Cuban Journal of Public and Business Administration
ISSN 2664-0856 RNPS 2458 / Vol. 9 (2025) / e362
Available in: https://apye.esceg.cu/index.php/apye/article/view/362

Original article

CONSTRUCTING AND INNOVATING RESEARCH-TEACHING COMMUNITIES DRIVEN BY INTERDISCIPLINARITY

CONSTRUYENDO E INNOVANDO COMUNIDADES DE INVESTIGACIÓN-DOCENCIA IMPULSADAS POR LA INTERDISCIPLINARIEDAD

Xiangbiao Liao [I *] https://orcid.org/0009-0001-0819-6066
Dezh Zheng [I] https://orcid.org/0009-0008-9585-6712
Qi Chen [I] https://orcid.org/0000-0002-9647-5873
Ping Li [II]
Jing Yang [I] https://orcid.org/0009-0002-2070-5238
Minghui Yang [I] https://orcid.org/0009-0004-2196-2556
Ao Zhang [I] https://orcid.org/0009-0009-1120-1100

[I] School of Interdisciplinary Science, Beijing Institute of Technology (BIT), Beijing, China
liaoxiangbiao@bit.edu.cn, 6120230097@bit.edu.cn, qic@bit.edu.cn, jingyang@bit.edu.cn, yangmh17@bit.edu.cn, ao.zhang@bit.edu.cn
[II] Beijing Institute of Technology (Zhuhai), Beijing Institute of Technology (BIT), Zhuhai, China
liping85@bit.edu.cn

* Corresponding author: liaoxiangbiao@bit.edu.cn

JEL Classification: A29

DOI: https://doi.org/10.5281/zenodo.16876513

Received: 02/07/2025
Accepted: 10/08/2025

Abstract

This paper provides a detailed analysis of the major challenges faced by universities both domestically and internationally in cultivating top-notch talent, primarily characterized by rigid disciplinary barriers and the weak integration of research and education. To implement the guiding principles of the Third Plenary Session of the 20th Central Committee of the Communist Party of China and the National

Published by the Higher School of State and Government Cadres, Havana, Cuba

Education Conference, and to establish a holistic “grand education perspective” that synergizes education, science and technology, and talent development, to advance the “scientifically organized talent cultivation”, the School of Interdisciplinary Science (SIS) at Beijing Institute of Technology (BIT) is moving towards establishing a physical Advanced Interdisciplinary Research and Education Center (AIREC). This initiative aligns with BIT’s strategy to deepen the “integration of research and education” and the main approaches involve leveraging first-class interdisciplinary research teams to build first-class teaching capabilities and utilizing top-tier interdisciplinary research platforms to shape first-class educational platforms. It can help foster a virtuous cycle among education, science and technology, and talent development, and cultivate doctoral graduates with comprehensive interdisciplinary capabilities. Hereby, these objectives will be achieved including advancing BIT’s high-quality development of its “Double First-Class” disciplines, providing a solid foundation for cultivating original leading talents urgently needed for national strategic priorities, including scientists, entrepreneurs and chief designers for national defense, as well as incubating and nurturing globally impactful and original scientific research innovations within China.

Keywords: interdisciplinarity, theory of research-education integration, practice of research-education synergy, multidisciplinary integrated cultivation, successive Undergraduate-Postgraduate cultivation

Resumen

Este artículo ofrece un análisis detallado de los principales desafíos que enfrentan las universidades, tanto a nivel nacional como internacional, para formar talento de primer nivel, caracterizados principalmente por las rígidas barreras disciplinarias y la débil integración de la investigación y la educación. Para implementar los principios rectores de la Tercera Sesión Plenaria del XX Comité Central del Partido Comunista de China y la Conferencia Nacional de Educación, y para establecer una perspectiva integral de educación con sinergia entre la educación, la ciencia y la tecnología, y el desarrollo de talento, con el fin de promover la formación de talento científicamente organizada, la Escuela de Ciencias Interdisciplinarias (SIS) del Instituto de Tecnología de Beijing (BIT) avanza hacia el establecimiento de un Centro de Investigación y Educación Interdisciplinaria Avanzada (AIREC). Esta iniciativa se alinea con la estrategia del BIT de profundizar la integración de la investigación y la educación, y sus principales enfoques consisten en aprovechar equipos de investigación interdisciplinaria de primer nivel para desarrollar capacidades docentes de primer nivel y utilizar plataformas de investigación interdisciplinaria de primer nivel para dar forma a plataformas educativas de primer nivel. Puede contribuir a fomentar un ciclo virtuoso entre la educación, la ciencia y la tecnología, y el desarrollo del talento, y a formar doctorandos con amplias capacidades interdisciplinarias. De esta manera, se alcanzarán estos objetivos, incluyendo el avance del desarrollo de alta calidad de las disciplinas de "Doble Primera Clase" del BIT, sentando las bases para la formación de talentos líderes originales, urgentemente necesarios para las prioridades estratégicas nacionales, incluyendo científicos, emprendedores y diseñadores jefes de defensa nacional, así como para la incubación y el fomento de innovaciones científicas originales y de impacto global en China.

