Multi-Dimension Training Scheme to Improve the Innovation Capacity of Postgraduate and Undergraduate Students Collaboratively

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***Abstract*—This Innovative Practice Work in Progress Paper presents a multi-dimension training scheme to improve the innovation capacity of postgraduate and undergraduate students collaboratively. The current training of postgraduate and undergraduate education schemes cannot form a mutually beneficial relation, not suitable for the training of innovation capacity on postgraduate and undergraduate students collaboratively. There are various problems that need to be addressed. The main strategy of the proposed scheme is utilizing real research programs to establish an integrated team mixed with both postgraduate and undergraduate students, focusing on stimulating their innovation capacity in scientific research. In the scheme, we designed a multi-level joint training mechanism based on the mixed pedagogy, the collaborative resource pool platform, the multi-role and team-based innovation talent incubation mechanism, and the preparatory postgraduate student selection and training goal achievement evaluation mechanism. We applied the scheme to the training process of postgraduate students from the majors of Software Engineering, Computer Software and Theory, Computer Application, Computer Technology and Electronic Information Engineering, and undergraduate students from the majors of Computer Science and Technology, Information Security and Communication Engineering in Nanjing University of Posts and Telecommunications. The training results approve the feasibility and effectiveness of the scheme.**

Keywords—collaborative training; innovation; postgraduate education; undergraduate education

I. INTRODUCTION

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At the top of the whole educational chain, the postgraduate education has important significance to the national education system [1]. In order to cultivate outstanding postgraduate students with systematic specialized knowledge obtained during undergraduate education, and train advanced specialized talents with the innovative spirit [2,3], the collaboration ability [4-6] and the ability to pursue scientific research, teaching, management or specialized technical works, we should not only strengthen regulation and promotion on the aspects of degree management, scale and discipline construction, but also conduct improvement and innovation to the training model and methods for undergraduate students, who are the main sources of postgraduate students. In this way, the undergraduate and postgraduate education can form a mutually beneficial relation, i.e. "guiding undergraduate education with postgraduate education, and promoting postgraduate education through undergraduate education".

However, the current training of postgraduate and undergraduate education schemes cannot achieve the above goal, especially on the training of innovation capacity, and there are various problems that need to be addressed:

- The postgraduate educational system is separated from the undergraduate educational system, which lacks a channel for smooth communication, a platform of organic integration and a mechanism of collaborative innovation. And it is difficult to establish a scientific research team that combines both postgraduate and undergraduate students with matching research directions.
- Current measures, such as simple continuous education program for Bachelor's, Master's and Doctor's Degree or the Teaching Assistant (TA) program for postgraduate students, cannot truly and effectively realize deep integration, mutual promotion and common growth of postgraduate and undergraduate students in training their innovation capacity.
- Neither the rigid postgraduate entrance examination nor the postgraduate student selection mechanism based on the short-term "summer training camp" can effectively choose suitable undergraduate students to pursue education for a Master's degree in a certain direction or major.
- The undergraduate students with the ambition for the further education could not smoothly enter the preparation state in advance, and they could not make the adequate early-stage preparation in order to further improve their innovation and research capacity in scientific research during the limited postgraduate education.

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Under the support of the Jiangsu Province Postgraduate Education and Teaching Research Projects "Engineering Postgraduate Student Innovation Training Model and Method" and "Multi-Disciplinary Collaborative Innovation Capacity Training Scheme for Postgraduate Students", and the National Plan for Educating and Training Outstanding Engineers, etc., we proposed and practiced a multi-dimension training scheme to improve the innovation capacity of postgraduate and undergraduate students collaboratively.

II. MULTI-DIMENSION TRAINING SCHEME

The main strategy of the scheme is utilizing real research programs to establish an integrated team mixed with both postgraduate and undergraduate students, focusing on stimulating their innovation capacity in scientific research. In the scheme, we designed a multi-level joint training mechanism based on the mixed pedagogy, the collaborative resource pool platform, the multi-role and team-based innovation talent incubation mechanism, and the preparatory postgraduate student selection and training goal achievement evaluation mechanism.

