Investigation and Reform Measures of the Current Situation of Cultivating the Innovative Ability of HVAC

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Abstract—This article conducted a questionnaire survey on HVAC graduate students in the University of Shanghai for Science and Technology, analyzed the problems existing in the cultivation of innovative ability of them and combined with the actual situation of HVAC major postgraduates, it was proposed that the cultivation mode of hierarchically classifying and teaching students according to their aptitudes for students with different professional abilities and development directions. It is proposed some reform measures such as the reform of the graduate course system and teaching mode, strengthen the cultivation of post-graduates ability to discover and solve problems, implement joint schools-enterprises training and strengthen experimental teaching, which promote the cultivation of HVAC graduate students' innovative ability.

Index Terms—HVAC, Innovation ability, questionnaire survey, measures

I. INTRODUCTION

General Secretary Xi Jinping emphasized that innovation is the first driving force for development, if technological innovation cannot be achieved, we will be disadvantaged in the global economic competition. The rapid development of the times puts higher and higher innovation requirements on graduate students.

According to statistics from China Postgraduate Admissions Information Network, we can find that the number of professional master enrollment accounted for 26.48% of the total enrollment in 2011 and in 2016 it accounted for 47.41% [1]. The proportion of professional degree masters increases year by year. The Ministry of Education proposed that the focus of graduate education should be shifted to improving the innovation awareness and ability.

Wang *et al* [2] proposed a 721 training model for universities to train three types of talents: application-oriented, compound and innovative. Xie *et al.* [3] proposed to reform the experimental teaching methods and teaching content, enhance students' subjective initiative. Wang *et al.* [4] proposed that the specific characteristics of different courses in the HVAC should be combined and a multi-complementary teaching model should be adopted to improve students' innovative ability. Liu *et al.* [5] suggested to strengthen the tutor's ability and form various teaching forms to strengthen the cultivation of innovative talents. Zhang et al. [6] analyzed the problems in the training of talents between direct and indirect stakeholders from the perspective of stakeholders and the guarantee mechanism that should be established. Meng et al. [7] proposed to establish an international training platform to broaden the international vision of graduate students and to introduce an information-based teaching models. Xiao et al. [8] analyzed the characteristics and mechanisms of the "SJTU-Baosteel" postgraduate joint training model based on the theory of human capital and proposed that universities should adjust the postgraduate curriculum system, training links and evaluation system actively and orderly.

This article conducted a questionnaire survey on the first-year students of our graduates in HVAC from the aspects of their own factors and school environment, analyzed the problems of the students themselves and the school in the cultivation of innovative ability. In view of the era's demand for innovative talents, this article proposes to reform the graduate curriculum system, multi-level training for students and other optimization measures.

II. THE BASIC CHARACTERISTICS OF HVAC

HVAC major is a secondary discipline under the discipline of architecture and civil engineering. This discipline is mainly engaged in the research of satisfying the comfortable environment of human production and life. Students are required to perform heating, ventilation and air conditioning on the building according to different building characteristics and requirements to create and maintain a suitable indoor environment. It requires graduate students to be proficient in basic theory and professional knowledge, have good practical application skills, understand the frontiers of the discipline and be able to use advanced design methods.

III. ANALYSIS OF INNOVATION STATUS OF HVAC POSTGRADUATE

A. Subjective Influencing Factors

1) Lack of innovation awareness

Through the questionnaire survey, we found that only 35.94% of the graduate students have a strong

Manuscript received May 19, 2021; revised November 2, 2021.

willingness to participate in innovative projects. It shows that 40.63% of graduate students have not participated in the innovation project and 46.88% of the students have only experienced one project. The datas above indicate that the HVAC students have little contact with innovative projects and their awareness of innovation is scarce.