Palabras clave: interdisciplinariedad, teoría de la integración entre investigación y educación, práctica de la sinergia entre investigación y educación, formación integrada multidisciplinaria, formación sucesiva de pregrado y posgrado.

Introduction

The Report to the 20th National Congress of the Communist Party of China instructs "education, science and technology, and human resources" as foundational and strategic support for comprehensively building a modern socialist country, explicitly calling for strengthened interdisciplinary development.[1] Against the backdrop of intensifying global technological competition, strategic contests in emerging domains such as maritime rights, low-altitude economy, and meteorological preparedness are becoming increasingly fierce. Traditional single-discipline training models struggle to meet the demands of complex system innovation.

Research indicates that over 50% of more than 600 major discoveries across multiple fields were contributed by interdisciplinary talents holding two or more degrees.[2] However, China's doctoral training cycle is 2.8 years longer than the international leading standard, resulting in an innovation output density during the prime window period for innovation (25-35 years old) that is only one-sixth that of the United States. In this context, structural reform of the top-notch talent cultivation paradigm has become the central mechanism for breaking through bottlenecks in developing interdisciplinary talent.

This paper provides a detailed analysis of the major challenges faced by universities both domestically and internationally in cultivating top-notch talent, primarily characterized by rigid disciplinary barriers and the weak integration of research and education.

Challenges and Practices in Interdisciplinary Development

Currently, interdisciplinary programs in higher education institutions are confronted with three deeply entrenched contradictions.[3] Firstly, disciplinary fragmentation is rigid, and interdisciplinary institutionalization is insufficient. Traditional disciplinary classifications and the allocation model of departmental resource hinder cross-disciplinary collaboration. For instance, an internal survey at a "985 project" university reveals a 34% failure rate for engineering doctoral students in cross-disciplinary courses, while papers involving three or more disciplines face a 52% higher rejection rate compared to papers concerning single-discipline.

Secondly, there exists a deficiency in the integration of research and education, and a lack of vertical coherence across different educational levels. For example, on the national scale, laboratory equipment is seldom utilized in undergraduate instructional settings, the transformation of research findings into pedagogical cases remains progressing at a sluggish pace, which contributes to technological generational gaps; additionally, bachelor's, master's, and doctoral curricula exhibit a fragmented structure, delaying students' exposure to cutting-edge research topics until an average age of over 26.

To tackle these bottlenecks, global universities are implementing pioneering solutions through organizational restructuring and institutional innovation.

(i) <u>International Frontiers: Hybrid Models and Successive Undergraduate-Postgraduate Cultivation Programs</u>

Universities in America implement synergistic physical platforms and virtual organizations. MIT's Institute for Interdisciplinary Information Sciences employs a "hybrid physical-virtual model": leveraging AI and quantum computing as traction, it establishes physical laboratory operating independently of traditional departmental structure (e.g. the Center for Quantum Engineering) while building cross-institutional virtual research networks, attracting companies like Microsoft and Google to co-develop courses.[4] Although this model has yielded breakthroughs like quantum chips and cryptography, it demonstrates a notable "limitation in sufficient pedagogical transformation", characterized by the limited integration of research findings into educational curricula and teaching resources.

European universities promote successive integrated experiments. "Doctoral Factory" program at Delft University of Technology allows qualified Master's students to join 4-year doctoral programs, carrying out industry-university collaborative projects (e.g. collaboratively conducting drone airworthiness certification with Airbus) through labs like the "Intelligent Transport Systems Laboratory", which reduces the training duration by 1.5 years. Imperial College London has launched a "Cross-Disciplinary Seed Funding", subsidizing young scholars to form interdisciplinary teams. "Climate and AI" project of the college has incubated a carbon emission prediction model that has been adopted by the European Environment Agency.

