Construct a research-based teaching mode to enhance Undergraduates' innovation capability

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***Abstract*—In order to enhance the innovation capacity of undergraduates, we have constructed a research-based teaching mode. This model introduces the frontier and relevant interdisciplinary knowledge, integrates our faculty's latest scientific research, combines perfectly with the teaching materials, introduces research into classroom, practice and graduation thesis, stimulates students' innovative consciousness, inspires their innovative thinking and guides them to learn from doing research. Based on the course "Digital Signal Processing", we illustrate how to build a research-based teaching model to enhance undergraduates' innovation capability. Practice has proved that the introduction of scientific research to teaching is conducive to promote teaching quality, curriculum building, and cultivation of talents.**

***Keywords*—research-based teaching; innovation capability; teaching quality; research mode**

I. INTRODUCTION

The tasks of today's universities are mainly personnel training, scientific research and community service. It is the call of the times and the requirements at this stage to implement innovative education, train and bring up a large group of high-quality and innovative talents. So, how can we renovate education in order to increase the number of talents? We believe that curriculum is a process of cultural transmission; it is the crystallization of human wisdom, the summary of science and technology and a reflection of modern advanced development. Therefore, curriculum is an important carrier to train students with knowledge, ability and quality. Teaching quality has great impacts on the quality of talents. In recent years, we have been using the basic theory of education as our guideline, the cultivation of new talents as the highest goal in the teaching process of curriculum construction. All this aims to strive for a research-based teaching model which will in turn cultivate more outstanding talents. We have achieved remarkable results in renovating the teaching materials and teaching method and enhancing undergraduates' innovation capability.

II. RENOVATE TEACHING CONTENT AND CITE THE LATEST SCIENTIFIC RESEARCH INTO TEACHING

Research-based teaching must first renovate teaching content, which is the most basic part of education. So, how can we renovate teaching content? Our approach is to deal with the relationship between fundamentality and advancement of teaching content, introduce cutting-edge knowledge and overlapping knowledge of related disciplines, integrate teachers' scientific research, combine them perfectly with teaching materials, stimulate students' awareness of innovation and inspire their creative thinking[1][2].

In class, the teacher interacts with students by heuristic teaching, teaches frontier research and methodology, and promptly enriches the latest achievements of research into teaching; after class, the teacher offers some scientific researches, such as academic papers as references available to students for reading and thinking, thus providing relevant teaching materials for curriculum construction. This will not only enrich the curriculum, but also effectively improve the students' interest and attain good teaching results. During the process of class teaching, the students are very active in thinking, the collision of thoughts can happen between the teacher and students, which will inspire the teacher to ponder and promote scientific research [3]. The teacher should lay emphasis on cultivating students with scientific research methods and meticulous scholarship. Attract students who are interested in curriculum knowledge to participate in research through class teaching, guide them to combine with related research projects. In this process, students have learned how to gather information, consult the literature, participate in academic seminars and master the scientific methods. All this will lay a solid foundation for deeper further study. The teacher guides students to participate in research activities and let them do whatever they can, which will help expand the breadth and depth of undergraduate teaching; students will than develop academic interest and creative thinking skills, thereby enhance the quality of teaching, cultivate better talents.

In the research process, the teacher should divide a big problem into a number of small problems, leave the simple ones to students, and encourage them to challenge science. In addition, the teacher should combine students' theses directly with research projects. Research projects are generally new and difficult issues in a certain field. So, they are involved in a lot of abstract work. The teacher can assign sub-topics of research to students as the issues of their graduation theses. This will not only avoid thesis plagiarism, but also the same old meaningless topics the teacher arranges every year. In the study of the problem, students can better grasp a research method and have an overall understanding of the subject. Allow students to try to

be able to integrate and share a variety of resources, communicate with each other and understand series of scientific research on relevant topics as well as scientific research methods and techniques, so that undergraduates can have a better sense of the breadth and depth of thesis. Therefore, they will no longer blindly follow the law when confronting with research problems. Students' enthusiasm has been stimulated and educational experience is gained. In terms of the effects of our research, undergraduates' theses combining with research projects are relatively of high quality.

