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Exploration and Practice of Cultivating Top Talents in Computer Science

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***Abstract*—*The cultivation of top-notch talents is an urgent strategic task for the reform and development of China's higher education. Taking Anhui University of Finance and economics as an example, this paper discusses the training objectives, teaching system and education environment of top-notch computer professionals. The training goal of top-notch talents should be oriented at the cultivation of scientific research ability and innovation ability, the construction of a professional teaching system with thick foundation and emphasis on ability, the educational environment and various safeguard measures conducive to the emergence of innovative talents, so as to promote the cultivation of students' scientific research ability and innovation ability. Through the exploration and practice of top-notch class training mode, improve the level of talent training and students' comprehensive quality, and optimize the training mode of high-level talents*.

***Keywords*—*Emerging engineering construction, top notch training, innovation ability, practice education*.

I. INTRODUCTION

The cultivation of top-notch innovative talents is an important factor in achieving leapfrog development in China's socialist modernization construction and narrowing the gap with developed countries in the world. It is also an urgent strategic task for China's higher education reform and development[1][2]. Cultivating high-quality top-notch talents with broad Scientific literacy, strong engineering literacy, good humanistic literacy, strong innovation ability and broad vision has become an important topic that higher educators urgently need to study[3][4].

On the one hand, the construction of new engineering majors should establish and develop a group of emerging engineering majors, strengthen their construction, and improve their quality. On the other hand, it should promote the reform and innovation of existing engineering majors, and explore new training models that conform to the laws of engineering education and the characteristics of the times[5]. Due to different educational goals and positioning, higher education institutions at different levels have different models for cultivating top-notch innovative talents[6]. At present, many universities in China have explored the reform of talent cultivation models and achieved good results in practice. They have gradually played a positive role in cultivating top-notch innovative talents[7] [8][9][10].

In the context of the construction of new engineering and "new management", the cultivation of innovative and top-notch talents is attached great importance. In March 2015, we issued guidance on promoting the "four plans" for undergraduate talent cultivation, and established the main tasks of the top-notch talent cultivation plan[11]. Based on the layout of professional disciplines and the level of teaching quality, select a group of university disciplines with high teacher level, good teaching conditions, and advantages supported by characteristic disciplines to recruit high-quality students, and implement top-notch talent cultivation under the background of new engineering construction. In the form of top-notch classes, we will give special training to the top students who are diligent, eager to learn and brave to explore, guide students to clarify their learning goals and talent goals, promote the coordinated development of students' knowledge, ability and quality, cultivate students' Scientific literacy and innovation spirit, and create a group of top-notch talents with solid foundation, wide knowledge range, high comprehensive quality and strong innovation ability for the country.

II. TRAINING OBJECTIVE FOR TOP TALENTS

- **Objective**: Innovative and research-oriented talents
- **Positioning**: Cultivation of theoretical knowledge for Master's graduate admission
- **Features**: Selecting excellent undergraduate students, equipping them with high-level faculty, creating a strong academic environment and atmosphere, and highlighting the cultivation of innovation ability and scientific research quality

Fig. 1. Training objective, positioning, and features of top talents in computer science

The "Top Talent Training Plan", also known as the "Top Plan", is a program that fully utilizes high-quality educational resources both domestically and internationally, draws on the successful experience of top-notch talent training from first-class universities, selects outstanding undergraduate students, and highlights the cultivation of scientific research and innovation abilities by formulating personalized talent training plans, equipping high-level teachers, and creating a strong academic environment and atmosphere. It focuses on the source of students, teachers, atmosphere, and training mode In terms of training conditions, boldly innovate and deepen reforms, and open up new channels for cultivating high-level innovative research talents [12].

As shown in Fig. 1, the training goal of the top-notch talent training program in computer science and technology is to cultivate students with solid theoretical knowledge and professional technical skills, a good practical training background, and outstanding scientific research and

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innovation abilities. The orientation of the top class is mainly for the cultivation of theoretical knowledge for professional degree students in computer science and technology and the cultivation of scientific research innovation ability at the graduate stage.