(ii) Domestic Practices: Institutional Innovation and Reconstruction of Platform

In institutional innovation, Northwestern Polytechnical University (NPU) established a "Fundamental and Frontier Interdisciplinary Course Center", directly managed by the Vice President, with 33% external faculty (including academicians and overseas professors), developing 28 Problem-Based Learning (PBL) courses.[5] Its hallmark is a dual-module design of "0→1 basic research + 1→0 engineering translation", exemplified by its "Metamaterial Physical Modeling" course feeding back the domestic stealth material R&D. Shanghai Jiao Tong University (SJTU) implemented a talent recruitment plan, that is, "Directly Contract Principal". Its Zhangjiang Institute for Advanced Study recruited 74 leading scientists in three years, forming platforms like the "Research Center for Mathematical Foundations of AI", promoting significant and groundbreaking research outputs, including the detection of liquid xenon dark matter.[6]

In cultivation model reform, South China University of Technology (SCUT), leveraging its Guangzhou International Campus, established 10 new engineering schools,[7] pioneering the "Intelligent Manufacturing Engineering" interdisciplinary major and securing China's first doctoral degree-granting authority in Integrated Circuit Science and Engineering. Its core breakthrough is the "Enterprise Mentor Residency System", where Huawei engineers co-teach courses like "Chip Design Practice", with students participating in the tape-out of the Kirin 9010 chip. Dalian University of Technology (DUT) constructed a "Five-Cross" system integrating specialization and innovation (cross-discipline/program/college/undergraduate-postgraduate/time-space), which offers more than 500 interdisciplinary courses. Collaboration between Mechanical and Chemical Engineering tackled carbon fiber composite processing and developed 13 sets of high-end equipment effectively, which helps overthrow foreign monopolies in aerospace composite processing, and advance the technology to reach international standards.[8]

For resource aggregation, Qilu University of Technology (QLUT), leveraging the National Supercomputing Center in Jinan, created a “Disciplinary Development System Similar to the pattern of V-Shaped Wild Geese”: a system led by Computer Science (top 9% in Soft Science ranking), drives AI and Marine Information Science forward.[9] Its distinctive feature is transforming the “Supercomputing Internet” platform into teaching scenarios, where students directly participate in building Shandong Province’s government cloud platform, serving over 1,000 institutions. Chongqing Jiaotong University established the “Frontier Technology Interdisciplinary Research Institute”, focusing on strategic scenarios like polar transportation and air-space integration. Its “Center for Intelligent Construction and Maintenance of Extreme Environment”, collaborating with Tsinghua University on suspended tunnel technology, propels traditional transportation disciplines toward the eco-friendly and intelligent transformation.[10]

Analysis of Problems in Traditional Research-Education Models

Under the circumstance of intensifying global technological competition, industrial upgrading, and rapid development of strategic emerging fields, systemic flaws in traditional university disciplinary training models are increasingly prominent. Higher education institutions worldwide commonly grapple with two deep-seated contradictions: the institutionalization dilemma in organizational structure and the absence of successive undergraduate-postgraduate cultivation systems, severely constraining the cultivation efficacy of high-tech innovation talent.

(i) The Institutionalization Dilemma in Organizational Structure

This dilemma reflects deep contradictions in disciplinary governance. China’s long-standing “university-college-department” hierarchical structure is essentially an institutional legacy of 20th-century specialization logic.[11] This management structure solidifies rigid disciplinary boundaries through catalog controls, resource allocation mechanisms, and spatial segregation. However, against the backdrop of quick development of interdisciplinary science and technology, the traditional management system results in insufficient institutionalization of interdisciplinary research entities, leaving them in a state of “institutional suspension”, which means that the traditional pattern is unable to breach traditional departmental resource barriers and cannot gain independent institutional identity.[12]

The underlying mechanism involves three tensions:

- Power Allocation: University-level interdisciplinary platforms lack independent hiring authority and financial autonomy, rendering them perpetually dependent on traditional disciplinary units, which further results in power and autonomy deficits.
- Institutional Design: rigid disciplinary catalog systems can brute force the categorization of knowledge production into static classifications, constrain frontier technology development and erect high barriers among interdisciplinary fields.
- Spatial Organization: physical segregation and disciplinary territorialism continuously reinforce the psychological boundaries of academic communities.

These structural contradictions reduce interdisciplinary platforms to resource coordination intermediaries rather than innovation actors, their operational efficiency persistently eroded by the difficulties of effective cross-departmental coordination, ultimately leading to systemic decay in knowledge integration capacity.

(ii) The Absence of Successive Undergraduate-Postgraduate Integrated Cultivation

This absence exposes the paradigm lag in the current education system. Traditional segmented cultivation, based on Taylorism management philosophy,[13] mechanically decomposes knowledge transmission into discrete units through the linear separation of undergraduate liberal education and postgraduate specialization. However, this segmented design fundamentally conflicts with the non-linear knowledge construction required for interdisciplinary innovation,[14] manifesting in three fractures:

- Vertical Coherence: Structural redundancy between undergraduate and postgraduate curricula cause inefficiency. Students are forced to repeat foundational content during advanced studies, which doesn’t quite match with the critical period for capability leaps.
- Horizontal Integration: Disciplinary-bound credit recognition standards and course modules create institutional barriers to transference of interdisciplinary knowledge, which distracts students from their study.
- Temporal Sequencing: Delayed exposure to frontier topics leads to premature cognitive rigidity, hindering the development of cognitive flexibility that is essential for interdisciplinary innovation.