A. Multi-level Joint Training Mechanism based on the Mixed Pedagogy

We proposed a multi-level joint training mechanism based on the mixed pedagogy for postgraduate and undergraduate students, organically integrating the behaviorism, the constructivism and the humanism learning theories, and providing multi-level separated and integrated training to the postgraduate and undergraduate students in the innovation team. The mixed pedagogy advocates the interaction between subject and object, and emphasizes the integration of behavior, emotion, knowledge, information and wisdom. Both the practical teaching and scientific research innovation links are more suitable to train postgraduate and undergraduate students with different levels of scientific research capacity and innovation awareness, and they are also more consistent with the "student-oriented" educational concept, as shown in Fig.1.

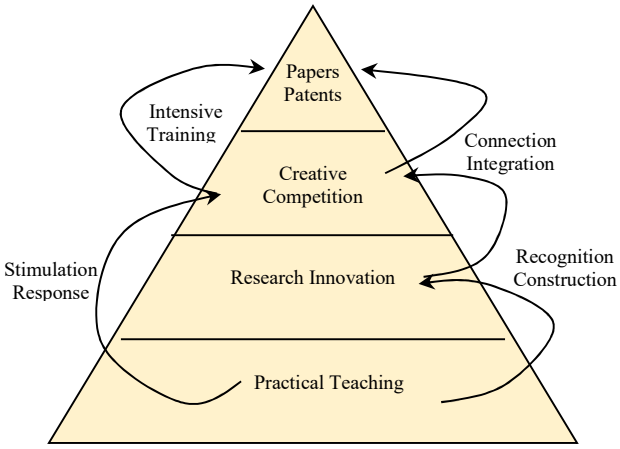

Fig. 1. Multi-level joint training mechanism based on the mixed pedagogy

Based on the theory of constructivism [7-9], the mixed scientific research team of postgraduate and undergraduate students is constructed, which can realize the integration between postgraduate and undergraduate students in the field of scientific research innovation. The instructor designs and builds learning "scenarios" suitable to the students with significance to the construction of teaching content, students on different levels play different roles of business and technology in the scientific research team, and they improve their scientific research ability and cultivate their innovation spirit through "collaborations" and "conversations", as shown in Fig.2.

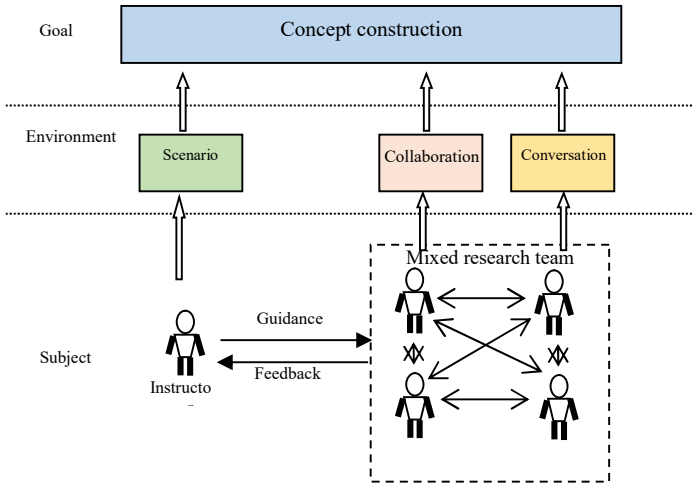

Fig. 2. Mixed scientific research team based on the constructivism

During the practice of scientific research innovation, based on the talent cultivation concept that focuses on the humanism teaching idea of "teaching students in accordance of their aptitude" and "applying the learned knowledge", we further proposed the multi-level flexible scientific research and practice training model. The students are assigned with different scientific research tasks and roles in accordance with their individual differences, so that they can improve their ability and obtain the experience of success. As a result, it can more significantly improve the students' initiation, and finally, students at different levels can achieve maximal progress and development based on their actual situation. In the meantime, the postgraduate students, the undergraduate students and the instructor can generate surprising sparks of thought during close and frequent communications and interactions, realize breakthrough in their scientific research innovation practice, and obtain achievement and confidence.

B. Dynamic Collaborative Resource Pool Platform

In order to address the problem of lacking the collaboration and interaction channel between postgraduate students, undergraduate students and teachers for recognition and communication, we designed and built an effective dynamic collaborative resource pool platform with the purpose to improve the internal & external information sharing and collaboration capacity. By utilizing the technology of Web 3.0, the "postgraduate student + undergraduate student + teacher" dynamic collaborative resource pool platform can better realize integration of information resources for the teachers and students, promote flatter collaboration between the postgraduate students, undergraduate students and teachers, and provide a self-organized, mobile and structure interactive environment to

the innovative scientific research team formed by postgraduate and undergraduate students, so that they will not be restricted by time and space during development of scientific research work, which can accelerate the scientific research innovation. As shown in Fig.3, the dynamic collaborative resource pool platform consists of various modules, such as the public resource module, comprehensive instructor research columns, postgraduate and undergraduate student scientific research BLOGs, and the rapid scientific research collaboration channel.

