The Construction of World-Class Universities with Chinese Characteristics as an Effective Practice for the Integrated Deployment of Education, Science and Technology, and Talent: A Case Study of the University of Science and Technology of China (Postprint)

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Abstract

The integrated deployment of education, science and technology, and talent provides the impetus and guarantee for building world-class universities with Chinese characteristics in the new journey, while pointing out the way forward. The implementation of the "Double First-Class" strategy—building world-class universities and first-class disciplines—represents a major strategic decision by the CPC Central Committee and the State Council, holding great significance for enhancing China's education development level, strengthening national core competitiveness, and laying a foundation for long-term development. Against this backdrop, high-level research universities, as an important component of the national strategic scientific and technological force, should take the lead in the integrated deployment of "education, science and technology, and talent." This article, taking the University of Science and Technology of China's efforts in advancing the construction of a world-class university with Chinese characteristics as a case study, seeks to explore the role played in the strategies of invigorating the country through science and education, strengthening the country with talented personnel, and innovation-driven development, under the guidance of the Chinese Academy of Sciences' guiding principle of "the whole Academy runs the university, and institutes are integrated with departments," through continuously promoting educational innovation and scientific and technological innovation.

Full Text

Construction of World-Class Universities with Chinese Characteristics is an Effective Practice of Integrating Education, Science and Technology, and Talent Training—Taking the University of Science and Technology of China as an Example

Abstract

Integrated deployment of education, science and technology, and talent training provides both a guarantee and a clear direction for Chinese universities on their new journey to build world-class institutions with Chinese characteristics. The "Double First-Class" strategy (building world-class universities and first-class disciplines) represents a major strategic decision by the Central Committee of the Communist Party of China and the State Council, holding profound significance for elevating China's educational development, enhancing national core competitiveness, and laying foundations for long-term growth. In this context, high-level research universities, as vital components of the national strategic science and technology force, should take the lead in this integrated deployment. This paper examines the University of Science and Technology of China's (USTC) efforts to build a world-class university with Chinese characteristics, exploring how—under the Chinese Academy of Sciences' guiding principle of "the whole Academy supports the university, and institutes collaborate with departments"—continuous advancement in educational and technological innovation enables the university to play pivotal roles in the strategies of revitalizing the nation through science and education, strengthening the nation with talent, and driving development through innovation.

Keywords

first-class universities, integrated deployment, strategy for revitalizing the nation through science and education, talent development strategy, innovation-driven development strategy

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The integrated deployment of education, science and technology, and talent training outlined in the 20th CPC National Congress Report provides a guarantee and points the way forward for building world-class universities with Chinese characteristics. The report emphasizes that "education, science and technology, and talent constitute the foundational and strategic pillars for building a modern socialist country," and that "science and technology are the primary productive force, talent is the primary resource, and innovation is the primary driver." It calls for deepening implementation of the strategies for revitalizing the nation through science and education, strengthening the nation with talent, and driving development through innovation, thereby opening new fields, tracks, and drivers of development.

To elevate China's higher education and enhance national core competitiveness,

the State Council issued the "Overall Plan for Coordinated Development of World-Class Universities and First-Class Disciplines" in October 2015. Subsequently, the Ministry of Education, Ministry of Finance, and National Development and Reform Commission jointly released the "Implementation Measures for Coordinated Development of World-Class Universities and First-Class Disciplines (Provisional)" in January 2017, establishing China's timeline and roadmap for building world-class universities. On September 21, 2017, these three bodies jointly announced the list of universities and disciplines selected for the Double First-Class initiative, launching a new round of higher education reform.

Universities perform critical functions in talent cultivation, scientific research, and social service, serving as the key intersection point for the three strategies of building an education powerhouse, a science and technology powerhouse, and a talent powerhouse. The Double First-Class strategy is a major strategic decision by the Party Central Committee and State Council, crucial for improving education development, enhancing core competitiveness, and establishing long-term foundations. In this context, high-level research universities, as important components of the national strategic science and technology force, should leverage their advantages in science and education to lead the integrated deployment of education, science and technology, and talent training, playing a principal role in basic research and becoming a vital force in major scientific and technological breakthroughs.