III. RENOVATE TEACHING METHODS TO BUILD RESEARCH-BASED ONES

We introduce widely-used DSP software, which is also used in domestic enterprises and research institutes under support of Information and Control Experiment Center and Training Center of Information and Control. Students' design quality and difficulty have been improved. They get to know the overview of the software and how the software operates, which will lay necessary technological knowledge for further research and development and scientific research.

We are fully aware that the specialized teachers must actively explore and practice the combined model of scientific work and teaching, use their own scientific research to improve teaching level and the quality of talents. If the teacher is able to break through on some certain point and apply it to teaching practice, he or she will have better influence on the students and achieve better teaching results. As we assume Shandong Province Natural Science Fund Project - "MSINS / GPS integrated navigation system data fusion algorithm," we proposed a variety of data fusion algorithms, including linear fitting method, polynomial fitting method, interpolation method and symmetry point method. The speed and stability of the new algorithm is significantly better than conventional algorithms predecessors have ever proposed. How will the research results be applied to teaching practice and improve teaching quality? We adopt that teachers conduct innovative teaching demonstration lessons, which are well-organized by a trilogy of "guide before class, guide in class and guide after class ", encourage them combine their own latest research with course teaching, cultivate students' awareness of innovation and inspire them to innovate. The "guide before class" refers to that the teacher tells students when a demonstration lesson will begin and how the lesson will be conducted. The teaching content should be designed by the teacher. Then guide the students to consult various versions of domestic and international "Digital Signal Processing" textbooks and the previous and the teacher's own related research papers, compare various algorithms to find where the innovation lies. Doing so not only can cultivate students' ability to gather information and study on their own, but allow students to have a preliminary understanding of teachers' research work and develop their interest in that. The "guide in class" means that the teacher gives a brief introduction of the previous study, focuses on guiding students to discover what are the problems of previous work, lists detailed ideas and methods to solve these problems, and the teacher uses examples to prove that the new method is better than the previous ones. Through "guide in class", students' curiosity in research will be transformed into a sense of admiration on their teachers' innovation ability of research and sprout a sense of participation in the study of innovation. The "guide after class" refers to that after the demonstration lesson, the teacher puts students who have research ability and a strong sense of innovation, and who are willing to do research together, guides them in their research work, and encourage them to put forward new ideas, new thinking modes and new methods in the research. The teacher may divide the students into groups and choose one of them to lead the group. This can help students practice teamwork and form a favorable atmosphere of intra-group and inter-group contests. The teacher gives each group a planned task which is in full accordance with the requirements of the research project. The task has everything needed, including the specific requirements, the standards for evaluation and even every right and obligation of the group members and confidentiality requirements. Allow students to build awareness of risk, sense of responsibility and credit awareness in the course of scientific research activities. In accordance with the provisions of the planned task, the teacher's responsibility in this process is to teach students the corresponding design methods, enable them to learn how to use design software and help them to complete the corresponding design task. The teacher's counseling work is very heavy. The teacher not only needs to instruct students in scheduled time, but also answer all kinds of questions from students on BBS. After receiving the task, the research group analyzes it and divides it to each group member: one to do arithmetic, one to do interface, one to do graphics output and so on. This can make each student be actually involved in the design activity and get complete design training, and through a comparison of multiple programs, students can see more structure forms and learn from each other. Better teaching results can be realized. As can be seen from the above process, the curriculum is entirely set up in accordance with a formal research process.

