Practical Teaching System Reform for the Cultivation of Applied Undergraduates in Local Colleges

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Abstract—Practical teaching is an important teaching link in safety engineering. It plays an irreplaceable role in cultivating innovative spirit and practical ability. At present, there is a series of problems in practical teaching of safety engineering in China, such as the incomplete practical teaching system, the substandard teaching organization, and the lack of funds. Drawing on the best practice of Anhui University of Science & Technology (AUST), this paper puts forward a basket of measures to cultivate the practical and innovative abilities of students in safety engineering. The specific measures include developing "peak" disciplines, fusing multi-discipline theories, setting up school-enterprise cooperation platforms, deepening second-classroom education, and promoting institutional construction. Our measures help local colleges to train advanced safety engineering talents with practical and innovative abilities.

Keywords—Safety engineering major, practical teaching, reform measures, school-enterprise cooperation

1 Introduction

Local colleges are the main ground for cultivating engineering talents for national engineering and technical projects, and they are assuming the important responsibility of training advanced engineering talents [1, 2]. In China, the Anhui University of Science and Technology (AUST) is a famous provincial-level university with excellent teaching level and unique teaching features. The university was established by the joining efforts of the Anhui province and the Ministry of Emergency Management, and supported by the program of basic quality construction of colleges and universities in central and western regions of China. The name of the school is listed in the "Excellent Engineer Education and Training Program" initiated by the Ministry of Education of China, and now AUST has grown into an influential university in the country, holding on its school-running objectives of basing on Anhui, serving Anhui, and facing China, it has cultivated a batch of senior innovative engineering talents that can promote the development of economy and society of Anhui and China.

Safety engineering is an applied discipline with significant practical features. For the safety engineering major, practical teaching is an essential teaching content and a key link in training students' practical ability, innovative ability, scientific thinking, and engineering concept, and it's especially important for enhancing the comprehensive ability of students [3-5]. Through practical teaching, students can understand the usefulness of knowledge and realize their shortcomings and ignorance, then, they can gain new scholarships during course selection, classroom lecturing and comprehension, and their learning consciousness and initiative will be promoted accordingly [6]. Besides, students could get precious perceptual knowledge and professional experience from practical teaching, which is conducive to their learning of subsequent professional courses. Therefore, how to construct a practical teaching system that suits modern education and industrial particularities and train innovative safe engineering talents has become a hot topic in the reform of safety engineering major in recent years. This paper draws on the successful example of AUST to further discuss means and methods for the reform and optimization of the teaching of safety engineering major.

2 Status quo of practical teaching of safety engineering

In China, now more than 170 colleges and universities in the country have set up the safety engineering major, and more than half of them launched this discipline since year 2000 [7, 8], therefore, this young discipline often has insufficient schooling experience, and there're a load of problems with it due to the limitations of teaching resources, faculties, and academic levels, and there're quite a few unneglectable troubles with the practical teaching of this major, such as:

2.1 Ignorance of the importance of practical teaching

Theoretical teaching has dominated the classroom teaching of Chinese schools for a very long time, and practical teaching receives few attentions from teachers in these years. Most teachers take practical teaching as a mere supplement or an assisting tool, so they are unwilling to spend much time on it. As for the schools, colleges and universities generally took science research achievement as their evaluation criteria, and in such a context, naturally the teachers would devote more efforts and energy to research program application, research paper writing, and patent application, etc., and they are very stingy of their time in teaching [9, 10]. Speaking from the students' perspective, the majority put most of their energy on examinations, believing that practical teaching only takes a small credit and exams are not required in practical teaching (the assessment of practical teaching in some schools only requires students to submit a report), so they do not have any enthusiasm for practical teaching.

2.2 Incomplete practical teaching system

A mature practical teaching system hasn't been formed in most local colleges, and few of these schools have a set of complete syllabi or teaching plans for practical teaching, let along the ones with unique features. The teaching links are not systematically arranged or connected and the hierarchical structure is unclear. When formulating plans for practical teaching, most schools do not have a top-level design; the training goals are not enacted centered on serving professional talents; and they haven't invited enterprises in the industrial field to participate in practical teaching, thus the enterprises' requirements for talents haven't been taken into the consideration of schools, which ultimately leads to a disconnect between discipline development and social needs [11-13]. In terms of specific teaching links in practical teaching, experimental courses, course design, cognition practice, production practice, graduation practice and other links haven't been integrated and there isn't a sound or scientific system that can push the links to proceed step by step and make them closely connected, which is not good for cultivating students' innovative and practical abilities.