A deeper contradiction lies in the single-discipline dependence of the academic guidance system. The combination of single-supervisor mentorship and discipline-bound evaluation criteria gets the development of interdisciplinary thinking into an institutional dilemma. When interdisciplinary research breaches established paradigms, its innovative value is often misjudged by traditional quality standards. This cognitive conflict creates persistent blockages in teaching, degree conferral, and the recognition of research findings.

The combined effect of these two problems constitutes a systemic predicament for frontier interdisciplinary education. Insufficient institutionalization directly constrains resource integration, hindering the implementation of foundational conditions like cross-disciplinary course development and shared experimental platforms. Concurrently, the fracture in successive undergraduate-postgraduate integrated cultivation impedes innovative talent cultivation, preventing synergy between talent development and research innovation, thereby weakening the sustainable development capacity of interdisciplinary platforms.

The institutional root lies in a dual logic conflict within disciplinary governance: Traditional disciplinary systems maintain knowledge production order through catalogs, structures, and evaluations designed for specialization, while the new paradigm represented by interdisciplinary research demands the dissolution of interdisciplinary boundaries and the establishment of problem-oriented, networked collaboration. This conflict manifests operationally as power struggles concerning the allocation of resources—traditional disciplinary clusters often leverage performance accounting and spatial strategies to safeguard established interests, whereas interdisciplinary platforms remain occupying a peripheral position within academic power structures due to a lack of institutional grounding. To address this issue effectively, it is important to fundamentally reconstruct disciplinary governance paradigm by establishing flexible organizational structure and implementing a coherent paradigm of talent cultivation. This represents not only an inevitable adaptation to evolving modes of knowledge production but also a crucial institutional innovation for fostering innovation-driven talent.

Theoretical Innovation in Research-Education Integration Driven by Interdisciplinarity

Concerning the "disconnection between virtual and real" and the insufficiency of institutionalization (i.e. separation of teaching and research resources) in traditional schools, the core of theoretical innovation lies in reconstructing teaching organizations based on physical research platforms, so as to realize "platform as classroom, project as course". Its breakthrough points manifest in three aspects:

1. Institutionalized Organizational Mechanisms: Unlike traditional schools that struggle with the dichotomy between laboratory/project work and teaching system, integrated physical platforms can effectively unify these elements. For instance, Xi'an Jiaotong University's (XJTU) Aerospace Propulsion and Intelligent Manufacturing Platform employs a "dual-chief-commander + dual-chief-engineer" model that fosters the collaboration between university and industry. Experts from the Sixth Academy of Aerospace Science & Technology co-lead with professors in university, facilitating instruction within the "real combat environment" of project development. With dedicated R&D bases, testing facilities, and mentorship teams, students engage directly in five national major projects (e.g. aerospace propulsion), illustrating the principle that "where the mission is, the classroom is".[15]

2. Deepened Resource Integration: Physical Platforms Break down "Four-Chain Integration" Barriers:

    - Education Chain: There is the credit reciprocity between Undergraduate/Postgraduate (UG/PG) courses and research projects.
    - Industry Chain: Enterprises provide real-world projects and funding (e.g. Guizhou's Industry Mentor Program driving >¥10 million in collaborative funding).[16]
    - Innovation Chain: The outcomes of platform are integrated back into teaching practice (e.g. Beihang University has developed 480 teaching cases based on its aerospace project repository).
    - Talent Chain: "Academician-Industry Mentor-University Mentor" echelon has been established (e.g. dual-mentor groups at Beihang University led by 19 academicians).

3. Immersive Learning Scenarios: Reshaping learning paradigms through "learning by doing". For instance, Beihang University's Astronautics Research Institute repurposes engineering sites (satellite design, remote sensing instrument development) into dynamic teaching environments. Students can complete four-tiered project modules ("Explore→Advance→Challenge→Innovate"), effectively mastering interdisciplinary knowledge by dealing with authentic, real-world problems.[17]

The **Table 1** shows the comparison of traditional schools versus integrated platforms of Research-Education, que constituted as one conceptual innovation, named Institutionalized Research Platforms as Carriers.