Basic Research as the Wellspring of Innovation

Basic research is the source of scientific and technological innovation. President Xi Jinping has emphasized that "basic research is the source of the entire scientific system and the master switch for all technological problems," calling for "organized advancement of strategic-oriented systematic basic research, frontier-oriented exploratory basic research, and market-oriented applied basic research." He has also stressed leveraging the leading role of national laboratories, the institutional organizational role of national research institutions, the principal role of high-level research universities, and the functions of leading tech enterprises as "question-setters, answer-providers, and evaluators." This provides precise guidance on future organizational paradigms for basic research and the functional relationships among relevant actors.

High-level research universities are the main force in basic research, the primary battlefield for original innovation, and the main front for talent cultivation. From 2009 to 2020, China's basic research funding in universities grew from 14.55 billion yuan to nearly 72.5 billion yuan—an approximately fivefold increase—making universities the main executors of basic research funding. Research and development institutions saw their basic research funding grow from 11.06 billion yuan to 57.39 billion yuan, also roughly a fivefold increase, while enterprise basic research funding grew from 442 million yuan to 9.56 billion yuan, a 21.6-fold increase [Figure 1: see original paper]. In 2020, universities

accounted for 49.4% of national basic research funding execution, research and development institutions for 39.1%, and enterprises for 6.5%.

USTC has consistently prioritized basic research. Under the leadership of the Chinese Academy of Sciences, the university has leveraged its strong basic research capabilities to strategically position itself from a high-level, broad-perspective, and large-pattern standpoint, taking multiple measures to secure early advantages in basic research layout. These measures include: implementing the Academy's "Ten Guidelines on Basic Research" and organizing symposiums for thematic discussion and deployment; establishing an organized research model oriented toward national strategic needs, built upon major platforms such as national laboratories, national research centers, and large scientific facilities, alongside an excellent scientific and technological innovation system based on schools, supported by key experimental platforms, and emphasizing free exploration; launching the "Li-Shi Project" to deploy original exploratory projects that guide and motivate researchers to engage in original basic research; utilizing central university basic research funds and Double First-Class construction special funds to establish multi-tiered university-level autonomous deployment projects focusing on key areas in national and CAS medium- and long-term science and technology development plans or major international scientific frontiers; promoting interdisciplinary integration among physics, chemistry, life sciences, information science, and materials science to strengthen the Hefei National Research Center for Microscale Materials Science; and establishing research centers for geometry and physics, Peng Huanwu theoretical physics, and applied mathematics in Anhui Province to enhance support for cutting-edge basic theoretical research.

In the Nature Index rankings, USTC's global ranking has continued to rise, jumping to 4th among global universities and 1st among Chinese universities in 2020, and maintaining a position within the top 10 globally and top 2 nationally since then.

Serving National Strategic Needs

National strategic science and technology forces are the cornerstone of national scientific and technological development, playing an irreplaceable role in safeguarding national security and promoting economic and social development. President Xi Jinping emphasized at the Academicians' Conferences in 2016 and 2021 that "national laboratory construction should be the 抓手 to strengthen national strategic science and technology forces" and that "national laboratories, national research institutions, high-level research universities, and leading tech enterprises are all important components of national strategic science and technology forces," providing clear direction for developing China's strategic science and technology capabilities.

As an important part of national strategic science and technology forces, high-level research universities are the main carriers and concentrated embodiment

of national scientific and technological strength. They must actively serve major national strategic needs and strive to become a vital force in major scientific and technological breakthroughs. Established in 1958 through the initiative of then-CAS President Guo Moruo and a group of scientists, USTC was born to serve the "Two Bombs, One Satellite" cause. Serving national strategic needs and cultivating cutting-edge scientific and technological talent for the Party and country constitute USTC's inherent value pursuit. As a CAS-affiliated university, USTC leverages its "institutes collaborate with departments" advantage and innovates through "science-education integration," shouldering the responsibility of national strategic science and technology forces.