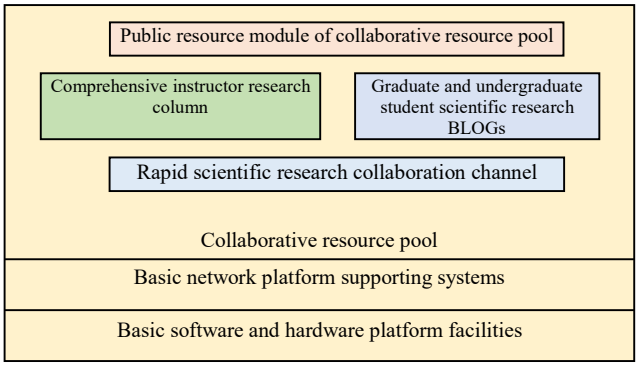

Fig. 3. The system structure of collaborative resource pool

The collaborative resource pool has provided a self-service teamwork space, which has the synchronous collaboration and the asynchronous cooperation functions. On this platform, the scientific research team can be conveniently established for certain scientific research projects and innovation programs.

C. Multi-role and Team-based Innovation Talent Incubation Mechanism

We proposed a multi-role and team-based innovation talent incubation mechanism to postgraduate and undergraduate students with entrepreneurship. Based on the model of "talent selection + building team + providing subsidy + incubator+ application and promotion", postgraduate and undergraduate students on different levels with different specialties are assembled to build hierarchical network of scientific research teams with real projects. During the project implementation process, students are assigned with one or multiple specific roles, and various works such as preparing a business plan, conducting feasibility research simulating corporate operation, participating in corporate practice and writing reports. In this way, all students can improve their research and development ability and teamwork spirit in the project. As a result, in addition to obtaining knowledge and improving their practical ability, it can also motivate the students' awareness to start up a business and their potential creativity.

D. Preparatory Postgraduate Student Selection and Training Goal Achievement Evaluation Mechanism

During the relatively long-term development of scientific research project, innovation and business mentioned above, the method of analytic hierarchy process (AHP) [10] can be used to conduct long-term continuous evaluation of undergraduate students in various teams. Based on the orderly hierarchical structure, and the quantitative and comprehensive evaluation of the potential of undergraduate students, we can choose undergraduate students with the intention for further education and the required capacity to pursue a Master's degree in suitable major and direction. The preparatory postgraduate student selection process is shown in Fig.4.

In order to check whether the training goal for postgraduate and undergraduate students has been achieved, we proposed the training goal achievement evaluation mechanism. Through the follow-up survey of graduates (including postgraduate and undergraduate students) on various aspects, the comprehensive measurement and evaluation can be conducted to examine whether the training goal has been achieved. By implementing the evaluation and feedback mechanism to examine the achievement of specialized training goal, it can effectively evaluate the training effects for postgraduate and undergraduate students, form a positive closed-loop architecture and provide the basis and support for the modification of next round of training goals based on the collected and grasped data material, so that the level of training mechanism for postgraduate and undergraduate students can be continuously improved.

