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World-Class Discipline Development in the United States and the United Kingdom: Current Practices and Experimental Insights

Lulu Qian, Yanyan Wang, Xujiayi Xu
School of Foreign Languages, Yancheng Institute of Technology, Yancheng 224051, Jiangsu, China

Abstract: This paper examines current practices in world-class discipline development at selected institutions in the United States and the United Kingdom. It summarizes their distinctive characteristics and successful strategies, aiming to provide insights for China's "Double First-Class" initiative. Key recommendations include strengthening disciplinary culture; fostering innovation and entrepreneurship; developing distinctive disciplinary strengths; promoting interdisciplinary integration; building a world-class faculty; and increasing strategic investment in discipline development.

Keywords: World-class disciplines; Current cases; Characteristic experiences; "Double First-Class" initiative

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1. Introduction

The concept of "world-class disciplines" carries distinctive Chinese characteristics. Building world-class universities and disciplines is a major national education strategy, crucial for enhancing China's educational development, strengthening its core competitiveness, and laying a solid foundation for sustainable growth. Consequently, the domestic academic community has shown significant interest in the selection and development of such disciplines. Scholars have extensively discussed related issues, including their essence, conceptualization, features, standards, objectives, and pathways. Focusing on current cases in the U.S. and the U.K., this paper summarizes their typical characteristics and successful experiences to offer reference and guidance for the ongoing "Double First-Class" construction in China and its provinces.

2. Current practices and case studies in the U.S. and the U.K.

2.1. Department of Physics, Princeton University, USA

Princeton University, a member of the Ivy League, hosts a Physics Department consistently ranked among the world's best. Its faculty of 73 includes 6 Nobel laureates in Physics, 12 MacArthur Fellows, 4 highly cited researchers, and 11 members of the National Academy of Sciences. A distinctive feature is its establishment of various committees and interdisciplinary units (e.g., the Humanities Council, Science and Technology Council, Institute for International and Regional Studies) to coordinate and enhance interdisciplinary education and research for both undergraduate and graduate students. The

University's International Programs Office further encourages students to study and conduct research at leading global institutions. This environment has nurtured numerous distinguished figures, including physics Nobel laureate John Bardeen, gravitational wave discoverer Rainer Weiss, and Fields Medalist Edward Witten. In research, the department's average citation score for physics papers was 94.1 (QS 2020), ranking 2nd globally, while its number of top-tier publications ranked 8th (GRAS 2020). It also boasts advanced experimental facilities like the Joseph Henry Laboratories, the Nano/Microscope Laboratory, and the Quantum Coherence Lab, providing a cutting-edge environment for high-level research.

2.2. Department of Chemistry, Massachusetts Institute of Technology (MIT), USA

MIT's Chemistry Department is a perennial global leader, with its core disciplines regularly placed within the top three worldwide. Its 35 faculty members include 1 Nobel laureate in Chemistry, 7 highly cited researchers, 10 National Academy of Sciences members, and 15 American Academy of Arts and Sciences fellows. The department's talent cultivation emphasizes hands-on experimentation (lab courses constitute 61% of degree credits), interdisciplinary training (requiring graduate students to rotate through different labs), and international exposure (offering year-long exchanges at renowned international chemistry departments). Its alumni include modern organic synthesis master Robert Burns Woodward, bioinorganic chemistry pioneer Stephen J. Lippard, and Genentech founder Robert A. Swanson. The department's average citation score for chemistry papers was 96.5 (QS 2020), ranking 8th globally. Beyond high-impact publications, it emphasizes groundbreaking discoveries, such as Clark Sheehan's synthesis of penicillin and F. Albert Cotton's pioneering work in cluster chemistry. Its facilities include the Laser Biomedical Research Center, featuring 7 NMR spectrometers, X-ray diffraction equipment, and a Beckman XL-I analytical ultracentrifuge, among other world-class biophysical instruments [1].