The university participates as a core force in building the Hefei National Laboratory, capitalizing on its strengths in quantum science, artificial intelligence, and aerospace. To address global space science frontiers and national aerospace power strategy needs, USTC co-established the Deep Space Exploration Laboratory with the National Space Administration and Anhui Province, conducting strategic, forward-looking, and foundational research around major national space science and technology projects and international big science programs to achieve integrated development of science, technology, and engineering. Focusing on the national "dual carbon" strategy, USTC consolidated its strengths in chemistry, materials science, and environmental science to establish the Carbon Neutrality Research Institute, deploying innovative team cultivation fund projects through a "reveal-and-grant" mechanism to help achieve national carbon peak and carbon neutrality goals.

Serving Regional Economic and Social Development

USTC consistently upholds that science and technology constitute the primary productive force, fully leveraging its science and education advantages to pool innovation resources and strengthen deep integration of industry, academia, and research. The university actively supports the construction of the Hefei Comprehensive National Science Center, the development of "USTC Silicon Valley," and deep integration into the Yangtze River Delta's integrated development strategy, thereby serving regional economic and social development through concrete actions.

In 2020, USTC was listed among the first 40 pilot units for the "grant of ownership or long-term use rights of job-related scientific and technological achievements to researchers" reform. The university formulated the "Opinions on Further Strengthening the Transfer and Transformation of Scientific and Technological Achievements," exploring a "USTC model" for this reform. By the end of April 2023, over 50 achievements had applied for inclusion in the ownership reform, with 31 achievements approved for transformation involving 130 intellectual property rights, leading to the establishment of 25 high-quality startups covering new-generation information technology, new materials, new energy, and biomedicine. Relying on the USTC Advanced Technology Research Institute, the university has opened up an innovation chain from "basic research—pilot

incubation—industrialization." The institute has cumulatively incubated 301 enterprises, including 90 national high-tech enterprises and 52 high-growth enterprises, forming industrial innovation chains in independent informatization, artificial intelligence, and biomedicine, and becoming a technological engine for the regional high-tech industry ecosystem.

Cultivating Talent: The Core Mission

The fundamental questions of what kind of people to cultivate and how to cultivate them have always been central to the Party and state's educational mission. As a university founded for the "Two Bombs, One Satellite" cause, USTC has adhered to the principle of cultivating talent for the Party and country since its establishment, upholding its original mission of "serving the nation through science and education, and pursuing excellence."

Scientific achievements require spiritual support. The spirit of scientists, accumulated through long-term scientific practice, is a precious spiritual wealth that has inspired generations of patriotic scientific and technological workers to shoulder the responsibility of scientific and technological innovation. Integrating the spirit of scientists into the spiritual blood of contemporary college students is the spiritual foundation for cultivating innovative talent and the fundamental need to fulfill the historical mission of Chinese higher education. The spirit of scientists is not an abstract doctrine but concrete, vivid, and dynamic, embodied in the historical practices of successive generations of scientists who carried forward the missions of "saving the nation through science," "serving the nation through science," and "strengthening the nation through science" [2]. As an important component of the Chinese Communist Party's spiritual genealogy, the spirit of scientists forms the core foundation of USTC's ethos. Founding figures like Qian Xuesen and Guo Yongwei established the university's spiritual foundation through their patriotic sentiments and aspirations. In the new era, USTC combines the spirit of scientists with the mission of cultivating talent for the Party and country, forging a powerful synergy for innovative talent cultivation.

