cultivation of interdisciplinary talents in medicine and engineering, and greatly improves the quality of talents.

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