2.3. Mathematical Institute, University of Oxford, UK

The Mathematical Institute at the University of Oxford enjoys high global esteem and leading international rankings. With over 170 faculty, including 3 Fields Medalists, 2 Abel Prize winners, and 1 Rolf Nevanlinna Prize recipient, it offers around 250 undergraduate and over 300 graduate courses, forming Oxford's distinctive composite course model. Distinguished alumni include physicist Stephen Hawking, Fields Medalist Simon Donaldson, and writer Lewis Carroll. As the UK's largest research hub, Oxford's output in top international journals surpasses that of any other British university. In the 2020 REF assessment, the Institute submitted 492 research outputs, with 45.2% judged "world-leading" and 58.5% "internationally excellent." Oxford provides rich resources, including world-class libraries and museums, and extensive electronic databases, such as Datastream, Scopus, Physical Engineering, and Computational Information Systems, for accessing the latest literature [2].

2.4. Department of Biology, University of Cambridge, UK

The Department of Biology at the University of Cambridge maintains a forefront global position and strong academic reputation. Its faculty of over 600 includes 26 Nobel laureates in Physiology or Medicine and 24 in Chemistry. Cambridge emphasizes cultivating students' innovation and problem-solving skills, offering practical entrepreneurship opportunities, and guiding the transformation of knowledge and patents into productivity, effectively integrating academia, industry, and research. It provides robust research and innovation platforms, collaborating with biotech firms like GlaxoSmithKline, AstraZeneca, and Pfizer. Notable alumni include Charles Darwin, Nobel laureate Robert G. Edwards, and Nobel laureate in Chemistry Qian Yongjian. The department's research funding for 2021-2022 reached approximately $200 million, primarily from UK charities, the World Bank, and the Royal Society. In the 2020 REF, 37.4% of its output was "world-leading" and 49.2% "internationally excellent." It hosts interdisciplinary units like the Proteomics Research Centre and the Stem Cell Institute, alongside 7 biology-specific libraries, providing ample space, materials, and advanced equipment for high-level research.

3. Characteristics and successful practices

3.1. Defining characteristics

3.1.1. Emphasis on innovation and interdisciplinarity

World-class disciplines are typically characterized by cutting-edge, interdisciplinary, and leading research directions that evolve with the times. The research scope of the examined disciplines encompasses not only fundamental theoretical knowledge but also applied research across various fields, as well as emerging areas born from interdisciplinary collaboration. Multidisciplinary applied research—for instance, applying mathematics to medicine or finance—represents a key mechanism for integrating academia, industry, and research. Interdisciplinary studies form the foundation for generating novel fields, such as biochemistry, computational mathematics, and physical chemistry. The case disciplines host numerous interdisciplinary research centers and applied research teams that facilitate work across diverse fields. This infrastructure also underpins their ability to yield innovative outcomes, cultivate innovative talent, and generate societal value.

3.1.2. Building a high-level faculty team

The caliber of a first-class discipline is fundamentally determined by the quality of its faculty. World-class disciplines are invariably distinguished by outstanding scholars and internationally influential academic leaders. The faculty constitutes a critical driver of disciplinary development, and in the cases examined, it comprises not only renowned figures such as Nobel laureates and members of national academies, but also emerging and mid-career academic talents [3]. Together, they form a sustained academic team, where experience, mentorship, and leadership combine to ensure the discipline's continuous and long-term advancement.

3.1.3. Cultivating socially recognized talents

Talent cultivation is a core mission of universities. World-class disciplines consistently produce elites and leaders across various sectors. Their graduates are widely recognized for their innovative and entrepreneurial capabilities. Alumni from the case disciplines have achieved significant scientific breakthroughs within their fields, while others have excelled as prominent politicians, entrepreneurs, writers, and more.

3.1.4. Generating high-level research output

World-class disciplines must consistently produce high-level, original, and groundbreaking research. Such discoveries often propel the discipline forward and deliver substantial economic or social benefits. Importantly, innovative research output relies on access to international platforms, clusters of distinctive disciplines, and quality research resources.

3.1.5. Maintaining a strong academic reputation

World-class disciplines invariably enjoy a strong academic reputation, as perceived by peers and society at large. This reputation generally encompasses academic prestige, teaching quality, and graduate employability, reflecting a comprehensive evaluation of teaching, management, faculty integrity, graduate outcomes, social contribution, and institutional culture. The case disciplines' excellent faculty, ample resources, personalized teaching, and high employment rates are essential to their esteemed reputation. A strong reputation, in turn, attracts top students, ensuring a high-quality intake.