USTC deeply implements the "Action Plan for Enhancing First-Class Undergraduate Education Quality" and the "Postgraduate Moral and Innovative Leadership Talent Cultivation Plan," striving to build a high-level talent cultivation system that integrates ideological and political courses with curriculum-based ideological and political education. The CAS President has repeatedly delivered the "First Lesson for Freshmen," while the USTC Party Secretary teaches the first ideological and political theory course for undergraduates and the graduation ideological and political course for graduating students, and the President delivers the "Opening Lesson." The university organizes exhibitions on the "Two Bombs, One Star" spirit and series of scientist memorial exhibitions, compiles advanced deeds of scientists, produces micro-films about senior scientists, publishes commemorative albums for scientists like Qian Xuesen, Yan Jici, Qian Linzhao, and Zhao Zhongyao in the *USTC Teaching Review*, and creates the

"Red and Expert Forum," planting the seeds of "serving the nation through science and education" in students' hearts. By selecting expert scholars who are passionate about education and possess both moral integrity and professional competence as academic advisors, USTC has achieved 100% coverage of ideological and political elements in undergraduate courses, fully tapping into the spirit of scientists in basic courses to help shape scientific and technological innovators who are morally upright, professionally excellent, and dedicated to serving the motherland and society.

Science-Education Integration for Cultivating Innovative Talent

More than 200 years ago, Wilhelm von Humboldt established the principle of "unity of teaching and research" at the University of Berlin, which has since become a hallmark of modern universities [3]. Since its founding in 1958, USTC has followed the CAS principle of "the whole Academy supports the university, and institutes collaborate with departments," concentrating the Academy's strength and research institutes' scientific advantages to promote integration of education and research. Through continuous development, CAS and USTC have advanced educational and technological innovation, evolving from version 1.0 of "institutes collaborate with departments, whole Academy supports the university" at founding, to version 2.0 of "science-education collaboration, cooperative talent cultivation" in the early 21st century, and now to version 3.0 of "science-education integration, striving for first-class excellence," achieving comprehensive integration in talent cultivation, scientific research, and achievement transformation.

USTC emphasizes equal importance on teaching and research, continuously promoting students' involvement in frontline research and inquiry-based learning to enhance scientific literacy and innovative capabilities. The university encourages undergraduates to "enter research topics early, enter laboratories early, and enter research teams early," establishing nearly 300 undergraduate research projects annually. Leveraging quality research resources from CAS and high-tech enterprises, USTC hosts the national "College Student Entrepreneurs Growth Plan" summer camp and other activities, establishing over 200 college student innovation and entrepreneurship projects, and integrating the latest scientific research achievements and technological transformations into teaching content. The university has built on-campus innovation practice bases to create favorable environments for student innovation, established mandatory research practice credits, and ensured all students in elite classes participate in research practice, guiding them toward national strategic needs and frontiers of basic disciplines. Undergraduates are encouraged to participate in national key R&D projects such as quantum computing and artificial intelligence. Deng Yuhao, recognized as one of the "Most Beautiful College Students" in 2022, received standardized research training and led independent research projects as a junior, and has now become a key member of the quantum computing prototype "Jiuzhang-3" team. USTC was among the first to establish a Future Technol-

ogy College and launch a Quantum Information Science Elite Class, fully relying on platforms like the Hefei National Laboratory and Hefei National Research Center for Microscale Materials Science to cultivate future scientific and technological innovation leaders with significant influence in frontier interdisciplinary and future technology fields.

Since 1978, responding to the call to "produce talent quickly, early, and in large numbers," USTC pioneered the establishment of the Youth Talent Class, conducting a series of educational experiments centered on "teaching according to aptitude" that emphasized practicality, innovation, and adaptation, and continuously extending successful experiences to regular undergraduate cultivation. Since 2009, USTC has deepened the "whole Academy supports the university, institutes collaborate with departments" model by exploring new models for jointly cultivating top innovative talent with CAS institutes, successively launching 19 Science and Technology Elite Classes. Over the past decade, these classes have cultivated 3,128 students, accounting for 18% of total undergraduates, with an overall deep cultivation rate of 96.1%.

