

Innovation and Practice of a Dual-Award Talent Cultivation Model in Biomedical Informatics Through Sino-Foreign Cooperative Education

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Abstract. The foundation of “new quality productive forces” lies in BTIT integration, but China faces challenges of talent shortage and technology dependence. Zhejiang University pioneered biomedical informatics education in China and, in 2018, launched a dual-award undergraduate program in biomedical informatics (BMI) with the University of Edinburgh. The BMI program, integrating “medicine + biology + informatics”, aims to cultivate global-minded, interdisciplinary talents proficient in cutting-edge technologies. This paper, taking the award-winning institute Zhejiang University-University of Edinburgh Institute (ZJE) as an example, explores the four-dimensional talent cultivation system in biomedical informatics dual award program at ZJE, addressing challenges in traditional biomedical informatics education to foster leading talents with computational biology skills, global competence, and industry-innovative thinking.

Keywords: Biomedical Informatics; cultivation of talent; dual award undergraduate program; Sino-foreign cooperative education model.

1. Introduction

The foundation of “new quality productive forces” is the profound integration of biotechnology and information technology (BTIT). However, the field of BTIT in China faces the dual challenges of a shortage of interdisciplinary talents and dependence on foreign nations for key technology. Therefore, there is an urgent need to revamp the model for cultivating independent talent to support the development of new quality productive forces. Educational programmes in the area that we nowadays refer to as biomedical informatics cover topics from the field of medical informatics and bioinformatics. The conceptual roots of such programmes lead back more than thirty years and the programmes are well established in many countries. [1] Biomedical informatics in China, a pivotal interdisciplinary field bridging life sciences and information technology, is increasingly vital for both the bioeconomy and the digital economy. [2] Zhejiang University was among the first in China to establish an undergraduate program in biomedical informatics in 2002. Zhejiang University started a novel concept for collaborative talent nurturing between China and other nations in order to overcome the talent cultivation bottleneck. In partnership with the University of Edinburgh in the UK, it introduced the first dual award undergraduate program in biomedical sciences in 2016 that offered dual degrees and full English instruction, opening a new avenue for improving undergraduate instruction in the country by incorporating top-notch international educational philosophies. In 2018, it was further expanded into a fully English-taught dual award undergraduate program in biomedical informatics (BMI). By establishing a trinity biomedical informatics training system integrating “medicine + biology + informatics” and implementing joint scientific research efforts along with an industry-academia-research collaboration mechanism, BMI program is committed to cultivating interdisciplinary talents who possess a global perspective, master

cutting-edge biomedical informatics technologies, and are capable of driving innovation in life sciences and the development of the healthcare industry, thereby setting a benchmark for interdisciplinary talent cultivation with both an international perspective and Chinese characteristics.

Building on the international platform of Zhejiang University's International Campus, BMI program deeply integrates the top-tier educational resources of Zhejiang University and the University of Edinburgh. Based on the interdisciplinary nature of biomedical informatics, it innovatively constructs a four-dimensional integrated talent cultivation system characterized by "interdisciplinary integration, convergence of Chinese and Western wisdom, industry-research integration, and future orientation." Through three core measures—reconstructing interdisciplinary curricula, organizing thesis committee dual supervision, and fostering global industry collaborations—it systematically addresses the challenges of "high disciplinary barriers, weak industry-education integration, and narrow international perspectives" in traditional biomedical informatics education. BMI program aims to cultivate interdisciplinary leading talents with core competencies in computational biology, global competence, and industry-breaking thinking.

2. Integrating Disciplines to Build a Hub for Interdisciplinary Talent Cultivation

As the first Sino-foreign cooperative education institution and the sole pilot institute for cultivating top-tier innovative talents in medicine at Zhejiang University, ZJE has pioneered an innovative training system in biomedical informatics that features in-depth interdisciplinary collaboration. It deeply integrates methodologies from computer science, statistics, and bio-medicine to offer a dual-degree undergraduate program in biomedical informatics, with its international interdisciplinary curriculum being selected as a provincial-level first-class undergraduate course and a provincial-level first-class internationalized undergraduate course.