III. Construction of Teaching System for Cultivating Top Talents

A. The Knowledge, Ability, and Quality Structure for Cultivating Top Talents

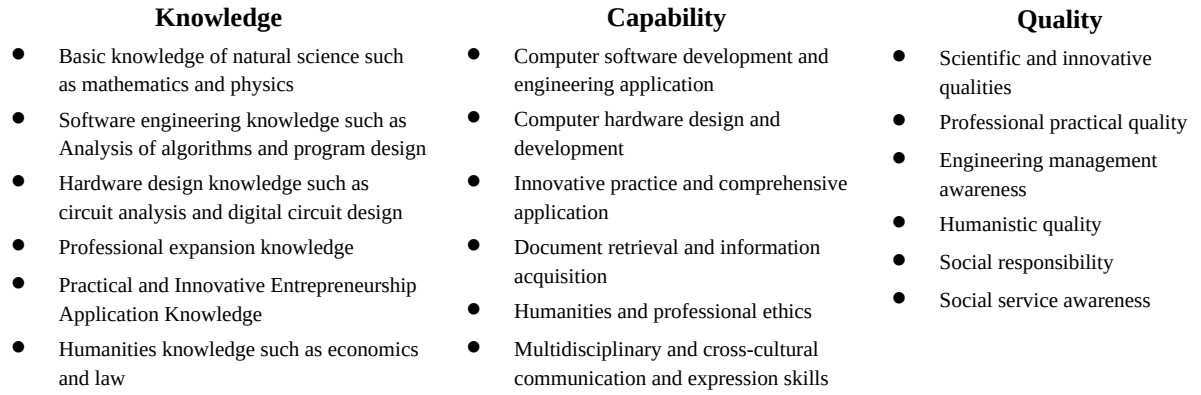

Fig. 2. The knowledge, capability, and quality structure for cultivating top talents in computer science

As shown in Fig. 2, students in top tier classes should have the following knowledge, abilities, and quality structures.

(1) Have solid basic knowledge of mathematics and natural science, as well as good knowledge of economics, law and other humanities. Proficient in English, capable of reading, understanding, and writing foreign language materials, able to use technical language for communication and expression in cross-cultural environments, adaptable to team collaboration, and able to participate in international competition and cooperation;

(2) Have the ability to comprehensively use multi-disciplinary knowledge and skills such as basic science, computer science and information technology to analyze and solve problems; Possess the ability to comprehensively apply knowledge and methods in economics, engineering management, etc. to organize and manage engineering projects.

(3) Having strong knowledge transfer ability, able to integrate knowledge from system analysis and design, development, application, maintenance, organization and management in software engineering and apply it to practical innovation, possessing strong engineering innovation awareness and basic abilities in engineering innovation, as well as basic abilities in software and hardware development;

(4) Familiar with the technical standards in the field of computer science, familiar with computer related policies, laws, and regulations, with good professional ethics and social service awareness.

B. Curriculum Structure for Cultivating Top-notch Talents

As shown in Table I, the curriculum structure of top classes in computer science is divided into six parts, namely, ideological and political theory and practice, general education, disciplinary fundamentals, professional theory and practice, innovation and entrepreneurship practical training, and postgraduate entrance examination promotion, with a total of 170 credits.

TABLE I. Curriculum structure and credit requirements for top classes in computer science

Curriculum	Category	Credit
Ideological and political theory and practice	Compulsory	16
General education	Compulsory	44
Disciplinary fundamentals	Compulsory	30
Professional theory and practice	Compulsory	18
	Elective	19
Innovation and entrepreneurship practical training	Elective	28
postgraduate entrance examination promotion	Elective	15
Summary		170

The curriculum system of the top tier class is shown in Fig. 3. The first part is ideological and political courses and Liberal education courses. Due to the division of majors in our school in the third semester, the selection and division of top tier classes starts from the third semester. This part of the courses is mainly completed in the first two semesters, which is the same as other engineering majors such as Internet of things engineering and electronic information engineering. The second part is the subject foundation course, which is divided into two modules: software and hardware. All of these courses are compulsory. The third part is professional theory courses, mainly about AI and big data related knowledge. The fourth part is the professional experiment and practice course. On the basis of the course experiment and course design, in order to improve the practical ability, five comprehensive training courses, namely, high-level programming language programming, digital system design, software algorithm design, software development and mobile development, are set up from the third semester to the seventh semester. In addition, obtaining innovation and entrepreneurship program projects, subject competition awards, publishing scientific research papers, and passing the College English Test Band 6 can serve as alternative credits for innovation and entrepreneurship, postgraduate entrance examination and improvement courses.

Chang Hao, Fu Ming, and Xu Yong, "Exploration and Practice of Cultivating Top Talents in Computer Science," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 4, pp. 62-67, 2023.