Dimension	Traditional School Model	Research-Education Platform Model
Teaching Entity	Sole University Faculty	Dual University-Industry Mentors (Academician + Engineer)
Course Carrier	Fixed Textbooks/Experiment Kits	Major Engineering Projects (e.g. Lunar Exploration Program)
Resource Support	Simulated Laboratories	National Key Labs/Leading Industry Enterprises
Competency Certification	Credits + Exam Scores	Project Contribution + Patent/Paper Output

Table 1. Comparison of Traditional Schools vs. Integrated Platforms of Research-Education
Source: own elaboration

Mechanism Innovation: Project-Driven Multidisciplinary Integration of Successive

(i) The Institutionalization Dilemma in Organizational Structure Undergraduate-Postgraduate Cultivation

To address the issues of “segmented stages” and “disciplinary barriers” (i.e. absence of coherent integration), the primary innovation involves defining the curriculum system based on project requirements, and this approach reconstructs the traditional sequence of “discipline→student→course” into a reverse design logic of “project→competency→course”:

1. Reconstruction of Interdisciplinary Curriculum:

- Needs-Driven Course Generation: for instance, the School of Future Aerospace Technology at Beihang University has divided spacecraft development into 30 secondary technical areas (including material mechanics, intelligent control, space physics). This structure allows students to shape modular courses tailored to specific project needs.
- Dynamic Adjustment Mechanism: AI knowledge graphs (e.g. Beihang University’s “Xiao Hang” platform) analyze project competency gaps in real time and dynamically recommend courses to eliminate irrelevant coursework.[17]

2. Successive UG-PG Capability Progression: Designing “research competency ladders” to break segmentation of education levels:

- Vertical Integration: Beijing Jiaotong University’s Jeme TienYow Honors College implements a “3+5” UG-PhD system: three years of foundational instruction in mathematics and physics, followed by five years of customized research in specific area (e.g. aerospace equipment R&D). The program features tiered course difficulty with offering “Space Propulsion Technology” available at UG Intro/MSc Advanced/PhD Frontier levels).

- Horizontal Integration: Beijing Jiaotong University provides access to high-quality courses across various disciplines (e.g. interdisciplinary “AI + Traditional Discipline” gold courses delivered by cross-college teams).[18]

3. Collaboration of Multidisciplinary Mentorship:

- Cluster Configuration of Mentors: Each project group is supported by mentors who encompass the entire technical spectrum. For example, an aerospace vehicle project necessitates mentors specializing in propulsion, materials, and information science. This kind of synergy enhances professional innovation capabilities by exposing students to a variety of perspectives both within and across disciplines; besides, it overcomes the limitation of compartmentalization of knowledge and intellectual rigidity related to the single-supervisor model, which can foster a broader academic vision and promote collaborative innovation.[19]
- Integrated Evaluation: The recognition of research outcomes keeps a balance between academic innovation and engineering value. For example, Harbin Institute of Technology requires that doctoral candidates to achieve demonstrate innovative outcomes in practical applications (e.g. addressing significant engineering challenges and promoting industrial upgrades), which are validated by technical assessment reports recognized by enterprises or the specific industry.[20]

The **Table 2** shows the multidisciplinary support in Project-Driven Curriculum, taking aerospace equipment R&D as an example.

Requirements of Project	Supporting Disciplines	Core Course Modules
Lightweight Structural Design	Materials Science / Mech. Eng.	Composite Materials / Structural Optimization
High-Precision Orbit Control	Control Science / Celestial Mech.	Space Navigation / Nonlinear Control
Reliability Verif. of Extreme Env.	Physics / Electrical Eng.	Space Env. Simulation / Fault Diagnosis

Table 2. Multidisciplinary support in Project-Driven Curriculum in aerospace Equipment R&D
Source: own elaboration

(ii) Practical Efficacy and Universal Value of Theoretical Innovation

This dual-dimensional innovation has demonstrated significant efficacy:

1. Platforms Enhance Talent Competitiveness: graduates from XJTU platform actively participated in 5 national major projects, winning 2 national science/tech awards; students from Beihang University secured 69 awards in provincial and ministerial-level innovation competitions.[5]

2. Project-Driven Efficiency: Jinan Changqing University Town Experimental School implemented “vertically integrated STEM courses”, boasting a 40% increasing in student’s innovation practice abilities; Guizhou’s Industry Mentor System facilitated the co-development of 329 new products.[6]

This theory provides a replicable methodology to overcome the "virtual-real disconnect" and "integration gap" by anchoring resource integration through physical platforms and reconstructing curricula along project lines, ultimately achieving an integrated "Education-Science-Talent" virtuous cycle.

Practical Pathways for Research-Education Synergy Driven by Interdisciplinarity

To implement the spirit of the Third Plenary Session of the 20th Central Committee and the National Education Conference, and to establish holistic "grand education perspective", advance scientifically organized talent cultivation, and execute BIT's strategy for deepening research-education integration, BIT's School of Interdisciplinary Science (SIS) plans to collaborate with Zhuhai Campus, XUTELI School, Jinggong College, Graduate School, and Academic Affairs Office to establish the physical AIREC. AIREC integrates research, pedagogy, education, teaching, and talent development, promoting a research-driven approach that empowers and integrates into educational practice, thereby enhancing the quality of autonomous talent cultivation comprehensively. Guided by the aforementioned theory, this section details BIT's pioneering practices: the establishment of AIREC and the development of a vertically integrated UG-PG curriculum system.