Guided by the educational philosophy of "holistic development, global immersion, and full-chain practice", the institute leverages the top-tier biomedical informatics resources of the University of Edinburgh to address the core challenge of weak high-throughput data analysis capabilities faced by bio-pharmaceutical industry in China. It has constructed a three-dimensional curriculum matrix encompassing "genomics + machine learning + cloud computing." In terms of interdisciplinary integration, the institute has established a multidisciplinary integration platform and mechanism called "Medicine + X". By utilizing biomedical informatics analysis as a vehicle, it incorporates the latest open-source datasets and computer algorithms into teaching, promoting deep integration between medicine and biomedical informatics and fostering the cultivation of multidisciplinary composite skills. The curriculum system, characterized by the integration of medicine, engineering, and information technology, significantly expands knowledge across various disciplines, forming a brand-new biomedical informatics educational curriculum system and laying a solid foundation for cultivating interdisciplinary talents. Through a modular, fully English-taught curriculum system and teaching models jointly developed by China and the UK, the institute cultivates a new generation of leading disciplinary talents who possess data science thinking, biomedical literacy, and global competence.

3. Integrating Chinese and Western Approaches to Build an Internationally Leading Teaching System

The institute has absorbed and adapted the teaching management system of the University of Edinburgh and Zhejiang University, establishing a standardized teaching implementation plan and a teaching quality monitoring system for biomedical informatics. The primary teaching issues are attempted to be addressed by the course design: First of all, traditional curriculum tend to compartmentalise biology, medicine, and informatics, making it challenging to develop composite

talents. This results in a lack of depth in interdisciplinary integration. Second, there is still a lack of dynamic feedback in teaching evaluations that does not take into account the features of interdisciplinary studies, and traditional biomedical informatics education is frequently beset by fragmented and superficial international resources. These factors contribute to the low level of internationalisation in teaching. Last but not least, there is insufficient industry and research integration, which separates classroom instruction from scientific advancement and real-world production. This makes it difficult to effectively apply knowledge and drive teaching through practice, which eventually leaves students without the practical combat skills they need. With biological knowledge as the framework, medical clinical problems as the guide, and informatics capabilities as the bridge, the course design at ZJE constructs three inter-crossing, mutually supporting, and layered knowledge modules. This approach aims to cultivate biomedical informatics students who possess a comprehensive understanding of biology, medicine, and informatics.

The teaching quality of biomedical informatics adheres to the dual standards of Zhejiang University and the University of Edinburgh. Much attention is paid to in-course assessment (ICA). ZJE breaks away from the traditional single assessment model that relies solely on final exam scores to determine course grades, and instead establishes a process-oriented assessment system that spans the entire semester. Guided by the objective of cultivating academic abilities, ICA consists of a diversified assessment approach encompassing paper writing, experimental design, experimental reports, grant proposals, paper presentations, and poster displays. This approach aims to equip students with research writing and communication skills. Process-oriented evaluations account for 70% of the course grade, while the final exam makes up 30%, effectively motivating students to engage actively in learning throughout the semester.



Fig. 1 In-course Assessment

Rigorous teaching quality control is ensured through mechanisms such as external reviewers and internal feedback from teachers and students: external reviewers participate in evaluating exam difficulty, engage in annual course assessments, and respond to student feedback, providing suggestions for optimizing course structure and content; effective organizations such as Staff-Student Liaison Committees (SSLC), Undergraduate Program Committees (UPC), and Course Assessment Groups (CAG) are established to oversee course quality. For instance, the SSLC convenes once per semester, with student representatives collecting opinions and suggestions from all students and providing feedback to program supervisors and lead instructors, while the Pedagogical Coordination Group (PCG) holds regular monthly meetings. These teaching organizations have established effective channels for feedback on teaching implementation among lead instructors and participating instructors of the same course, between teachers and students, and between lead instructors and undergraduate program supervisors. This enables real-time monitoring of the teaching process, identification and rectification of gaps, and steady improvement of teaching