Higher mathematics	Basic principles of Marxism	Principles of management	College English
Linear algebra	Mao Zedong thought and the theory	Marketing	English listening
Probability and statistics	Outline of Chinese modern history	Managerial operations research	Writing
General physics	Morality and the rule of law	Situation and policy	Computer English
Discrete mathematics			
Programming（C）	Java programming	Database principles	Operating system
Data structure	Object-oriented programming	Computer network technology	Software engineering
Circuit analysis	Digital electronic technology	Principles of computer composition	
Analog electronics	Microcontroller and embedded system	Compilation principles	
Artificial intelligence	Applications of big data technology	Cloud computing	Large database design
Machine learning	Business big data analysis (Python)	Visualization technology	Software project management
Computer graphics	Data warehouse and data mining	Embedded linux network development	Intelligent logistics training
Programming experiment	Data structure experiment	Computer network technology experiment	
Database principles experiment	Object oriented programming experiment	Operating system course design	
Digital electronic technology experiment	Experiments on microcontrollers and embedded systems		
Comprehensive training of advanced programming	Comprehensive training of software algorithm design		
Comprehensive training for mobile development	Comprehensive training on digital system design		
Comprehensive training of software development			

Fig. 3. Curriculum structure for cultivating top-notch talents

IV. Education Environment Construction for Top-notch Talents

By leveraging the leading role of teachers in the teaching process and the subjective role of students in the learning process, a new teaching process centered on learners and based on students' autonomous activities is constructed, vigorously promoting the transformation of teaching activities from teaching to learning, and forming an educational environment conducive to the healthy development of students' subjective spirit, innovative consciousness, and innovative ability.

A. Selection Criteria

We plan to select 30% of undergraduate students in this major, with a total of 50 undergraduate students with solid basic knowledge and high comprehensive quality, to form a top tier computer science and technology program. In the third semester, voluntary registration, teacher group interview, and selection based on comprehensive quality and ability assessment. Selection criteria: (1) Strong professional foundation and interest in further graduate studies; (2) Good foundation in mathematics and English; (3) Have you any expertise in software programming, hardware knowledge, subject competitions, etc; (4) According to the comprehensive score (average score of compulsory courses in the first and second semesters * 60%, interview score * 30%, and specialty score * 10%), the best candidates will be selected for admission.

B. Teacher Guarantee

The construction of teaching staff is crucial. The computer science and technology major has been approved as a national first-class professional construction pilot, a provincial-level characteristic major, and a provincial-level outstanding talent education and training plan project. After years of construction, this major has formed a highly educated, professional, and high-quality teaching team. At present, the Department of Computer Science has 36 faculty members, including 6 professors, 13 associate professors, 18 doctors, 6 "Longhu Scholars" of Anhui University of Finance and Economics, 5 outstanding young scholars of Anhui University of Finance and Economics, and 25 people with overseas visiting experience. Good teaching effect and strong scientific research strength. The Computer Science Department currently undertakes 3 National Natural Science Foundation projects, 2 National Philosophy and Social Science Foundation projects, and more than 20 provincial and ministerial level projects, with a total research funding of over 8 million yuan. The teachers of the Department of Computer Science won 14 awards in provincial and school level teaching competitions, one was named a famous teacher of Anhui University of Finance and Economics, and many were awarded the honorary title of outstanding teachers of the university. The Computer Science Department pays special attention to the construction of various soft environments, actively introducing subject leaders, hiring highly educated and high-level young teachers with rich practical experience from well-known universities both domestically and internationally to join the faculty team of the department. Take measures to actively cultivate teachers' sense of professional responsibility and a broad international perspective, and also hire experts with rich practical engineering experience to teach and guide students at the school.

C. Guarantee Measures

Top notch talents have put forward higher requirements for cultivating innovative abilities. As shown in Fig. 4, the guarantee measures for cultivating top talents in computer science are mainly divided into six categories: postgraduate entrance examination guidance, research tool training, expert lectures, participation in teacher projects, application for projects and publication of papers, and subject competitions.

(1) Guidance for postgraduate entrance examination

Anhui University of Finance and Economics opens various quality development activities in the 10th week from the second semester to the seventh semester, which is called Quality Development Week. We can use Quality Development Week to provide guidance for professional courses and postgraduate entrance exams. Firstly, the main target universities for undergraduate students majoring in computer science in the first three years will be analyzed, and then promotion and mobilization for the postgraduate entrance examination will be conducted. Excellent professional

teachers will be selected to analyze and explain the national unified examination and the past years' postgraduate entrance examination questions from famous universities.

