

"Research Boosted by Innovation & Study Promoted by Competition" Construction and Effect of Top Level Innovative Talents Training System

A Case Study of University of Electronic Science and Technology of China

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ABSTRACT

Innovation-driven development has been highly valued by the whole society in recent years. Universities' mission of providing talents for the country and society is crucial. Talent cultivation needs to be deeply integrated with the national innovation and development. Following the idea of "Research Boosted by Innovation & Study Promoted by Competition", we have actively innovated the undergraduate top level talent training system, and carried out the overall construction and improvement in three aspects: namely, the whole process elite tutorial system, the immersive scientific research platform, and the integrated ecosystem of scientific innovation and education. Relying on the authoritative education evaluation index of the state and universities, the quality inspection of talent training has achieved remarkable results.

Keywords: Innovation-driven development, Talent cultivation, System construction, Effectiveness analysis.

1. INTRODUCTION

Young generation's power boosts a nation's prosperity. Driven by the tide of the times, the growth and struggle of the young generation has been deeply integrated with the innovation and development of the country and society. In 2019, Ministry of Education of the People's Republic of China issued the "Opinions on Deepening Undergraduate Education and Teaching to Comprehensively Improve the Quality of Talent Cultivation", which set forth a series of opinions on improving the quality of talent cultivation, such as deepening the reform of innovation and entrepreneurship education as well as promoting scientific research feedback of teaching. It

encourages colleges and universities to fully tap and enrich the innovation and entrepreneurship education resources of various courses and links to strengthen the cooperation of innovation and entrepreneurship and the function of scientific research in education [1]. While pointing out the direction for the construction of top level innovative talents training system for colleges and universities, it puts forward higher requirements. As a "double first-class" and "985" national key university, the University of Electronic Science and Technology of China (UESTC) bears the important mission of providing top level innovative talents for the country. In recent years, the university has vigorously promoted the reform of talent training system. By establishing a high-level education team and building practice platform for students' innovation and entrepreneurship, as well as improving support service system, the university

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has comprehensively improved students' scientific and technological innovation ability and broadened the training caliber of comprehensive quality. From the perspective of the UESTC's construction of top level innovative talent training system. From the perspective of constructing top level innovative talent cultivation system in UESTC, this paper expounds the construction of the system, and analyzes its effectiveness in the whole university as well as the relevant schools.

2. CONSTRUCTION OF TOP LEVEL INNOVATIVE TALENTS TRAINING SYSTEM

Innovative thinking opens up the future. Focusing on the education of innovative thinking for undergraduate students will accumulate potential kinetic energy for serving the major strategic needs of the country. This means that the starting point of talent cultivation is no longer limited to the classroom, but should emphasize on the idea of "Research Boosted by Innovation" on the multimodal scientific research training platform to comprehensively improve students' research ability. Meanwhile, the evaluation index of learning ability is no longer limited to GPA, but to emphasize on the idea of "Study Promoted by Competition", which is to examine the comprehensive application ability of knowledge, the ability of raising questions and solving problems on a high-quality subject competition platform, so as to stimulate the internal motivation of study. Therefore, relying on the "troika" of high-level teaching staff, high-level scientific research platform and cascade competition platform, UESTC fully exploits resources and integrates advantages, taking students' growth and success as the center, adheres to the cultivation concept of "Research Boosted by Innovation & Study Promoted by Competition", and runs innovative thinking through the whole process of education and teaching, so as to build a practical and effective comprehensive practical ability system for college students. It is a top level talent training system implementing the ability of scientific and technological innovation.

2.1 The Whole Process Elite Tutorial System: Meeting the Masters Whenever and Wherever You Are

Undergraduate tutorial system is a new type of teacher-student relationship. The communication space between teachers and students extends from

classroom to academic forum, laboratory, coffee shop and even outdoor. "Tutorial system" originated from Oxford University in the 14th century, and gradually prevailed in famous universities in various countries [2]. This kind of teaching system has greatly promoted the cultivation of independent thinking and innovation ability of students in undergraduate teaching in China [3]. "The whole process elite tutorial system" is commonly adopted by UESTC, which means accompanying students throughout the four years in University and cultivating outstanding talents.