quality across multiple dimensions. The integrated Chinese-foreign teaching and talent cultivation model has yielded remarkable results, with educational achievements receiving triple recognition: awards from Chinese and British educational institutions, a special first prize and a second prize in the Zhejiang Provincial Higher Education Teaching Achievement Awards, and selection as an outstanding case of Sino-foreign cooperative education. The biomedical informatics program took the lead in being selected as a provincial-level first-class undergraduate program construction site. The institute has successfully passed the undergraduate teaching evaluation by the Ministry of Education, the first round of evaluation for Sino-foreign cooperative education institutions, and the undergraduate program evaluation by the University of Edinburgh. It has received high praise from external experts as “second to none” in the annual teaching evaluation organized by the University of Edinburgh.

3.1 Implementing a Novel Four-in-One Teaching Model

Based on the disciplinary characteristics of biomedical informatics, an internationalized “Four-in-One” undergraduate teaching model has been established, integrating “classroom instruction - knowledge application - discussion & presentation - research innovation”. Core professional courses extend beyond traditional classroom teaching, emphasizing small-group discussion-based instruction to cultivate students’ critical thinking skills. Process-oriented teaching evaluation is prioritized, with each in-class assessment contributing to the final grade. An Examination and Progression Committee has been established to ensure maximum student benefits through a rigorous re-examination system for exam results. Starting from the second year, students are encouraged to independently seek research training opportunities in top-tier domestic and international laboratories, with an emphasis on nurturing the qualities of future scientists through hands-on research experience.

3.2 Cultivating “Scholar-Oriented” Undergraduates Through Early Research Training

In addition to the class advisor and counselor system, each student is paired with a one-on-one academic advisor, as well as development mentors, academic mentors, and life mentors from the Residential college. Academic advisors (comprising all faculty members from the UK side and full-time/part-time faculty of the institute) integrate educational administration and management to provide comprehensive professional guidance and life support to students. Students are encouraged to participate in the Student Research Training Program (SRTP). 90% of biomedical informatics undergraduates in their sophomore and junior years engage in research laboratories. Thanks to this training mode, students have achieved remarkable success, including 5 gold medals at the national finals of the “Internet+” Innovation and Entrepreneurship Competition, 1 silver medal at the International Genetically Engineered Machine (iGEM) Competition, and the publication of over 20 first-authored research papers. The institute actively signs agreements with leading industry enterprises to establish practical training bases, supporting the holistic talent development of undergraduates. Special funds are allocated to invite academicians and renowned scholars to deliver academic lectures on campus, actively fostering an ecosystem for undergraduate education and research in biomedical informatics and thus ensuring a sustained immersive academic atmosphere.

4. Integrating Industry, Research, and Education to Forge a High-Level Ecosystem of Industry-Academia-Research Collaboration

Implementing the development strategy of medical-industry integration is the only way for innovation and development of biomedical technology in China.[3] In alignment with Zhejiang University’s overarching goal of accelerating its ascent to the forefront of world-class universities and adhering to the educational philosophy of cultivating “scholar-oriented” undergraduates, ZJE has recruited a top-tier international faculty team, constructed an open and integrated academic ecosystem, and conducted high-caliber scientific research that integrates industry, academia, and

research to serve the health and well-being of the people. The institute has established a research infrastructure in accordance with international standards, including two fundamental research platforms—a public technology platform and an experimental animal center—providing first-class support for talent development and disciplinary advancement.