(i) Advanced Interdisciplinary Research and Education Center (AIREC)

AIREC leverages major national platforms like the State Key Laboratory of Environment Characteristics and Effects for Near-Space, the Complex Environment Sensing Center, the Low-Altitude Technology Innovation Institute, and major projects like "Blue Eye". It focuses on emerging strategic domains (e.g. marine, meteorological) and interdisciplinary clusters centered on information disciplines, initially setting research directions in Aerospace Information, Smart Energy, and Low-Altitude Technology. Top undergraduates will be selected annually from the Jinggong College to form AIREC pilot classes for vertically integrated UG-PG-PhD cultivation.

Cultivation Model: A "2+1+4" seven-year UG-PhD integrated program. Students complete UG coursework during the first two years and initiate integrated coursework in the third year. Upon fulfilling the UG credit requirements by the end of the third year, they earn their bachelor's degree and complete remaining PhD coursework in the next four years. Mentors progressively engage with students' cultivation that starts in the first year (e.g. course guidance/research training), and assume full responsibility for research supervision from the third year onward.

Curriculum Reform: Leveraging Zhuhai Campus's role as an international "bridgehead" and the advantages of the Greater Bay Area, AIREC adopts a flexible approach to hiring international faculty ("Bring In"), integrates AI-empowered online international courses with offline assessments ("Virtualize"), and facilitates student placements in partner enterprises/universities for practical and public elective courses ("Send Out"). This strategy overcomes resource constraints and helps build an internationally co-developed curriculum system, comprising high-quality general and foundational courses, frontier-tech-empowered core/interdisciplinary courses, and problem-oriented research-industry-practice courses, so that a model of "AI + International Faculty Co-Guiding" can be achieved.

Innovation Practice: Guided by practical courses, theses, and innovation competitions, AIREC establishes collaborative learning environment grounded in research projects. It refines mechanisms that connect projects/competitions to courses and credits, allocates specialized funds and innovation spaces, encourages cross-disciplinary teams, and cultivates innovation, practical, and problem-solving skills through real-world challenges.

Platform Construction: AIREC aggregates a multidisciplinary team of mentors (including dedicated technicians, national talents, strategic scientists). Utilizing National Key Labs, it builds a three-tier platform: Interdisciplinary Teaching Practice Center, Research-Industry Innovation Center, and Top Innovation Lab. This platform supports researches focused on verification (60%), innovation (30%), and creation (10%) of talent cultivation, which safeguards the innovative practice and Innovation and Entrepreneurship Competition. An interdisciplinary research-education system based on AI LLM-based facilitates autonomous learning and cultivates comprehensive interdisciplinary capabilities.

International Exchange: AIREC has established a comprehensive and high-support international exchange system aimed at cultivating globally competitive talent. By shaping partnerships with universities and leveraging mentor recommendations, it establishes collaborations for summer and winter courses or projects, semester exchanges and visits, and dual degrees programs with higher educational institutions in Hong Kong and Macao. With the support of specialized funds students can participate in international conferences.

(ii) Integrated UG-PG Curriculum System

Taking the “Cultivation Plan for Communication Engineering Major” and “2024 Academic Postgraduate Cultivation Plan (Science and Engineering) for Information and Communication Engineering (full-time)” as examples, AIREC designs a vertically integrated curriculum (See **Table 3**).

Course Category		**Min. Grad. Req.**		
		Credits	**Hours**	**Credit Ratio**
General Education	Required	66	1348	41.3%
	Elective	9	176	5.6%
Foundation Courses	Required	64	1296	40.0%
	Restricted Elect.	6	192	3.8%
Core Module Courses	Required	5	80	3.1%
University Electives	Elective	10	160	6.3%
Sum		160	3252	100%

Table 3. Communication Engineering Credit Structure
Source: own elaboration

Based on this structure, the integrated curriculum is designed based on General Education, Foundational, Core, and Elective courses:

1. General Education Courses.

- Building Premium MOOC Repository: Discipline-leading professors select high-quality courses from platforms like Tsinghua's XuetangX, Peking University's Chinese MOOCs, and SJTU's CNMOOC to build a repository of required general education MOOCs for knowledge expansion. MOOC learning serves as a crucial assessment component, offering flexible, high-quality options and promoting inter-university resource sharing.
- Example: majors of Communication Engineering taking "Engineering Mathematical Analysis I/II" can supplement their studies with relevant MOOCs from the repository.
- Inter-University Course Sharing: Strategic agreements with nearby universities (e.g. Zhuhai Campus of Beijing Normal University, Sun Yat-sen University) enable offline enrollment in high-quality general electives (e.g. humanities courses) within the Greater Bay Area.