Guidance for postgraduate entrance examination

- Mobilization for postgraduate entrance examination
- Analysis of National unified examination
- Analysis of examination in some universities

Tools training

- Endnote
- Mindmanager
- Visio

Expert lectures

- Big Data Frontiers
- IoT hotspots
- Artificial Intelligence Applications

Participate in teachers' research projects

- National Natural Science/Social Science Foundation
- Anhui Provincial Natural Science/Social Science Fundation
- Key Natural/Humanities Fund of the Department of Education

Project application and paper publication

- University student eesearch innovation fund
- Innovation and Entrepreneurship Training Program
- Publish academic papers

Discipline competition

- Computer Programming Competition
- IoT Application Innovation Competition
- Microcontroller and Embedded Application Skills Competition
- Smart Car Competition

Fig. 4. Guarantee measures for training top talents in computer science

(2) Training on scientific research tools

Scientific research tools and innovation capabilities are placed in a prominent position. Professional teachers are invited to provide short-term training on software tools such as Endnote, Mindmanager, and Visio. Endnote is very convenient for managing references for publishing papers, graduation papers, or graduation projects. Mindmanager is beneficial for cultivating students' global and divergent thinking. As a powerful vector drawing software, Visio is widely used in database design, program flow chart design in undergraduate stage or circuit structure design and software algorithm design in graduate stage. Undergraduate students majoring in computer science are more familiar with these three software options and have good promotional potential.

(3) Expert Lectures

Famous experts were invited to report on the development trends and frontier fields of computer science at home and abroad, especially in hot fields such as Big data, the Internet of Things and artificial intelligence. With scientific enlightenment lectures, tutor forums, student discussion groups, etc. as the discussion platform, we will establish an exchange, guidance and interaction mechanism between teachers and students, expand students' autonomy and personalized Learning space, guide students' innovative thinking, and create a loose, harmonious, open and efficient educational environment conducive to the emergence of innovative talents.

(4) Scientific research projects

Relying on professional disciplinary research platforms, we encourage teachers to carry out innovative labor, promote teaching through scientific research, and make scientific research and teaching achievements an incubator for the knowledge system of universities. They are applied to the theoretical and experimental teaching system of students, ensuring that the theoretical and experimental content is constantly updated with the development of the discipline, and establishing a new teaching system with disciplinary characteristics.

The research ability gradient cultivation mechanism has been established. Based on students' personal qualities and interests, we encourage top-notch students to enter research groups and laboratories in advance, follow high-level teachers for research training, and join national and provincial research projects. In the next three years, a gradient training mechanism guided by "Basic research training-Research ability improvement -Innovative thinking" will be implemented to enhance research interest and cultivate research innovation ability.

(5) Application for scientific research projects and publication of papers

The top-notch class implements autonomous, personalized, and research-oriented professional education under the guidance of professional mentors. In the third semester, each undergraduate in the top class will be assigned a professional tutor to play the leading role of high-level teachers in talent training, cultivate students' Scientific literacy and innovation spirit, and promote the coordinated development of students' knowledge, ability and quality.

While studying the core courses of their majors, students engage in personalized reading through methods such as seminars and interdisciplinary course selection. In addition, professional mentors guide students in formulating research based learning plans, arranging students to participate in academic and seminar activities, organizing and guiding students to carry out various forms of scientific research training, enhancing students' interest in scientific research and engineering practice, and promoting the cultivation of students' innovative and practical abilities.

Top class students are encouraged to actively apply for the Anhui University of Finance and Economics Undergraduate Research and Innovation Fund and Undergraduate Innovation and Entrepreneurship Training Program, and publish academic papers under the guidance of professional instructors. By applying for the innovation and entrepreneurship training program for college students, the motivation for self-directed learning has been stimulated in practice. By applying for university research projects, students can feel the atmosphere of academic research, master the key points of academic paper writing and publication process, and cultivate their innovation awareness and practical ability.

(6) Discipline competition

In response to professional characteristics, top class students are encouraged to actively participate in various subject competitions, in order to cultivate practical skills and research interests. Discipline competitions exhibit new trends

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in professional development and new directions for application, with guidance, foresight, and innovation. Some well-known professional competitions are usually set by experts in the field or engineers from well-known companies in the industry, and the proposition content usually combines hot topics or algorithms in research or application. By participating in various competition projects in the field of computer science, one can quickly introduce their perspective from the basic level of the textbook into a broader space, allowing teachers and students to grasp the latest developments in their field in the most direct way, which is conducive to stimulating students' interest and thirst for knowledge. It can also help teachers consciously associate basic concepts with advanced technology in the teaching process, thereby promoting the cultivation of innovative abilities for teachers and students.