4.1 University-Local Government Collaboration and Industry-Education Integration Forge a new Frontier for the Development of Young Talent

ZJE recruits full-time faculty members in line with first-class standards and strengthen faculty evaluation, recruitment, and development by adopting the internationally recognized Tenure-track system. “4+1” thematic research centers were established covering immunology and oncology, stem cell regenerative medicine, sub-cellular biology, systems biology, and consolidate research forces to cultivate organized, thematic scientific research. The Centre for Sub-cellular Biology and Signalling focuses on building a dynamic and comprehensive understanding on how organelles and other sub-cellular structures are organised and function in health and disease. Recent years have seen a tremendous increase in understanding cellular functions, and technical advances in super-resolution microscopy and genome editing. The centre supports research that systematically explores how the cell self-organizes to maintain cellular health using multidisciplinary approaches, including super-resolution imaging, mechanobiology, biomedical informatics, protein modelling, proteomics and molecular biology. Centre members have a shared research interests in function and interplay of various subcellular structures, in particular mitochondria, endoplasmic reticulum, cytoskeleton and the centrosome and have strong expertise in *C. elegans* as an *in vivo* model. The Centre for Musculoskeletal Regeneration and Stem Cell Therapy serves as an interdisciplinary collaborative research pipeline from fundamental biomedical discovery to clinical implementation, towards improved treatments for patients with conditions of the bone, cartilage, tendons, meniscus, and muscles. The centre aims to develop understanding of musculoskeletal diseases, including osteoarthritis, non-union of fracture, osteoporosis, tendinopathy, sarcopenia and other diseases in musculoskeletal system and advance research in stem cell biology, including stem cell lineage commitment (embryonic stem cells, cranial neural crest, mesenchymal stem cells, HSCs) and stem cell heterogeneity (mesenchymal stem cells). The Centre for Systems Biology and Data science uses systems biology approaches to address pressing biomedical challenges including immune-related diseases, cancer, metabolic diseases and infectious diseases. To benefit wider scientific community, the centre aims to develop methodologies, bio-informatics tools and databases for omics studies. By collaborating with other researchers and clinicians, the center aims to identify biomarkers or therapeutic targets for developing novel tools in diagnosis, prognoses and therapeutics. The Centre for Infection Immunity and Cancer CIIC is a disease-oriented centre that applies experimental medicine for human disease to facilitate bench-to-bedside medicine. The centre will focus on health and disease across the whole human body applying investigations of systemic diseases, multi-tissue models and multi-omics for the disease related Cancer & Immunity. The centre investigates organ-specific diseases (across the whole human), the systemic links between organs and how immune cross-talk correlates to pathophysiology in the hope of alleviating both infection and disease. The centre uses pre-clinical models with an immune & cancer focus and develops models with broad applications across ZJE and various university and clinical partners. There are a strong focus on comparative biology, spatial genomics and multi-omics coupled to development of computational tools for systemic comparisons. Models includes *in vivo* animal models of lung cancer & immunity, intra-oral delivery and immuno-stimulatory PRR mouse models for inflammation. The centre develops stronger links with the core animal facility in the development of these models and offer them for collaborators (service-based).

Besides 4 research centers, Biomed-X seminars invite top scientists from leading domestic and international universities and research institutions for symposiums and exchanges to foster a positive academic atmosphere. ZJE has meticulously planned and launched a well-known enterprise visit program, organizing student teams to visit leading companies and top-tier research institutions

in the biopharmaceutical industry, such as BGI Group, Roche Group, and Westlake University. Through these visits, students gain an in-depth understanding and grasp of the latest developments and cutting-edge trends in the industry. Emphasis is placed on integrating basic research with clinical translational research. Strategic cooperation agreements were signed with affiliated hospitals of Zhejiang University to align young faculty members with clinical departments based on disciplinary matching. Cooperation agreements on talent cultivation will be signed with renowned industry enterprises, integrating into undergraduate graduation projects and undergraduate research training programs to provide students with rich opportunities for practical scientific research. Drawing on the partner system, ZJE ensures meticulous implementation of safety and stability measures, including laboratory safety, to provide a favorable research environment.