The implementation of the whole process elite tutorial system takes strong top teachers represented by academicians and other well-known experts as well as scholars with top academic titles both nationwide and worldwide. With the help of their celebrity effect and leading power in scientific research and academic level, we are able to tap the space for undergraduate talent cultivation outside classroom teaching. Through the construction of school level and college level teacher-student exchange platform, students are able to meet the masters whenever and wherever.

As for the school level, we attach great importance to general education covering culture, art, sports, science and technology, debate and so on. By inviting domestic and international Nobel laureates, CCTV hosts, astronauts and other top teachers in various industries hold "UESTC Forum" regularly to help students broaden their horizons. We also invite the most popular experts and scholars in various disciplines to hold "UESTC Afternoon Tea Academic Salon" to help students walk into the forefront of science and technology in various disciplines to find out their own interests.

At the department level, we build up a full process tutor training system covering freshman year to senior year. While focusing on professional education, we also help students develop good ethics and code of conduct to lay a solid professional foundation, form a scientific knowledge structure, develop problem-solving ability, and make good preparation for career planning. Taking School of Life Science and Technology of UESTC as an example, we've built up the "1 + 1 + 1" whole process elite tutorial system which is "Freshman Tutor Rotation Program (freshman)" + "Advanced Science Experience Program (sophomore)" + "Scientific Research Training Program (Junior)".

2.1.1 Freshman Tutor Rotation Program

We select high-quality tutors to make two-way choices to allow students to carry out laboratory rotation experience three times within a year, and help students adapt to and integrate into university life as soon as possible, establish correct learning objectives and academic development direction so as to guide freshmen to understand and love their majors.

2.1.2 Advanced Science Experience Program

The tutors with innovative talent training experience are selected, and take sophomores who are willing to persevere in scientific research and technological innovation competitions as the main training objects. The tutor is responsible for guiding the students to carry out scientific research training, science and technology competition as well as scientific research project activities in their spare time, including winter and summer vacation, so as to cultivate them into high-quality life science talents with academic benchmark, scientific innovation spirit and team consciousness.

2.1.3 Scientific Research Training Program

It is meant for all junior students, taking the project team as a unit, combining with the guide of undergraduate graduation project release of scientific research training program. Students participate in the academic activities of their tutor's laboratory or research group, and complete the "Work Record of Scientific Research Training Program". This stage focuses on improving undergraduates' scientific research ability and innovative thinking, and helping students from "approaching" life science to "entering" life science.

2.2 Hierarchical Research Platforms: Providing Immersive Research Experience

The construction of scientific research platform in universities is closely related to the improvement of undergraduate teaching quality. High quality scientific research platform is conducive to promote teachers' initiative, and is symbolic of the quality of undergraduate teaching. In the process of cultivating students' scientific research and innovation ability, it is urgent to help students

broaden their horizons, open up the pattern and understand the high-end technology and cutting-edge direction of the industry, so that they can set up lofty goals and ideals. In order to achieve this goal, cooperation with a more open attitude among university and the relevant schools is needed to enable students to "touch" the high-level scientific research platform and make full use of it to try to achieve innovation and output results on the basis of the platform.

2.2.1 University-level Public Experimental Platform Ensures Basic Scientific Research Training

By establishing open and public experiment platform with the school, on one hand, it can ensure the basic experimental teaching of the whole university, and on the other hand, it can provide basic scientific research training for undergraduates through the popularization of scientific and technological knowledge. Such facilities include electronic experimental center, computer experimental teaching center, communication and information system experimental center, photoelectric information technology virtual simulation experimental teaching center and other national experimental teaching demonstration centers, university physics experimental center, engineering training center, liberal arts experimental teaching center and other provincial experimental teaching demonstration centers.