2) Insufficient comprehensive quality

We investigated the factors that influence the innovative practice activities of the students in this major. As shown in Fig. 1, 50% of students believe that their abilities are inadequate because of their learning attitude are not correct and their learning plans are not clear in the undergraduate stage. The theoretical knowledge cannot be grasped well, so it is more difficult to transform it into innovation. Because the former teaching is mainly taught by teachers, students sit down and accept knowledge passively, the enthusiasm of students' autonomous learning is greatly reduced. In addition, many graduate students of HVAC major come from colleges and universities whose education level is lower than our school. There are few contacts and studies of innovative projects. For various reasons, students have low innovation levels and weak comprehensive capabilities.



Figure 1. Factors affecting students innovation

3) Affected by examination-oriented education

Affected by the current examination-oriented education system in China, the level of innovation ability is not the first criterion for judging whether a student is excellent or not. Most students pay more attention to the level of their test scores subconsciously [9]. However, the application of the knowledge learned to work is often presented in the form of innovative design. As we all know, curriculum design and engineering design courses are important for students of the HVAC profession. Through our own innovative design, we can further consolidate professional knowledge, but many students did not pay attention to those, the design presented are similar to others and lacks their own thinking.

B. Objective Influencing Factors

1) Curriculum is unreasonable

Compared with undergraduates, the number of graduate students of HVAC majors in our school is relatively small. There are fewer types of postgraduate courses, more lecture-oriented courses and fewer courses that are close to the frontier. In addition, the courses of

professional masters and academic masters in HVAC are similar, the focus of school training is not obvious. Constructing a reasonable and appropriate curriculum system is a key step in cultivating the innovative ability of graduate students.

2) Insufficient equipment and funds

With the increasing enrollment of graduate students year by year, the phenomenon of shortage of resources such as laboratory equipment and scientific research activity venues is becoming more and more obvious. In the HVAC professional laboratory, insufficient or damaged instruments are also very common, some graduate students need to coordinate their time to use a set of instruments together, which often causes a lot of inconvenience and trouble.

IV. STRATEGIES FOR CULTIVATING INNOVATIVE ABILITY

Universities play an important role in the cultivation of graduate students' innovative ability. As shown in Fig. 2, 43.75% of students believe that the school reforms the curriculum system and adopting multiple teaching methods is the most meaningful reform method. 25% of students believe that joint activities with companies are more helpful for the cultivation of innovative ability and 21.88% of students believe that increasing experimental teaching is the most effective.



Figure 2. The most effective reform measures students think

A. Reform the Curriculum System

In order to broaden the innovative thinking space of graduate students and let students understand the innovation status of the HVAC industry as widely and deeply as possible, we implement mixed elective courses [10] for graduate and undergraduates. And use case guidance [11] in teaching. In view of the existence of graduate students with different professional abilities, different interests and different future development, we hope to carry out hierarchical classification management of students, divide students into different categories according to individual differences of students, according to the content of courses and requirements are divided into different levels. Offering innovative frontier courses of different difficulty and teaching direction, graduate students can study further in a targeted manner. At the same time, the college increased the proportion of HVAC professional practice courses, increased the opportunities for graduate students to enter the laboratory and

participate in engineering practice projects, which laid a good foundation for the research to meet the comfortable environment of human production and life.

B. Strengthen the Ability to Discover and Solve Problems

In addition to classroom education, literature reading and seminar exchange are two essential ways for graduate students to acquire knowledge [12], [13]. Literature review is the first step and the key step for graduate students to conduct academic research and innovation activities. For the new topics arranged by the instructors, students need to find a large amount of literature, understand the dynamics of the topics in the subject area, tap new ideas related to their own topics and then we can carry out the research. After several weeks of study, students' ability to learn and analyze problems will improve.

The graduate students of our school carry out academic exchange activities widely. HVAC graduate students hold academic seminars and exchanges regularly to communicate with literature readings and project progress, tutors and other graduate students comment on and ask questions about their reports. On the one hand, a large amount of literature reading can broaden our horizons and provide a foundation for the research. On the other hand, we can learn from the reports of other students about the latest developments and new technologies in the industry and application, which can greatly arouse our enthusiasm for scientific research and innovation.