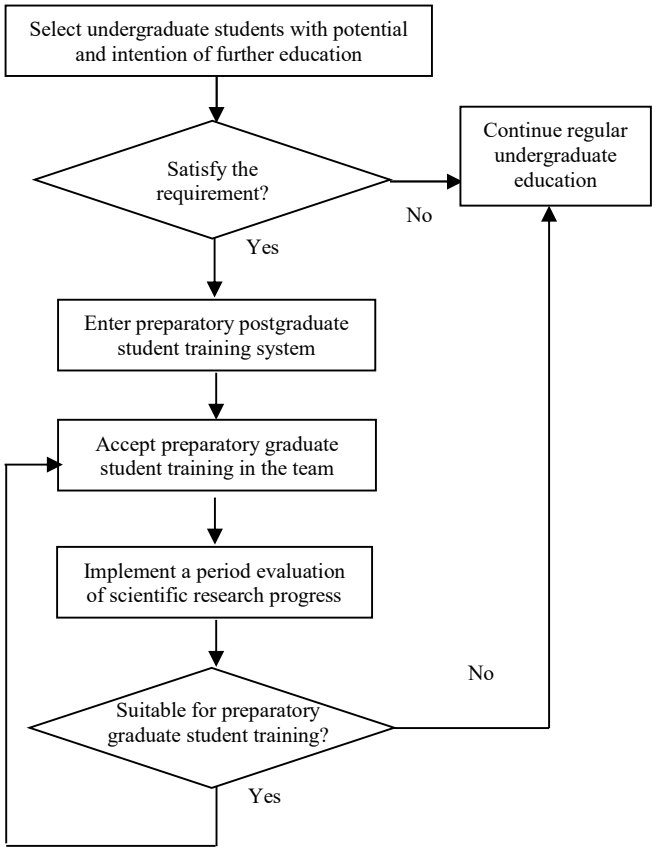

Fig. 4. The preparatory postgraduate student selection process

III. APPLICATIONS AND VALIDATIONS

Supported by the Jiangsu Province Postgraduate Education and Teaching Research Projects, etc., we conducted active explorations and achieved a series of innovative results. We conducted practical applications and

validations during the training process of postgraduate students from the majors of Software Engineering, Computer Software and Theory, Computer Application, Computer Technology and Electronic Information Engineering, and undergraduate students from the majors of Computer Science and Technology, Information Security and Communication Engineering in Nanjing University of Posts and Telecommunications, and achieved significant training results.

By building multiple mixed scientific research teams of postgraduate and undergraduate students, and applying the multi-dimension training scheme, the scientific research innovation and practice ability of postgraduate and undergraduate students was significant improved, and they won various innovative competition awards. Some postgraduate and undergraduate students had great career developments after graduation. Their representative competition awards and career developments are shown in Table I.

TABLE I. INNOVATION AWARDS AND CAREER DEVELOPMENTS

Member type	***Name***	***Major***	***Status Quo/ Career Development***
Postgraduate student	Wenjun Yang	Computer Technology	Employee of Tencent
	Yongning Huang	Computer Technology	Employee of ZTE
	Jinxin Xiang	Software Engineering	Employee of Baidu
Undergraduate student	Xiaoyu Lü	Computer Communication	Employee of CERNEWTECH Co., Ltd.
Awards	Injured People Search System based on Wearable Physical Sensors, The Third Prize of the 2014 TI-National IoT Design Contest		

By applying the scheme, some postgraduate and undergraduate students in the team improved their scientific research ability and team work spirit through actual entrepreneurial training and practice programs. The information of entrepreneurial awards and student career development is shown in Table II.

TABLE II. ENTREPRENEURIAL AWARDS AND CAREER DEVELOPMENTS

Member type	***Name***	***Major***	***Status Quo/ Career Development***
Postgraduate student	Yichao Jin	Computer Software and Theory	Ph.D. student in Nanyang Technological University, Singapore
	Jing Tang	Computer Software and Theory	Engineer of Singapore Technologies Engineering Co., Ltd.
	Jing Li	Computer Software and Theory	Engineer of Jiangsu Communications Planning and Design Institute
Undergraduate student	Miao Zhu	Business Administration	Engineer of Nantong TeleCom
	Xiao Shen	Human Resource Management	Engineer of Zhejiang TeleCom
Awards	Aineng Technology Co., Ltd., the Second Prize of the 6th Jiangsu College Student Entrepreneurial Contest		

The mixed team composed of some postgraduate and undergraduate students published a series of papers and obtained a series of patents through collaboration, and they presented great research and development quality and innovation ability.

IV. CONCLUSION

Through the actual collaborative training program on postgraduate students from the majors of Software Engineering, Computer Software and Theory, Computer Application, Computer Technology and Electronic Information Engineering, and undergraduate students from the majors of Computer Science and Technology, Information Security and Communication Engineering, we implemented the training mechanism, platform and strategy proposed in this paper. Significant training results have been achieved, which have won broad approvals from the education experts.

The multi-dimension training scheme to improve the innovation capacity of postgraduate and undergraduate students during research and development has practical value and promotion significance to further improve the postgraduate and undergraduate student training quality, strengthen the innovation practice ability of postgraduate and undergraduate students and satisfy the social demand for high-level talents.

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