In 2010, USTC officially approved and implemented the "Experimental Program for Cultivating Top Students in Basic Disciplines," developing a new talent cultivation model featuring "two-stage, three-combination, long-cycle, personalized, and internationalized" approaches that closely integrates teaching with scientific research innovation and inquiry-based learning to actively cultivate students' research and innovation capabilities. In 2019, USTC established the Innovation and Entrepreneurship College to continuously explore new models and carriers for leading and demonstrative innovation and entrepreneurship education, initially forming a multi-level, progressive innovation and entrepreneurship education system. With strong support from Anhui Province, the university established the "Eaglet Fund" and "Eagle Fund" to provide financial support, education, and platform guarantees for faculty, student, and alumni innovation and entrepreneurship projects, actively exploring support mechanisms, training models, and guarantee systems for innovative talent and scientific innovation projects. According to incomplete statistics, USTC produces one academician for every 1,000 undergraduate graduates on average—the highest ratio among Chinese universities.

Discipline Construction as the Foundation for Innovative Talent Cultivation

USTC regards discipline construction as its developmental foundation, using key disciplines to drive breakthroughs in related supporting disciplines and providing fertile ground for innovative talent cultivation. Since the Double First-Class initiative began, USTC has focused on building 18 disciplines according to its "11+6+1" layout [Figure 2: see original paper]. Adhering to the development philosophy of "supporting the excellent, the needed, the distinctive, and the emerging," the university has optimized its disciplinary structure, refined disciplinary development directions, and built disciplinary peaks with teams and

platforms as the 抓手, promoting deep integration of emerging and interdisciplinary disciplines and cultivating new disciplinary growth points. This has formed a first-class disciplinary system featuring "basic disciplines taking the lead in becoming world-class, new engineering disciplines achieving leapfrog development, new medical disciplines achieving integrated development, and management and humanities developing distinctively." The university has added six first-level discipline doctoral programs, including Marxist theory, clinical medicine, and chemical engineering and technology, six professional degree authorization points including electronic information, biomedicine, and energy power, and seven undergraduate majors including data science and big data technology, artificial intelligence, and applied experimental physics, achieving continuous improvement in overall disciplinary level and competitiveness.

In the new round of Double First-Class construction, USTC aims for distinctive and high-quality development, implementing the "Basic Disciplines Deepening Construction Action" and formulating the "Implementation Plan for First-Class Disciplines Excellence Action." The university is building its Future Technology College at a high level and establishing Double First-Class discipline key projects focused on priority areas such as dual carbon, artificial intelligence, quantum science, and deep earth and space, continuously enhancing overall disciplinary level and competitiveness.

Institutional Reforms to Stimulate Talent Innovation Vitality

President Xi Jinping has emphasized that the policy focus for cultivating national strategic talent should be placed on young scientific and technological talent, providing them with greater trust, better assistance, and stronger support to enable them to play leading roles. Through whole-cycle planning, staged development, and precise support measures, USTC has leveraged a "magnetic effect" for talent cultivation and released a "chain effect" for talent attraction, cultivating a large pool of young scientific and technological talent who are becoming the main force of scientific and technological innovation.

The university has implemented comprehensive reforms: establishing an academic honor system with endowed professorships and distinguished endowed professorships to motivate faculty to pursue excellence through rigorous selection standards and management systems; improving the talent management system by "breaking the four obsessions" (sole emphasis on academic credentials, professional titles, awards, and project leadership) while "establishing new criteria," streamlining administration and delegating power to researchers, and actively reducing burdens and pressures; implementing flexible long-cycle assessment mechanisms that replace "annual assessments" with "stage assessments" and "performance evaluations" with "peer exchanges" to fully stimulate innovation vitality among high-level basic research talent; building a tenure-track research workforce by strengthening the postdoctoral and special-term associate researcher system to reinforce the strategic science and technology talent reserve; ensuring smooth talent development pathways through flexible structural an-