2. Professional Foundational, Core, and Elective Courses:

- Recruit Renowned Faculty: BIT adopts flexible recruitment strategy encompassing full-time/part-time/short-term positions for distinguished domestic/international faculty members (e.g. HKU, UM, NUS, NTU) to teach courses, thereby gradually replacing portions of existing programs. Example: the course "Circuit & Analog Electronics-B" (taught by renowned expert) will be offered for pilot class students (with availability extended to others if capacity allows).
- "Virtual Classrooms" and Online International Courses: Introduce top-tier online courses (e.g. Harvard, MIT) to replace core/interdisciplinary courses, creating blended models. Students learn via virtual classes with support from teaching assistants for tutorials/discussions. Example: majors of Communication Engineering can take Harvard's online "Intro to AI" for credits.
- Successive UG-PG Integrated Courses: Develop "Advanced Edition" courses by integrating UG/PG content. High-performing UG juniors/seniors can master PG-level knowledge early; and PG students can consolidate/broaden expertise. Flexible credits transference/course substitution policies enable coherent study. Example: Merging UG "Intro to Radar Systems" and PG "(Eng) Intro to Radar Systems" into an "Advanced Radar Systems" course (modular: Basic/Advanced/Research) for UG students who enroll in the academic system lasting for 7 years.
- TOEFL/IELTS as a substitution of PG English Course: To enhance the PG English reform, students who achieve a score TOEFL ≥90 or IELTS ≥6.5 (all bands ≥6.0) within the first year can be exempted from PG English courses.

3. Professional Internships and Industry-Education Practice:

- Professional Internships: The "Greater Bay Area Elite Enterprise Internship Program" facilitates credit-bearing internships for top students at partner organizations (e.g. Huawei, Tencent, DJI, BYD). Students can engage in real-world projects, which helps integrate theoretical knowledge with practical application.
- Industry-Education/Research-Education Practice: Partner enterprises/platforms decompose real complex problems/projects into challenging sub-tasks, which are offered as required core courses. Student teams (2-5 members, cross-disciplinary encouraged) tackle one sub-task per semester under the guidance of enterprise mentor. A final defense conducted by panels from enterprise/academic

assesses innovation/feasibility/value. Outstanding teams may receive honorary certificates and their plans or solutions may be adopted.

4. Interdisciplinary AI LLM Research-Education System: To strengthen AI research/talent cultivation, AIREC will carry out internship activities in the “Interdisciplinary Large Language Model Boot Camp” focusing on:

- Knowledge Foundation: Intensive training on LLM theory/frontiers.
- Hands-On Training: Full-cycle practice (data prep, training, evaluation) using latest LLMs.
- Domain-Specific Research: Building vertical-domain LLMs for key interdisciplinary challenges.
- Integrated Cultivation: Linking AI tech with innovation competitions/early research, supported by mentor teams/resources.

AIREC will forge first-class teaching capabilities through the establishment of first-class research teams and the creation of first-class educational platforms sponsored by first-class research infrastructure. This initiative fosters the virtuous cycle of Education-Science-Talent. AIREC aims to set a benchmark for cultivating high-level, interdisciplinary, and innovative talent, cultivating cohorts of exceptional, comprehensively interdisciplinary PhD graduates who can gain the doctoral degree at the age of 25. The center strives for national teaching achievement awards, supports BIT’s “Double First-Class” construction, provides foundational support for nurturing strategic leaders (including scientists, entrepreneurs, chief designers for national defense), and promotes the incubation of world-class, China-rooted, original research innovations.

Conclusions

To propel research to lead, empower and integrate into education, thereby comprehensively elevating the quality of autonomous talent cultivation, Advanced Interdisciplinary Research and Education Center AIREC is committed to cultivating first-class teaching capabilities through forming first-class interdisciplinary research teams and building first-class educational platforms through first-class interdisciplinary research infrastructure.

This fosters a virtuous cycle among education, science and technology, and talent, by which top-tier and comprehensively interdisciplinary 25-year-old PhD graduates emerge. AIREC will support BIT’s high-quality “Double First-Class” development, provide foundational support for nurturing original pioneering talents in nationally strategic directions (scientists, entrepreneurs, chief designers for national defense), and incubate and cultivate world-class, China-rooted and original research innovations.

Bibliographic references

1. Zang RN, Bao CQ. breaking through for the sake of reconstruction, innovating for future: a report of the establishment and development of BIT’s school of interdisciplinary science. BIT News Network. 2024-10-28. [Accessed 11 June 2025]. Available in: https://bit.edu.cn/xww/lgxb21/0d60f4fb2ecb4d98ad0c15dbd670d176.htm.