3.1.6. Possessing a rich cultural heritage

World-class disciplines are not created overnight; they develop through long-term accumulation. They possess a rich history and profound cultural heritage, having cultivated excellent academic traditions and a free, stimulating intellectual atmosphere over time. The case disciplines exemplify this by fostering a tolerant and open academic environment that allows faculty to integrate teaching and research freely and encourages students to pursue truth with perseverance.

3.2. Successful practices

3.2.1. Teaching, research, and social service

All world-class disciplines maintain close integration among teaching, research, and social service. The case disciplines encourage all faculty to engage in frontline teaching, enhance the relevance of curricula to local societal and industrial needs, involve students in faculty research projects, and develop students' teamwork, innovative research, and social service capabilities. They provide opportunities for faculty and students to engage with industry, guiding the integration of research, technological innovation, and social service. In summary, teaching, research, and social services mutually promote and coordinate development, serving national strategic needs together.

3.2.2. Balancing foundational and frontier disciplines

In terms of disciplinary composition, world-class disciplines maintain a balance between foundational and frontier fields. Foundational disciplines provide the theoretical base for frontier development, while frontier disciplines lead the field and represent the cutting edge of progress. For example, Princeton University's physics department has expanded from fundamental and theoretical physics into frontier areas such as high-energy physics, condensed matter physics, mathematical physics, biophysics, nuclear physics, and astrophysics. Disciplinary development can only broaden its research scope and reach international frontiers when built upon a solid foundation of basic research [4].

3.2.3. Developing distinctive disciplinary areas

Given finite institutional resources, world-class disciplines adopt a strategic focus on developing key strengths and distinctive fields. The case disciplines identify their comparative advantages, build disciplinary clusters, and, through long-term commitment, cultivate unique and outstanding world-class disciplines. For instance, the California Institute of Technology strategically shifted its research emphasis to geochemistry and geophysics during its development, leveraging strengths in chemistry and physics to build a leading cluster in geochemistry, geophysics, and planetary science, eventually becoming a top earth sciences discipline in the United States.

3.2.4. Attracting global top talent in faculty development

In cultivating their faculty teams, world-class universities place a strong emphasis on attracting top-tier academic talent. The faculty members in the examined disciplines typically possess international research experience and demonstrate robust innovative capabilities in their fields [5]. During the recruitment process, these institutions not only prioritize improving tangible incentives such as competitive salaries and state-of-the-art laboratory facilities but also place significant importance on fostering a supportive and intellectually engaging environment to attract and retain outstanding scholars.

3.2.5. Fostering cross-disciplinary integration

World-class disciplines do not develop in isolation; they require support from foundational disciplines, resources from related fields, and a conducive ecosystem. The case disciplines strongly emphasize interdisciplinary collaboration, establishing interdisciplinary research centers, institutes, or laboratories to promote integration and actively utilize resources that support disciplinary development.

3.2.6. Securing external resources and enhancing internal efficiency

The development of world-class disciplines requires advanced equipment and the most authoritative and comprehensive data resources for support. The case disciplines benefit from secure funding streams, which vary according to national context and institutional type. In the United States, public university funding primarily comes from federal and state governments, while private universities rely more on endowment income, social donations, patent royalties, and research grants. In the United Kingdom, university funding largely comes from government bodies such as the Higher Education Funding Council for England and the National Institute for Leadership, supplemented by self-generated income.

4. Insights and suggestions for the “double first-class” construction in our country and province

4.1. Strengthening disciplinary culture

Current disciplinary divisions in our country often result from administrative planning, which can weaken the intrinsic connections within knowledge systems [6]. This artificial separation may create barriers between disciplinary cultures, hindering their development. Therefore, it is necessary to soften disciplinary boundaries, foster an inclusive and collaborative academic community, identify shared cultural elements across disciplines, and promote mutual understanding and recognition. An open disciplinary culture is vital for building first-class disciplines in China and is part of their internationalization. We should break away from closed and rigid cultural patterns while strengthening exchanges and cooperation between Chinese universities and world-class disciplines.