As of March 2025, among the faculty members, National-level talents account for 17% of the faculty group, while provincial and ministerial-level talents make up 34%. The increase in the proportion of senior faculty members will play a mentoring role, promoting the joint growth of young teachers within the team. The institute has secured projects such as those under the National High-Level Talent Special Support Plan and the Overseas Outstanding Young Talent grant, obtaining 48 provincial and ministerial-level and major key horizontal research project approvals. The institute is distinguished by its international research cooperation, having secured 2 international cooperation projects and 1 Zhejiang Provincial International Science and Technology Cooperation Base, and participating in the publication of over 110 internationally collaborative research papers. Leveraging the strengths of the two universities in disciplines such as biomedicine, genetics, immunology, and pathogen biology, ZJE has formed interdisciplinary research teams focusing on global scientific challenges, including innate immune regulation, novel tumor mutations, and epigenetic regulatory mechanisms. The institute has demonstrated outstanding academic influence in international joint research in the life sciences, with relevant achievements published in leading CNS journals. Since its establishment, faculty members have published over 520 papers as first or corresponding authors in high-level academic journals, with an average impact factor of 7.8.

4.2 City-University Collaboration and Industry-City Integration to Create an International Cooperation Education Model Zone

The institute is located at the International Campus, Zhejiang University. Alongside other Sino-foreign joint educational institutions and programs on the campus, such as Zhejiang University-University of Illinois Urbana-Champaign Institute (ZJUI Institute) and International Business School, Zhejiang University (ZIBS). The international Campus jointly advances the construction of the core area of an open innovation circle for international science, education, and technological resources. It participates in the formulation of the action plan for the International Cooperation Education Model Zone, actively implementing the requirements of the CPC Central Committee outlined in the Outline of the Development Plan for the Integrated Regional Development of the Yangtze River Delta regarding the sharing of high-quality educational and medical resources. This effort promotes the joint development of universities, strengthens cooperative educational programs with internationally renowned universities, and collaboratively builds world-class universities and disciplines with international influence. Additionally, the institute actively collaborates with the Jiaying Municipal Government and the Haining Municipal Government to participate in planning the local biomedical industry roadmap, serving as a think tank advisor. In particular, leveraging the characteristics of the biomedical industry, it established the Zhejiang University-University of Edinburgh Joint Research Center for Biomedicine and Health Translation. By aligning with the Haining Juannu Lake International Science and Technology City, the center facilitates project translation and incubation, supporting the strategic cultivation and layout of the local industry.

Through the joint efforts of the campus and the Haining Municipal Government, the National Development and Reform Commission, the Ministry of Education, and the Ministry of Science and

Technology jointly issued the Construction Plan for the International Cooperation Education Model Zone at International Campus, Zhejiang University (Haining) and Duke Kunshan University in September 2022. This plan sets a benchmark for non-independent legal entity Sino-foreign cooperative educational institutions and their locations to gather world-class talent and scientific and educational resources, promote high-level integration of science, education, and industry, and drive the international transformation of campus-city integration. The International Campus drives the Haining Municipal Government to jointly create an international talent metropolis, establishing the “Thousand PhDs” program to attract doctoral talent to the Haining Talent Community. Through comprehensive cooperation with the Haining Municipal Government, it has created an international cooperation education model characterized by “self-led, high-level, and one-to-X partnerships” as well as the “Haining model” for collaborative development between the campus and local government, integrating education, science, talent, industry, and urban development. Relevant achievements were honored with the 2023 Zhejiang Provincial Reform Breakthrough Award.