2.2.2 School-level Professional Experimental Platform Guarantees Special Scientific Research Training

College level professional laboratory is closer to the discipline, which is indispensable for students who are eager to make great progress in scientific research. Representative platforms at all levels guarantee the research space, for instance, "immersion" scientific research training space provided for the students based on the national/international science and technology cooperation base, key laboratories of the Ministry of Education, subject innovation and talent introduction bases for colleges and universities, provincial key laboratories, provincial new research institutions, etc. Meanwhile, all kinds of advanced equipment provide experimental support, such as opening 3.0T MRI, optical fiber communication platform, integrated circuit design platform and other major instruments and equipment, all of these provide conditions for students to design

experiments, implement experiments and be experimented as "subjects". Funding originated from projects and subjects of all levels, such as National Natural Science Foundation of China, frontier innovation program, provincial and ministerial level scientific research projects, all of these funding supports are provided for the students with research direction in their scientific exploration.

2.2.3 The Special Experiment Competition Platform Ensures the Training of Competition Talents

For undergraduate students with various scientific and technological basic knowledge and interests, a special experiment platform is set up for competition, where customized training equipment, instructors, and fund management are provided to ensure the growth of scientific and technological talents reserved. For example, we have the mathematical modeling training laboratory combined with the American Mathematical Modeling Contest, the network engineering laboratory combined with the International Collegiate Programming Contest, the international genetic engineering innovation laboratory combined with the International Genetically Engineered Machine competition etc.

2.3 Science and Technology Competition System: Creating an Integrated Ecosystem of Science, Innovation and Education

Centering on the innovation-driven development strategy, the students are guided and promoted to apply the models and paradigms in books to the scientific and technological works of independent innovation, and further on, through the incubation of scientific and technological achievements, the scientific and technological power will be injected by a steady stream of innovation kinetic energy to drive economic development. This has become the common operation logic of discipline competitions carried out by universities both domestically and internationally [4]. With the advantages of interdisciplinary integration, UESTC takes root in the cascade science and technology competition platform, and guides the UESTC's Makers with a solid scientific innovation training system.

2.3.1 Construction of Discipline Mainstream Competition System

We build an in-depth scientific innovation system and form a pyramid competition gradient including university competition, provincial competition, domestic competition and international competition in each discipline, so as to open up a competition channel directly related to disciplines and majors for students. Among them, the school competition is mainly based on "one school, one competition", focusing on the selection and talent reserve for higher level competitions; the provincial competition is mainly based on the competition held by the Provincial Department of Education in the locality of the school, which selects and cultivates the seed projects in the province through mutual exchanges among colleges and universities within the province; the domestic competition is mainly based on the competition held by the teaching steering committee of various disciplines, China Society of Higher Education, and Ministry of Education, etc.; the international competition focuses on a few international well-known subject competitions, and selectively supports students to participate in the competitions held by various international associations and international well-known enterprises, so as to help students shine and glow on the international stage. In all levels of the pyramid, social hot issues have attracted wide attention. By completing the entries, students are able to provide for the society with their feedbacks to the problems; meanwhile, high-quality achievements attract social resources for incubation. A virtuous circle between students and society is gradually formed.

2.3.2 Construction of an Integrated Ecosystem of Science, Innovation and Education

It refers to revising the traditional education mode and building an integrated ecosystem of science, innovation and education from the first classroom to the third classroom. Students are the main body in the first class, where stimulating interest is the starting point. Competition oriented innovative training courses and cutting-edge science popularization courses are set up to help students from passive learning to active acquisition. In the second class, competition clubs, "Maker Space" and other high-quality teams are built to guide students to consolidate and use their knowledge in innovative learning to promote their comprehensive quality. While the third classroom

uses the mobile Internet to place the project on a broader platform for demonstration and polishing, and at the same time, it broadens the channels for achievement and attract investment, where the last "kilometer" of the transformation of scientific and technological competition achievements into real productivity can be completed. In this process, the teaching paradigm used by teachers in the first classroom is updated and iterated by practical experience of the second classroom and the third classroom, and further feedback to the first classroom will improve the efficiency of knowledge transfer in a more vivid way.