Modern university's teaching should be an integration of theory teaching, practice teaching and scientific research. Practice teaching is the source of the current teaching theory and a source of future invention. Design of practice teaching system should be diverse, comprehensive, hierarchical and focusing on innovation. Diverse means a variety of teaching practice, including a variety of experiments, curriculum design, technology contests and innovation activities. Comprehensive refers to that the teaching content shifts from unicity to comprehensiveness. Hierarchical means the teacher starts from cognitive, confirmatory practice, and gradually increases the design, open and integrated practice. First, we should strengthen the foundation and broaden knowledge, emphasize practice, cultivate capacity, encourage innovation, develop personality, improve the overall quality. Build a practice teaching system with the ability cultivation as the core; strengthen students' practical and innovative ability of engineering practice and promote coordinated development of knowledge, ability and quality. Secondly, optimize experiment course, strengthen the comprehensiveness, design, innovation and openness of experimental teaching, enhance students' engineering design ability, establish coordinated experimental and theoretical courses, engineering application and research capabilities complement each other, create a comprehensive practice teaching mode of digital signal processing and

integrate advanced hardware development platforms and system simulation tools like DSP development platform, Matlab programming language, System View simulation software and virtual instruments into the practice teaching. Link students' practice directly with the current project development and improve students' adaptability at work. In the experiment, we set up the problem scenarios and guide students to study their independent experimental research programs. Students show curiosity, doubt and confusion in the problem scenarios, which effectively stimulates students' desire for knowledge and the urge to explore. We have found that the use of research-based teaching mode in curriculum design and experimental teaching can really inspire students' awareness of innovation and enhance the innovation capability of undergraduates.

IV. RENOVATE HIERARCHICAL CULTIVATION AND DEVELOP RESEARCH GRADUATES' ACADEMIC CAPABILITY

Currently, we implement "dual system" of graduate education in China: academic degree graduate and professional degree graduate, which is to meet the social requirements for academic talents and complex talents. In view of this, graduate sustainable innovation ability training model should take into account differences between the different types of degrees to form a complementary and coordinated functioning mechanism.

The goal of academic graduate training is to cultivate high-level researchers to engage in rigorous academic study. For a long time, under heavy employment pressure, many colleges and universities have focused too much on applied courses in the process of academic graduate training, while ignoring the learning of basic theory and the cultivation of innovation capacity, resulting in a lack of excellent academic talents. Therefore, in order to foster sustainable innovation capability for academic graduates, some reform work should be done in aspects like training plan, curriculum and mentoring system.

Professional degree education should break the blind pursuit of occupation and introduce innovative ideas among the professional degree education. Develop students' creative thinking, innovative spirit and ability and be occupation-oriented. Develop their personality while teaching them basic knowledge [4-7]. The teaching content of professional degree should reflect the latest academic achievements and technological developments, closely link to actual needs and focus on students' ability. The construction of materials should introduce high-level foreign textbooks and combine domestic excellent teaching materials. Teaching methods should be diversified and combine the lectures with seminars, simulations, case teaching, practice and so on. Advocate and promote the involvement and investment of graduate training institutions, authorities and other social forces; carry out multi-level and multi-form graduate education innovation activities and create good ambience for innovative research. We must vigorously carry out professional degree education innovation projects to provide intellectual support for production invention by enforcing academic graduates' research capacity and directly link to the training of practical ability, apply what they learn. We should strengthen the building of the training base and increase investment in laboratory construction; enhance team building of training instructors and focus on cultivating application and practical ability.

V. CONCLUSION

In traditional teaching, students passively accept existing knowledge. They are lack of training in creative thinking, let alone foster innovation capability. So they can't put forward new ideas, new models and new algorithms. But, in the "research-based teaching", students no longer just take previous knowledge and research, but are provided with the frontier knowledge and their teacher's research. The teacher makes some improvements or innovations on the basis of inheritance and encourages students to explore and discover problems which their predecessors couldn't solve or are poorly-solved. Students can put forward new ideas and new ways in the process, which will train the students' creative thinking, inspire innovative actions and enhance the innovation capacity of undergraduates. The above research has fully proved that the level of course construction and innovation capability of undergraduates have been significantly improved though using the "research-based teaching" mode. So we can predict that it will be widely used. We are determined to continue to explore it on the road to research teaching and we believe that it will bear more fruitful teaching results

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