2.3 Substandard practical teaching organization

In some schools, the textbooks, teaching plans, experimental procedures and methods haven't been changed for several years or decades, and are far falling behind the real engineering practical applications. Methods of practical teaching adopted in some schools are still the tedious and boring indoctrination-style classroom lecturing, students passively learn what teachers teach in the class, and they don't take initiative in learning. During internships, visiting usually replaces hands-on practice, and there isn't an atmosphere for students to explore by themselves freely, independently, and actively. The assessment of practical teaching is unreasonable, the main method is based on the internship reports handed by students; there's no effective measure or mechanism for assessing the process of practical teaching, which has resulted in that the effect and quality of practical teaching cannot be guaranteed [14, 15].

2.4 Lack of funds for practical teaching

As the prices for various goods are on the rise in these years, the expenditures of the schools are mostly used for salary and daily maintenance, the money spent on improving experimental and internship conditions is reducing gradually; however, the scale of student enrollment didn't shrink, and some schools even expanded their enrollment scales. The construction of teaching equipment cannot keep up with the student size, some facilities have been used for nearly twenty years and now they are still in service. The lack of funds for practical teaching disables schools to purchase new equipment for practical teaching, thus the practical teaching cannot meet students' needs for mastering new skills or techniques [16]. Various internships such as visiting internship, production internship, and upon-graduation internship also lack of teaching funds, so the internship locations and companies have been greatly limited.

3 Measures for reforming practical teaching system

AUST is one of the earliest universities in China to set up the safety engineering major. In 1983, the school enrolled the first batch of safety engineering undergraduates, and in 1986, it's permitted to grand master's degree in safety technology and engineering, and the doctorate degree in 2003. Then in 2011, the safety technology and engineering major has become a first-level doctorate degree in AUST, and in 2012 a post-doctoral mobile research base for safety technology and engineering major has been established in the school, since then, the AUST has formed a complete talent training system for bachelors, masters, and doctors of the safety technology and engineering major, and this major has been selected as one of the construction pilots of the first batch of national characteristic major, one of the second batch pilot majors of the national "Excellent Engineer Training Program", one of the "Professional Comprehensive Reform Pilot Programs" initiated by the Ministry of Education, one of the first-level national disciplines of Anhui province, and one of the first-level disciplines of the nation. In recent years, AUST aims at cultivating innovative and engineering ability, grabs the opportunity of constructing peak disciplines, integrates multiple disciplines, takes school-enterprise cooperation as the platform, and takes system construction as the guarantee to constantly deepen the teaching reform of safety engineering major, and further improves the quality of cultivated safety engineering talents.

3.1 Grab the opportunity of constructing peak disciplines and improve the conditions of practical teaching

In 2017, the safety engineering major was included in the name list of national first-level discipline construction program of Anhui Province; in 2020, it was included in the list of higher educational school I-class peak discipline construction program of Anhui Province. AUST has increased investment in the construction of laboratories for the safety engineering major; in the past five years, the cumulated investment has exceeded 76 million yuan, the school has purchased more than 30 equipment with a unit price of more than 1 million yuan, and the construction area of the laboratories has increased by more than 10,000 square meters. The existing laboratories for safety engineering major include: the national key laboratory of deep coal mining response and disaster prevention and control, the national-local joint engineering research center for coal safety and accurate mining, and the coal mine safety and efficient mining laboratory jointly established by Anhui province and the department of education, etc. The currently in-service teaching and research equipment and devices are worth of nearly 100 million yuan, and the conditions for the experimental teaching of the safety engineering major have been greatly improved. In the meantime, in 2015, AUST's average teaching expenditure for per student was 2,000 yuan, and this number had increased to 3,500 yuan in 2020. The experimental courses and course design classes of the safety engineering major are carried out in these laboratories, there're sufficient experimental devices for them to operate by themselves, and the actual experimental course rate (the ratio of actually-carried out experimental courses to the planned experimental courses) reached 100%.

3.2 Integrate multiple disciplines and enrich the content of practical teaching

The traditional practice teaching systems generally lack overall optimization and collaborative innovation, and they cannot be adjusted according to the differences in students' abilities and interests, which is not conducive to the cultivation of students' comprehensive quality [17]. In order to break the single pattern in which students could only graduate from one major, AUST has fully utilized its advantages in the research on coal mine disaster prevention and monitoring and control, and arranged students of different grades to form practice teams to participate in key and major scientific research programs of the school or the cooperative enterprises aiming at issues such as the complexity of coal mine gas and fire disaster prevention. By personally joining in scientific research programs and experiencing the organic collaboration of technique, practice, and organization, students could establish an awareness for engineering gradually. In classroom teaching, a teaching mode integrating multiple disciplines has been adopted in AUST, as shown in Figure 1. Under this mode, students can verify the professional knowledge they learnt, study the knowledge of other disciplines, truly realizing learning while using, and in this way, we could ultimately train these students to become senior innovative engineering talents.