4.2. Emphasizing innovation and entrepreneurship education

First, we should enhance the development of innovation and entrepreneurship curricula. Based on close alignment between disciplinary content and industry needs, an integrated curriculum system should be formed, considering educational philosophy, objectives, content, structure, and activities. Curricula should include both foundational knowledge and specialized content in innovation and entrepreneurship. Teaching methods should link theory with practice, combining classroom instruction with hands-on courses to effectively develop students’ relevant skills. Additionally, universities should foster a campus culture centered on innovation and entrepreneurship, creating a free and open academic atmosphere.

4.3. Focusing on developing distinctive disciplines

The development of distinctive disciplines should align with national strategic needs and local economic development. To achieve sustainability, these disciplines must actively address societal demands and contribute to national and local socioeconomic progress. Building distinctive disciplines requires innovative vision, driven by high-level faculty and academic leaders, and supported by advanced platforms and original research. Different disciplines emerge from different contexts; therefore, each should choose a suitable development path and pace. In summary, universities should actively seek integration points between different disciplines, tradition and modernity, and disciplinary development and national strategy.

4.4. Promoting interdisciplinary integration

Interdisciplinary studies are a new driving force for university development and a prerequisite for building world-class disciplines. However, the prevailing organizational structure in Chinese universities—often centered on distinct schools, colleges, and departments—can hinder interdisciplinary collaboration, education, and the cultivation of interdisciplinary talent. Therefore, first, interdisciplinary entities such as research institutes, academic innovation units, and comprehensive laboratories should be established to promote horizontal collaboration across departments. Second, emphasis should be placed on building disciplinary clusters that link closely related fields to form multidisciplinary synergies. Third, interdisciplinary facilities should be developed to bring together scientists from different fields and laboratories, providing conducive spaces for interdisciplinary integration.

4.5. Establishing a first-class faculty team

First, the current faculty appointment system should be reformed to overcome the rigidity that hinders the recruitment of outstanding scholars and the removal of underperforming staff, thereby revitalizing hiring practices and facilitating greater talent mobility. Second, a “master scholar + team” model should be promoted to establish a well-structured academic team within each discipline. Faculty teams ought to comprise esteemed senior leaders, core mid-career academics, and dynamic early-career researchers [7]. Through collaborative work, team members can progressively develop independent research

capabilities and collective leadership, fostering the sustainable growth of the faculty. Third, a supportive and intellectually open research environment must be cultivated to nurture innovative teams that span disciplines and fields.

4.6. Increasing investment in first-class discipline construction

All the aforementioned measures depend on financial support. Indeed, without sufficient funding, disciplinary development is challenging. Building world-class disciplines is a long-term endeavor that requires sustained financial commitment from national, local, and societal sources. Simultaneously, universities should promote a culture of donation, encourage contributions from various social sectors, actively collaborate with enterprises in research and commercialization, secure loans, and diversify fundraising channels to expand income sources [8].

5. Conclusion

Based on the analysis of top disciplines in the United States and the United Kingdom, we identify common characteristics of world-class disciplines: a strong academic reputation and rich cultural heritage, a focus on high-level faculty and talent cultivation, and a strong emphasis on interdisciplinary collaboration and research innovation. The successful experiences from the U.S. and U.K. suggest that, in terms of disciplinary functions, teaching, research, and social service should develop in a coordinated manner; in disciplinary structure, a balance between foundational and cutting-edge elements is essential; in development strategy, focusing on distinctive areas is key; in faculty development, attracting global top talent is crucial; in disciplinary integration, cross-disciplinary approaches should be emphasized; and in resource allocation, securing external funding and enhancing internal efficiency are vital. The construction of world-class disciplines in China should adhere to the core principles of Chinese characteristics and world-class standards, remain rooted in the Chinese context, aim to enhance international competitiveness and serve socioeconomic development, progressively inherit and develop outstanding traditional Chinese culture, and strive to explore a path to world-class disciplines with Chinese and regional distinctive features.

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