4.3 Empowering with Intelligence and Fostering Industry-Research Integration: Ushering in a New Chapter of Win-Win Cooperation Between Universities and Local Regions

Based on the distinctive disciplinary resources, Zhejiang University-University of Edinburgh Institute has strategically focused on fostering interdisciplinary research themes at the intersection of biology, medicine, business, and engineering. By aligning with the research priorities of our partner institution, the University of Edinburgh, Zhejiang University-University of Edinburgh Institute has introduced short-term foreign experts, allocated spatial and financial resources, assembled dedicated teams, incubated international collaborative research projects, and cultivated national-level international joint laboratories in the field of biomedical informatics. Zhejiang University-University of Edinburgh Institute has actively served the development of local industries such as bio-medicine and comprehensive health, aligning with the construction of Juan Lake Science and Technology City. The institute has been approved to establish the Zhejiang International Science and Technology Cooperation Base for Bio-medicine and Engineering Translation. To conduct collaborative translational research in life and health, the institute established the Second Affiliated Hospital of Zhejiang University-University of Edinburgh International Research Center for Interdisciplinary Bio-medicine and the Zhejiang University-University of Edinburgh Joint Research Center for Biomedical and Health Translation.

A new era in university-local government collaboration has begun with the opening of the Zhejiang University-Ordos City Etuohe Banner Joint Biomedicine Centre. Zhejiang University made a major strategic move by signing the cooperation agreement for the Joint Biomedicine Research Centre in order to capitalise on its talent advantages and support innovation-driven development in central and western China. It is also an important measure to implement the new round of strategic cooperation between Zhejiang University and the Inner Mongolia Autonomous Region. The centre will support close and in-depth collaboration in the field of biomedicine based on the principles of co-construction, sharing, and mutual benefit. It is the first university-local (enterprise) research centre on the international campus with cooperation funding exceeding RMB 100 million. The center's objectives are to lead high-quality development in agriculture and animal husbandry, empower the area as a hub for innovative elements in central and western China, and drive the transformation and upgrading of traditional energy industries in Ordos City and Etuohe Banner, all while leveraging Zhejiang University's strong research capabilities and creative talent.

5. Summary

The four - dimensional talent cultivation system within the dual award undergraduate program in biomedical informatics at ZJE aims to tackle the obstacles present in conventional biomedical informatics education, with the goal of nurturing top-tier talents equipped with computational biology skills, global competencies, and innovative thinking for the industry. After establishing a

globally focused, research-driven talent nurturing system with impressive outcomes, the dual award undergraduate program in biomedical informatics at the Zhejiang University-University of Edinburgh Institute looks to the future and strives to lead innovation. By March 2025, 89% of the 81 graduates from the program's three cohorts have pursued further studies, which significantly surpasses the national average in similar majors. 54% have enrolled straight in PhD programs, and 46% have been accepted into the top 20 universities in the world. With their advanced studies covering cutting-edge fields like biomedical informatics, neural computation, and gene regulation, graduates have gained admission to esteemed universities like the University of Cambridge, Harvard University, and Tsinghua University, amply illustrating the forward-looking benefits of the talent cultivation approach.

The institute uses a research-problem-oriented education style in conjunction with scientific research training to improve students' practical skills in order to build research and innovation capabilities. A total of 67 SRTP projects have been started by biomedical informatics students. Furthermore, eight undergraduate students have served as first authors on 20 papers published in SCI journals, demonstrating a unique educational characteristic of tiered training and extensive research engagement. In addition, students have won five gold medals at the national finals of the "Internet+" Innovation and Entrepreneurship Competition and one silver medal at the "iGEM" Competition. In order to create practice bases and assist the comprehensive development of undergraduate talents, the institute actively enters into agreements with top industrial enterprises. The institute actively signs agreements with leading industry enterprises to establish practice bases, supporting the holistic cultivation of undergraduate talents. Furthermore, it allocates special funds to invite academicians and renowned scholars to deliver lectures on campus, actively creating an ecosystem for undergraduate education and research in biomedical informatics and ensuring a sustained academic atmosphere.

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