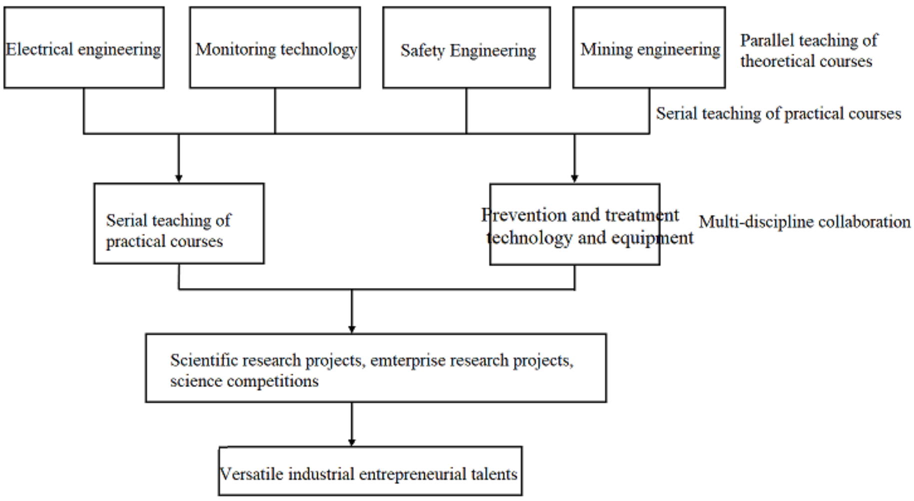

Fig. 1. Multi-discipline innovative practical teaching mode

3.3 Take school-enterprise cooperation as platform and establish the industry-school-research integrated cultivation mode

In recent years, the safety engineering major has worked with other relevant departments of the school and built a few stable engineering practice platforms. The construction of school-enterprise cooperative education bases could provide students with on-site internship opportunities, trigger their learning enthusiasm, and cultivate their ability to apply the knowledge they learnt. At present, AUST has built more than

20 bases of such kind, including famous companies, listed companies, and even Fortune 500 companies such as Anhui Conch Cement Co., Ltd., Chery Holding Group, Anhui Sunhere Pharmaceutical Excipients Co., Ltd., Huaihe Energy Group, and Huaibei Mining Group, etc. During internships in these companies, students carry out various internship activities in the real working environment under the guidance of instructors assigned by the companies, they can feel the real working atmosphere, fit in the company environment, get in touch with the advanced production technologies, get familiar with the management style and operating mechanism of the companies, cultivate their professionalism and work ethics, thus preparing themselves for entering the society in the upcoming future [18, 19]. Besides, the course design and graduation design of students are directly integrated with engineering practice, and all design themes are derived from actual engineering projects of the companies or the research tasks of the teachers, in this way, students' abilities of comprehensive knowledge application, analysis, and problem-solving could be enhanced accordingly. Moreover, AUST selects newly recruited young teachers to assume temporary posts in the cooperative companies for their personal training and development, the teachers could directly participate in the engineering practice of the companies and join in their R&D programs, two examples of such cooperative companies are the Wanbei Coal-Electricity Group, and the Shanxi Huozhou Coal-Electricity Group, etc.; in this way, not only the teachers' practical engineering experience has been greatly enriched, but also the technical problems of the companies could be solved and the development of the companies could be promoted.

3.4 Take the second-classroom as an effective means to expand the ways to train innovative and practical abilities

To encourage self-learning and self-innovation in practice, AUST and the safety engineering major have seamlessly integrated the first-classroom with the second-classroom, integrated the on-campus resources with off-campus resources, integrated professional learning with science competitions, and integrated professional practice with social practice, in this way, the school has truly implemented the cultivation of students' innovative and practical abilities [20-23]. AUST has built a set of cultivation and guarantee systems for college student practice and innovation training programs from four dimensions of national level, provincial level, university level, and school level. So far, it has successfully held 15 discipline competitions to cultivate students' innovative ability, students' enthusiasm for these competitions has been improved continuously, and a number of students have achieved good results in national-level and provincial-level competitions. Relying on national key laboratories, national engineering research centers, key laboratories of the ministry of education, key laboratories of Anhui, and other high-end scientific research platforms, AUST has selected a few experimental projects suitable for undergraduate students from national-level key research and development programs or national natural science foundation research programs led by teachers and let students choose these programs freely. By experiencing these research programs, students' professional learning and practical activities have been closely combined, their abilities of comprehensive knowledge application and problem-solving have been developed, and their practical ability and comprehensive quality have been strengthened. In addition, the school encourages the students to actively participate in academic seminars and symposiums, and it has created a bunch of opportunities for students to exchange, demonstrate, and share their experiences, achievements, and resources of innovation and research.