C. Joint Training between Schools and Enterprises

The study of theoretical knowledge and the application of innovative activities are in our work ultimately, which requires us to combine campus and enterprise. During the first year of postgraduate study in HVAC, enterprise should hold lectures regularly to communicate with students about current industry trends and research problems of the enterprise. Enterprises should encourage students to use innovative thinking and theoretical analysis to solve the problems .Also the enterprise encourages excellent employees to share excellent cases, which will lead the way for HVAC graduate students to improve their innovation ability and practical ability. The HVAC graduate students will enter construction companies for internships in an organized manner in July and August of each year. Graduate students need to have a deep understanding of the company's engineering practice. They can learn the latest research content of the industry from the current work dynamics of the enterprise. By the time the school starts in September, students can gradually enter the laboratory to carry out new topics. Study a large number of literature readings at school and work in construction companies during the holiday often makes us have a clear and complete research ideas in our minds. Graduate students continue to progress through the process of practice, induction, learning, research and re-practice.

D. Strengthen Experimental Teaching

Experimental teaching can arouse students' enthusiasm and enable students to inspire research in practice. The survey shows that more than half of graduate students believe that experimental teaching can stimulate their research interest. Therefore, the college has increased the proportion of experimental courses and adopted open experimental teaching. From the design of the experimental plan to the analysis of the results, it's all done by the students themselves. They help each other in groups to exercise their sense of cooperation. For example, when learning advanced heat and mass exchange, the teacher ask students to optimize the evaporative cooling equipment. In this process, students need to study the influence of various factors on the results through experiments rather than theoretical analysis, which will trigger them innovative thinking. At the same time, the school should strengthen the supplement of laboratory equipment and try to avoid the repeated purchase of the same equipment or the same functional equipment in the case of insufficient funds and create a good material foundation for our experimental teaching.

The college encourages students to participate in innovation projects and provides laboratories for students who applying for innovation projects. The college has established many experimental platforms, such as building heat recovery variable air volume system energy saving, large space indoor thermal environment, supercritical carbon dioxide heat pump, building solar energy integration, etc. The HVAC laboratory is open to students at a fixed time every week and students can carry out experiments related to the project.

V. COMPETITION RESULTS OF HVAC POSTGRADUATE

Participating in the innovation competition is an important way to test the feasibility and appropriateness of the innovative ability training model of HVAC graduates in our school. It is also an effective way to communicate and collide with innovative thinking so that the professional level of students can be rapidly improved. In recent years, our HVAC graduates have completed more than 20 national, Shanghai and school-level innovation projects in various experimental platforms established by the college. We won one first prize and three second prizes in the MDV Central Air Conditioning Design Competition, one second prize and three third prizes in the Car-Ashrae Student Design Competition. We won the first prize in the second "Tianjia Cup" National HVAC Student Science and Technology Competition and won the third prize in the third "Tianjia Cup" .Besides, we won the championship in the third World HVAC Student Science and Technology Competition in 2019. More and more graduates of HVAC participate in innovative projects and bring back many awards and honours, which shows that with the active cooperation of the college's reform leadership and students' hard working, the reform about innovative ability training model of HVAC graduates has achieved obvious results. The students' innovative consciousness and innovative ability are strengthening continuously and their comprehensive quality is improving gradually.

VI. CONCLUSION

In this article, according to a questionnaire survey, we find the innovation status of postgraduates of HVAC majors in the school, propose reform the curriculum system and teaching mode of this major, strengthen students 'ability to find and solve problems, implement joint schools-enterprises training and strengthen experimental teaching. In recent years, the cultivation of innovation ability of graduate students of HVAC has achieved remarkable results, which has an important guiding role for the cultivation of graduate students in the future. Universities should pay attention to teaching methods to create an environment conducive to the growth of innovative talents, postgraduates should be strong in themselves and strive to become innovative talents.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Lv proposed the idea and structure of the paper; Huang and Feng designed the questionnaire; Lv, Huang, and Feng analyzed the data, draw conclusions, and proposed solutions together; all authors had approved the final version.

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