2. Krauss A. Science's greatest discoverers: A shift towards greater interdisciplinarity, top universities and older age. Humanities & Social Sciences Communications. 2024; 11 (01): 1-11. [Accessed 13 June 2025]. Available in: https://doi.org/10.1057/s41599-024-02781-4
3. Cao PP. The more disciplinaries integrate, the broader scientific view becomes. Tencent Cloud Developer Community. 2017-12-21. [Accessed 15 June 2025]. Available in: https://cloud.tencent.com.cn/developer/news/15675.
4. Exploring AI + X: A comprehensive analysis of MIT's interdisciplinary projects on artificial intelligence. Sohu News Network. 2025-03-21. [Accessed 15 June 2025]. Available in: https://www.sohu.com/a/874034290_121956424.
5. Zhang YN. High-level understanding, high-standard planning, and high-efficiency implementation. China Education Daily; 2024-5-17.
6. Shanghai Jiao Tong University's multiple measures to build an international frontier cross-disciplinary innovation highland for basic disciplines. Education Lawyer Network. 2025-02-26. [Accessed 15 June 2025]. Available in: http://huanqiulawyer.com/article/3061.html.
7. New campus of a "985 Project" university: 10 colleges are coming! All of them focus on new engineering disciplines! NetEase News. 2021-02-20. [Accessed 15 June 2025]. Available in: https://www.163.com/dy/article/G3ABPL260536N8D8.html.
8. Xu Q, Du J. Cross-disciplinary collaboration promoting the overall transition of disciplines. Urumqi Micro Life. 2022-06-28. [Accessed 14 June 2025]. Available in: https://www.wlmqw.com/view/35591.
9. Tang YW, Yu M. The integration of science and education and the quick development of the computer discipline. China Education Daily; 2024-12-26.
10. Gong H. China Transport News: Building "high-level" scientific research platforms to promote future transportation technology innovation. Chongqing Jiaotong University News Network. 2024-11-21. [Accessed 16 June 2025]. Available in: https://news.cqjtu.edu.cn/info/1021/60574.htm.
11. Bai Q. Transformation of the knowledge production mode in university and innovation of disciplinary construction. University Educational Sciences, 2020; (03): 31-38.
12. Liu H, Xie R. The historical context, influencing mechanism and development of institutional changes in interdisciplinary construction within China: An analysis based on historical institutionalism. Jiangsu Higher Education. 2023; (05): 49-53.
13. Taylor, F. The principles of scientific management. Beijing: Peking University Press; 2018.
14. Zhang SL, Cao YH, Gu JB, et al. Analysis of the reform of the training mode for innovative talents in basic research. Graduate Education Research. 2013; (02): 35-38.
15. Yang M. Lu Jianjun's research on the school-enterprise deep integration platform for aerospace round-trip power and intelligent manufacturing. Xi'an Jiaotong University Alumni Network. 2024-09-26. [Accessed 11 June 2025]. Available in: https://alumni.xjtu.edu.cn/info/1115/8102.htm
16. Guizhou's promoting the deep integration of the education chain, talent chain, industrial chain and innovation chain. The People's Government of Guizhou Province. 2024-08-07. [Accessed 19 June 2025]. Available in: https://www.guizhou.gov.cn/home/gzyw/202408/t20240807_85333712.html
17. Jia AP. Xinhua News Agency: "Big field + big project + big teacher", Beihang University's industry-education integration blazed a new trail for cultivating aerospace experts. Beihang University News Network. (2025-03-24. [Accessed 18 June 2025]. Available in: https://news.buaa.edu.cn/info/1006/64941.htm.

18. Beijing Jiaotong University has developed the “Four Connections” model for talent cultivation to further promote the comprehensive reform of education and teaching. Office of Development Planning and Comprehensive Reform at China University of Geosciences (Office of Discipline Construction, Office of Academic Committee). 2021-09-23. [Accessed 24 June 2025]. Available in: https://fzghc.cug.edu.cn/info/1017/2415.htm.
19. Yue GF. Research on the cultivation of graduate students’ innovation ability based on the mentor team model. Journal of Nanjing Medical University (Social Sciences). 2012 (5): 401-402.
20. Regulations on the requirements for innovative achievements of doctoral students at Harbin Institute of Technology during their doctoral studies. Graduate School of Harbin Institute of Technology. 2024-08-21. [Accessed 25 June 2025]. Available in: https://hitgs.hit.edu.cn/2024/0821/c17461a351258/page.htm.

Conflict of interests:

The authors declare that they have no conflicts of interest.

Authorship contribution:

- Xiangbiao Liao: Conceptualization, Writing- original draft, Research, Writing - review & editing.
- Dezhi Zheng: Conceptualization, Writing- original draft, Research, Writing - review & editing.
- Qi Chen: Conceptualization, Research, Writing- original draft, Writing - review & editing.
- Ping Li: Conceptualization, Research, Formal Analysis.
- Jing Yang: Writing - review & editing.
- Minghui Yang: Formal Analysis.
- Ao Zhang: Writing - review & editing.