3. EFFECTIVENESS ANALYSIS BASED ON THE DIRECTIONAL AUTHORITATIVE EDUCATION EVALUATION

With the construction of innovative talent training system in various colleges and universities, the state as well as colleges and universities timely release and update the ranking lists of evaluation indicators, and effectively strengthen the role of education evaluation baton. The expert group of "Research on University Competition Evaluation and Management System" convened by the Chinese society of higher education has been releasing the "National University Discipline Competition Ranking List" for four consecutive years. The ranking list provides reference and information for colleges and universities to improve the quality of talent training, and is one of the important standards to examine the quality of innovative talent training in colleges and universities [5]. UESTC has opened an application channel for new graduates with special academic expertise. Through year by year revision of the "Rules of Bonus Points Calculation for Comprehensive Evaluation" [6], high-quality important competitions and academic achievements which are fit with the characteristics of students are included as bonus points. It is regarded as a necessary condition for the selection of Excellent Undergraduates with special academic expertise. Referring to these two authoritative evaluation systems, this paper examines and analyzes the effectiveness of the construction of the top talent training system of "Research Boosted by Innovation & Study Promoted by Competition" in UESTC.

3.1 Effectiveness Analysis Based on the Ranking of Subject Competition

Most of the competitions selected in the ranking list are science and engineering competitions, among which computer, machinery, electronic information etc. take a large proportion. China's "Internet+" Innovation and Entrepreneurship Competition for College Students", the "Challenge Cup" National College Students' Extracurricular Academic Competition, and the National Undergraduate Mathematical Contest of Modeling are all covered in the list, reflecting the strong demand for talents in traditional engineering and new engineering. UESTC has made remarkable achievements in recent years, mainly centering on the listed competition and supplemented by the discipline characteristic pyramid competition system.

3.1.1 Ranking of Subject Competitions

Looking back at the 2015-2019 national university discipline competition ranking (undergraduate, top 300), the UESTC ranked fourth in China. In the latest updated list of 44 competitions in 2019, the number of subjects in 2015-2019 of UESTC is respectively 11, 13, 15, 18 and 25, showing an upward trend year on year; the number of winning subjects in 2015-2019 was respectively 10, 13, 15, 17 and 21, and the total number of winning subjects in was respectively 67, 74, 92, 108 and 147. The number of winning items has increased by more than 100%. It fully shows that UESTC attaches great importance to the competition list and encourages students to participate actively, which has resulted in remarkable achievement in the construction of teacher support, funding support and platform support.

3.1.2 The Discipline-characterized Pyramid Competition System

Taking the College of Life Science and Technology mentioned above as an example, in 2016-2019, the pyramid competition system of this discipline included: International Genetic Engineering Machine Design competition (international level), National Biomedical Engineering Innovation Design competition (national level), National College Students' Life Science Competition (national level), Sichuan College Students' Life Star Science and Technology Invitational competition (provincial level). In this

pyramid competition system, the total number of winners in each year was 42, 46, 69 and 85 respectively, showing a significant upward trend. It shows that, driven by the integrated ecosystem of science, innovation and education, the orientation of students' participation is more accurate, the participation channels are more opened, and the supporting force is stronger, which shows a systematic training effect. Students' enthusiasm for participating in the competition has been enhanced, and their potential for winning awards has also been effectively stimulated. At the same time, in the atmosphere of "Study Promoted by Competition", the number of junior students in each year's award-winning list has accounted for more than 50%, indicating that the proportion of prize winners has been gradually inclined to lower grades, and the science and innovation activity index has been significantly improved.

3.2 Effectiveness Analysis Based on the Index of Recommended Graduate Students

In order to encourage the full-dimension development of undergraduates, each university has its own recommendation index under different preconditions. Under the basic conditions of ranking among the top 50% of the comprehensive evaluation results of major, and at the same time, meeting at least one of the following six items, a fresh graduate of UESTC can apply for exemption of students with special academic expertise: (1) the accumulated bonus points of key disciplines competition are up to 4 points; (2) at least one full-text academic paper reflecting scientific research work (excluding supplements) is accepted as the first author and UESTC as the first signature unit, including SCI, SSCI, EI journals and domestic major journals (subjected to Peking University's latest edition of "Overview of Chinese Major Journals"), EI's inclusion of international conferences publication or acceptance; (3) winner of the national or provincial science and technology award (with award certificate); (4) winner the national invention patent in the name UESTC as the first applicant and; (5) as the main researcher of national or provincial scientific research project appraisal (top 5 national projects, top 3 provincial projects).