V. Implementation Effect and Practical Experience of Top-notch Class

A. Implementation Effect of Top-notch Classes

TABLE II. Comparison of implementation effects between top-notch class and regular class

Class	Project approved	Paper published	Discipline competitions awarded	CET 4 pass rate (%)	CET 6 pass rate (%)	Rate of promotion to master's candidate (%)
A1	17	6	23	94.44	31.71	20.09
A2	22	7	30	91.30	36.17	28.11
A3	19	12	25	91.49	34.48	24.32
B1	26	9	21	95.65	26.09	23.22
B2	20	8	24	90.68	24.86	19.34
B3 (top-notch)	47	14	68	100.00	75.00	68.00

The top-notch class emphasizes the cultivation of students' scientific research and innovation abilities. In this paper, the main indicators are project approval, paper publication, award winning in discipline competitions, passing rate of CET-4 and CET-6, and promotion rate to master's degree. A comparative analysis is conducted on the implementation effect of top-notch classes and regular classes. Among them, the project approval mainly includes national and provincial university student innovation and entrepreneurship training projects and university level undergraduate scientific research and innovation fund projects. Paper publication refers to an academic paper with undergraduate students as the first author. In addition, subject competitions mainly include multiple A/B subject competitions represented by the National College Student NXP Cup Intelligent Automobile Competition, Anhui Province College Student Microcontroller and Embedded System Application Skills Competition, National Software and Information Technology Professional Talent Competition, Anhui Province College Student Programming Competition, etc. For simplicity, only the number of provincial-level third prizes and above will be counted here. The pass rates of the CET-4 and CET-6 are based on the final pass rate after graduation. The master's degree promotion rate statistics include the number of students studying abroad.

Table II provides data on the implementation effects of top-notch and regular classes, which are analyzed from two aspects. On one hand, compared to Level B including top-notch class, the number of project approvals has increased from 58 to 93, the number of published papers has increased from 25 to 31, and the number of subject competitions has increased from 78 to 113. The average passing rates of CET-4 and CET-6 have increased from 92.41% and 31.12% to 95.44% and 41.98%, respectively, and the average passing rate has increased from 24.17% to 36.85%. Through the comparison between level A and level B, it can be found that the top-notch class has made a major contribution to the improvement of various indicators in level B. On the other hand, compared to the top-notch class, the average project approval rates for the regular class are 20.8 and 47, respectively. The average number of published papers has increased from 8.4 to 14, the average number of awards in subject competitions has increased from 24.6 to 68, the passing rate of the fourth level has increased from 92.7% to 100%, the passing rate of the sixth level has increased from 30.66% to 75%, and the master's degree promotion rate has increased from 23.02% to 68.00%. The indicators of the top-notch class are very significant in terms of quantity and improvement range. From the above analysis, it can be seen that top-notch class makes a significant contribution to various indicators, and the top-notch talent training model has achieved significant implementation results.

B. Practical Experience in Top-notch Class

After a year of practical implementation, the Top Class project has been summarized as follows.

(1) Using experimental training and subject competitions as carriers to comprehensively enhance students' awareness of innovation and entrepreneurship. By seamlessly linking comprehensive practical training courses with subject competitions, we integrate the positioning of subject competitions with the cultivation of applied talents in universities, and practice the cultivation characteristics of "practical education", effectively enhancing students' innovation awareness and practical ability.

(2) A top-notch high-level talent training model with the goal of taking the entrance examination for master's degree programs. A top-notch talent cultivation model is constructed from the main aspects of talent cultivation plan formulation, educational environment, curriculum construction, etc. After establishing a top-notch talent cultivation model, the national admission rate for master's degree students has exceeded 80%, and the admission rate has exceeded 60%.

(3) The development of international exchange and cooperation still needs to be strengthened. Although top-notch talent cultivation has achieved outstanding results in subject

competitions, practical ability cultivation, and master's degree enrollment and further education, the external exchange and cooperation of talent cultivation are mainly concentrated in domestic universities. The lack of international exchange and cooperation is partly due to a shortage of high-level teaching talents such as national level teachers and overseas teachers. The shortcomings of high-level teachers to some extent limit the quality of cultivating high-level talents. On the other hand, as a local finance and economics university, the funding for talent cultivation is limited. The introduction of overseas teachers, international exchange of students, and international talent cultivation still need to be further improved.

VI. Conclusion

Establishing a pilot program for top-notch classes, constructing a knowledge system that integrates similar disciplines, and establishing a top-notch talent cultivation model that emphasizes "solid foundation, innovation, and quality" is a new exploration and practice for top-notch talent cultivation in the context of new engineering construction. The professional teaching system with a solid foundation and strong ability, which is matched with the training mode of top talents, lays the foundation for top talents to continue their further study and creative learning. At the same time, the educational environment and various safeguard measures conducive to the emergence of innovative talents promote the cultivation of students' innovative ability, and ensure the continuity of teaching links, the progressiveness of teaching concepts and the effectiveness of reform programs in talent training.

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