Practice has proved that, after the training of science and innovation programs, from 2016 to 2020, undergraduates of the safety engineering major of AUST had applied for 38 invention patents, 160 utility model patents, and published 290 academic papers. AUST students had won 62 awards in the "Challenge Cup" national undergraduate curricular academic science and technology works (also known as the Chinese college students of academic science and technology "Olympic" event), the "Challenge Cup" national undergraduate entrepreneurship plan competition, the national competition of innovation and creation in mechanical engineering for Chinese university students, the national higher education of mining engineering practical work contest, and the national higher education of safety engineering practical work contest; also, the AUST students had also won multiple honorary titles of the stars of self-improvement of Chinese college students, and the outstanding students granted by the Sun Yueqi Science and Technology Education Foundation.

3.5 Take system construction as the guarantee and optimize the content of practical teaching

AUST has formulated a series of relevant management rules and regulations for practical teaching to optimize its content, enhance its effect, and improve students' practical engineering ability, such as *Implementation Measures for the Construction of High-level Undergraduate Education and Teaching in AUST (Trial)*, and *Implementation Opinions of AUST on Promoting Innovation and Independent Entrepreneurship Education of Students*. In traditional practical teaching, the teaching content is mostly arranged by teachers, students just passively receive knowledge in the class, their subjective initiative has not been exerted. However, students vary greatly from person to person in terms of knowledge foundation, personal ability, hobby, and interest, therefore, when building the practical teaching system, it's necessary to give different instructions for different types of students, divide students into different levels and train them separately, teach students in accordance with their aptitude, and highlight their different characteristics [24]. Furthermore, when sorting out the programs for students of different grades, the experimental courses and course design should be integrated and classified into knowledge verification type or knowledge expansion type, and the two types of experiments constitute experimental course groups based on theoretical teaching [25, 26]. The basic experimental course group mainly contains verification experiments, which can improve students' understanding of the functions and operating methods of the equipment. The innovative practical course group mainly contains innovation and entrepreneurship activities, and various scientific and technological competitions, which can strength students' qualities that are necessary for innovation. Besides, based on AUST's advantages and reputation in the coal industry, the school has collected engineering research topics from coal companies and teachers and formed engineering practical course groups, then, the course groups have been released to students to satisfy the needs of students who are keen to innovation and knowledge transformation. Finally, with basic experimental course group — innovative practical course group — engineering practical course group as the main line, a pyramid-shaped practical teaching content system has been constructed, as shown in Figure 2. The system can stimulate students' awareness for autonomous learning, and change the passive learning pattern in the past to the active learning pattern; it enables students to integrate theory with practice; in practical courses, students can verify the knowledge they learnt, and apply the knowledge to solve engineering problems, thereby realizing the conversion from knowledge to achievement.

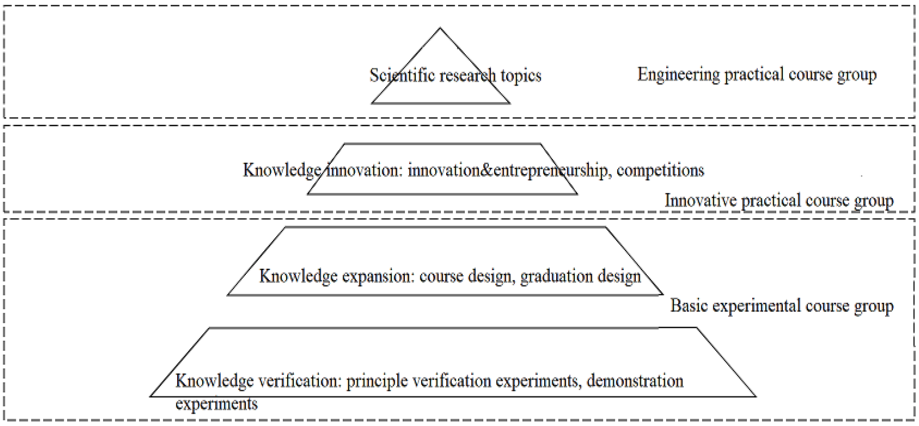

Fig. 2. The practical teaching content system

For the past few years, the safety engineering major of AUST has taken the initiative to adapt to the requirements of the new era for talents, with improving students' comprehensive quality and basic skills as the starting point, the university has formed an innovative talent training mode of safety engineering major with the characteristics of "laying solid foundation, emphasizing practice, and pursuing innovation"; it also constructed a diversified talent training course system and an engineering innovation and practice system. As a result, AUST has cultivated many senior innovative technical talents who are capable of promoting and leading the development of the safety engineering industry of Anhui province.

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