Among all the undergraduates for year 2018, 2019 and 2020 (including 57 in 2018, 45 in 2019 and 55 in 2020), 40, 28 and 37 (accounting for 70.2%, 62.2% and 67.3% respectively) were

qualified for 1), while 15, 18 and 21 (constituting 27.3%, 40% and 36.8% respectively) were qualified for 2). The number for 3)-5) is negligible. It can be seen that relying on the top level talent training system under the policy of "Research Boosted by Innovation & Study Promoted by Competition", the mode of classified and phased training according to students' interests has achieved initial results. For students who are willing to participate in science and innovation competitions, their innovation and practice ability has been effectively trained with all kinds of science and innovation competitions; for students who are eager with scientific research, based on the tutor group and leveled scientific research platform, their academic achievements have been significant.

Focusing on the departments, and still taking the undergraduate students from the College of Life Science and Technology as an example: the average number of students in each grade is less than 100, and the student-teacher ratio is close to 1:1. Under the "1 + 1 + 1" whole process elite tutorial system, the number of papers published by undergraduate in 2016-2019 was 6, 5, 11 and 16 respectively. Especially in 2018-2019, there was significant increase. This shows that more and more undergraduates are paying attention to scientific research and have achieved certain results with the effect of scientific research and education projects. Among the published papers, there are 28 SCI journal papers, which fully shows that the trained undergraduates have the ability to publish or participate in publishing high-level academic papers. In 2016 and 2018, the number of papers published by junior students was more than that of senior students. In 2019, the number of papers published by the two grades reached the same level, indicating that after long-term systematic training, students from the lower grades obtained the potential to participate in important scientific research. In the scientific research papers with undergraduates' participation, more than one third of them are the first or second authors, indicating that undergraduates can play an important role in summarizing scientific research achievements and writing papers. In addition, during 2016-2019, undergraduates published 16 patents, which indicates that they have also achieved significant results in engineering training.

4. CONCLUSION

After several years of exploration and research, UESTC has been carrying out the reform of talent

training system, and has gradually improved the top level innovative talent training system of "Research Boosted by Innovation & Study Promoted by Competition". Having learned from domestic and foreign experience as well as referred to the major strategic needs of the country, the university carried out a three-dimensional construction and a full research including whole process elite tutorial system, hierarchical scientific research platform, and science and technology competition platform. The university has turned education and teaching into an "invisible hand" to help undergraduates obtain guidance from famous teachers, immersive scientific research experience, and support from the science and innovation ecosystem in a full-time, full-scale and all-round way. It effectively motivates the students to treat their studies and scientific research with innovative thinking, cutting-edge perspective and international position, and helps them fully mobilize their subjective initiative and explore their own future development orientation. Being a first-class university, it has effectively promoted the reserve of science and technology, as well as the seamless connection between science and technology and social needs. From the teachers' perspective, through the incentive conditions such as honor recognition, professional title linkage, workload assessment, the university injected power into Teachers' multi-channel moral education. Classroom teaching and practice teaching go hand in hand, forming a circular feedback system of education-competition/scientific-research-education, helping teachers continuously optimize training methods, and comprehensively improving the quality of professional courses and scientific innovation training. From the students' perspective, the university guides the students to strengthen their innovative spirit and scientific research ability which gives consideration to their studies by constantly optimizing the ranking of subject competitions and recommended graduate condition indicators as well as other education evaluation batons, so as to lay a solid foundation for students to enter the society in the future. By forming the feedback system of society-competition-student-society, the participating students continuously make improvement in the market-oriented inspection, and their talent competitive advantage in the national and even the world stage has been significantly promoted. Therefore, it is clear to see that the top level innovative talent training system focusing on innovation-driven development and the ideology of "Research Boosted by Innovation & Study Promoted by Competition" has multi-faceted

benefit efficiency, which is of great value in reference for more colleges and universities and will benefit more students.

ANTHORS' CONTRIBUTIONS

Ling Quan was responsible for research design and wrote the manuscript; Cheng Luo contributed to setting research directions and analysed data; Xingbin Dong contributed to revising and editing the paper; Xuhong Wu was responsible for collecting data; Siqi Liu contributed to data statistics; and Yue'er Fan contributed to data statistics.

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