nual salary systems and coordinated implementation of various talent programs to guarantee that tenure-track researchers can devote themselves fully to scientific and technological innovation; providing research start-up funding for newly recruited talent and establishing programs such as the Academic Leadership Talent Cultivation Plan, Zhongying Young Scholars Program, and Zhai Guanglong Scholars Program, along with the CAS "Special Research Assistant Funding Project" and USTC "Mozi Distinguished Young Talent Special Allowance" to provide precise support for teachers at different development stages; implementing the "Mozi Forum" since 2017, which has provided a high-level exchange platform for over 1,000 young scholars at home and abroad who love academic research and care about China's development; leveraging alumni advantages by establishing a dynamic alumni information database to fully utilize alumni's important role in talent promotion and recommendation; and using international talent channels through programs like the International Visiting Professorship, master lectureships, guest professorships, and external academicians to leverage the influence and cohesion of high-level leading talent.

Over the past five years, USTC's talent recruitment scale has shown a continuous growth trend, with over 400 talents recruited from overseas who have become a core force driving the university's development.

Driving Original Innovation and the Innovation-Driven Development Strategy

Since the 18th CPC National Congress, USTC has achieved a series of world-leading original results in quantum information, high-temperature superconductivity, materials and energy science, and life sciences, along with numerous strategic key technologies in high-precision measurement and multilingual speech processing. The university has incubated several globally influential scientific and technological innovation enterprises in quantum science and other fields. Its "USTC protocol" of "tocilizumab plus conventional therapy" for critically ill COVID-19 patients received high international recognition, and its performance in "fighting the pandemic with science and technology" received national-level commendation. To address global space science frontiers and national aerospace power strategy needs, USTC co-established the Deep Space Exploration Laboratory with the National Space Administration and Anhui Province. Focusing on the national dual carbon strategy, the university established the Carbon Neutrality Research Institute.

Since 2016, multiple USTC achievements have been written into the 19th CPC National Congress Report and praised in President Xi Jinping's New Year speeches. As the first completion unit, USTC has received seven second prizes of the National Natural Science Award and two second prizes of the National Technology Invention Award. The university leads Chinese universities in the number of selections for major international progress and China's Top Ten Scientific Advances news, as well as in Nature Index rankings for 2020 and 2021.

USTC has consistently adhered to the "four orientations" (orienting toward world science and technology frontiers, toward major national needs, toward the national economy, and toward people's health and life). Under CAS leadership, the university has strengthened basic research, tackled key challenges, gathered talent, and promoted reform, enhancing collaborative innovation and seizing development opportunities. By building a research system dedicated to persistent breakthrough innovation, USTC has achieved world-leading original results and incubated numerous globally influential scientific and technological innovation enterprises.

Conclusion

High-level universities, especially those building world-class status with Chinese characteristics, perform essential functions in talent cultivation, scientific research, and social service, representing the critical intersection of the three strategies for building an education powerhouse, science and technology powerhouse, and talent powerhouse. Education cultivates talent, talent drives innovation, and innovation leads development. As a typical representative of Double First-Class universities, USTC's development and experience demonstrate that constructing world-class universities with Chinese characteristics is an effective practice of integrating education, science and technology, and talent training. This integrated deployment points the way forward for building world-class universities with Chinese characteristics on the new journey, inspiring Double First-Class universities to further leverage the roles of "science and technology as primary productive force, talent as primary resource, and innovation as primary driver," continuously explore the inherent laws of coordinated development among the three, and accelerate the construction of world-class universities with Chinese characteristics.

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Figure 1
Scale (a) and structure (b) of China's basic research executive department (2009–2020)

Figure 2
18 key subjects of the University of Science and Technology of China

Note: Figure translations are in progress. See original paper for figures.