Exploration of the Multi-dimensional Mutual Promotion Postgraduate Cultivating Model

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Abstract—**Postgraduate education is the main part of university education. The traditional postgraduate cultivating mode separates curriculum teaching from research ability training. The traditional postgraduate course teaching mode emphasizes knowledge teaching. In course teaching, there is a lack of training in postgraduate research thinking abilities and innovation abilities. The course teaching links are not fully utilized, so postgraduates' research thinking and innovation abilities are generally weak. In view of the above problems, this paper studies the multi-dimensional postgraduate cultivating model through the mutual promotion of course teaching and scientific research guidance. We hold that the postgraduate course teaching is an important link to cultivating the scientific research thinking abilities of postgraduates. Fully utilizing the course teaching link and multi-dimensional courses and scientific research combination can cultivate the postgraduates' abilities to analyze and solve problems, cultivate their scientific research thinking and innovative thinking, and enable them to enter the scientific research field earlier. Based on three aspects, we construct a multi-dimensional teaching and research mutual promotion cultivating model, and also verify the effectiveness of the proposed model through practice, and we also give some relevant suggestions.**

Keywords—**mutual promotion, model, curriculum teaching, research ability**

I. INTRODUCTION

Colleges and universities have always attached importance to the development of degrees and graduate education, The universities develop vigorously graduate education, and the enrolment scales of postgraduates have also been expanding. The universities are able to cultivate high-level innovative talents with solid professional basic theory and knowledge, who understand the development trend of related fields, master the latest cutting-edge technology, and have the innovative ability to cross disciplines to solve practical problems. Aim at the frontier and key areas of science and technology, and improve the talent cultivation model.

For graduate education, course learning is an important part of graduate education, and scientific research

thinking, scientific research ability and problem-solving ability are important abilities that postgraduates need to cultivate. The traditional postgraduate cultivating modes are that course teaching is just course teaching, scientific research is also just scientific research, course teaching only completes the pass on of course knowledge, course teaching and the cultivation of students' scientific research thinking are separated, these two cannot promote each other, and the phenomenon that course learning is just learning and mastering knowledge is widespread. The postgraduate students who have been cultivated can not meet the needs of social development, their scientific research diatheses and problem-solving abilities are not high, and their innovation abilities are not strong. The students are generally so-called "high-level talents" who have no academic advantages and are not competent for high-tech and scientific research posts.

In view of the existing problems in the course teaching and research thinking ability training in the process of postgraduate cultivating, in order to grasp the course teaching link in the process of postgraduate cultivating, we explore a multi-dimensional cultivating mode in which the course teaching process and research thinking ability training promote each other, so as to cultivate and guide students not only to master the theory and practical skills of professional disciplines, but also to cultivate professional discipline literacy in the learning process, to enhance the core quality and innovation abilities of students' own professional disciplines, and improve the level of teaching and research.

II. RELATED RESEARCH

There have been many explorations for high-quality student training. Authors of [1–3] studied the cultivation of computational thinking ability. Authors of [4–6] explored the cultivation of the innovation ability of graduate students based on cross disciplines. Hu [7] studied the problems in the cultivation of top talents in basic disciplines. Rosdianto and Teeka [8] analyzed that students actively participate in the whole process of learning which plays a positive role in cultivating students' scientific spirit. Parrado-Martínez and Sánchez-Andújar [9] analyzed that students should be educated on practical problems which is the learning motivation of students. Niu [10] analyzed the influence of tutor

guidance, postgraduate self-learning, and other aspects on postgraduate research problem-solving ability. Teaching students to raise issues and to spend enough time solving problems which can cultivate and improve students' ability to solve problems [11]. Problem-solving ability is an important part of promoting sustainable growth and innovative development of the industry [12].

The development level of computer science and technology determines the development level of the information industry and its comprehensive competitiveness. Due to a shortage of high-quality computer research professionals. It is an important task for colleges and universities to cultivate high-quality computer professionals. Specifically, this paper takes graduate cultivating of computer science and computer technology as an example and explores the multi-dimensional cultivating mode of mutual promotion between the course teaching process and the cultivation of scientific research thinking abilities.

III. METHODS

A. Cultivating with Multi-dimensional Mutual Promotion

The computer science and technology discipline play a supporting role in the science and technology of the information industry. The basic courses of computer science and technology and related algorithm courses are the main professional courses for master students of computer science and computer technology. The main content of scientific research in the information field is algorithms research, including artificial intelligence algorithm research, big data algorithms research, various algorithms research, and so on. We combine related algorithm courses, Explore the mutual promotion cultivating mode of curriculum teaching and promoting graduate students' scientific research thinking and scientific research ability, and effectively improve students' ability to analyze and solve problems by combining knowledge learning and innovation ability training.

1) Teaching with problem-analysis-oriented guidance course teaching

In the course teaching, adopt problem analysis-oriented teaching, analyze and mine the content of the course, and step by step gradually to brought up problems and solve problems. For instance, give an algorithm through a question, then analyze this algorithm's time performance and algorithm deficiencies, then improve the algorithm, and give a new algorithm with improved performance, next continue to analyze the problems in the new algorithm, and then continue to improve the new algorithm for the existing problems. Thus, multiple algorithms with different performances can be given for the same problem.

For a problem, first, analyze this problem, design a method to solve the problem, then analyze and find out the existing problems of the given method, and then give a new method to solve the existing problem again. By constantly improving the problem-solving method,

cultivating students' scientific thinking ability, and cultivating students' how to analyze a problem, how to find out the existing problem, how to define a problem, and how to improve an algorithm for solving the existing problems. For example, algorithms such as 0–1 knapsack problem, merge sorting and quick sorting and etc. can provide at least 3 different algorithms in a progressive way. In this way, the teaching of the course content can cultivate students' ability to analyze and solve problems.

2) Combining cutting-edge technology in course teaching

In course teaching, some content on cutting-edge technologies and research projects may be interspersed in the relevant content of the course. Such as introducing game ideas and deep reinforcement algorithms in polygon games problem, introducing the idea of constructive proof in Strassen matrix multiplication problem, introducing the tree search algorithms and deep reinforcement decision optimization algorithms of AlphaGo in the contents of the backtracking method and the branch and bound method, and introducing Google Cloud technology, Amazon cloud technology, and Microsoft cloud technology, as well as the similarities and differences and characteristics of these three cloud technology architectures in the content of the parallel workstation cluster, etc. Thus, it can broaden students' vision of cutting-edge technology, stimulate students' interest in professional learning and cultivate students' innovative thinking and ability.

3) Combining multiple courses in course teaching

In course teaching, in combination with the contents of multiple courses, design a comprehensive instance. For example, in the instance, the algorithms contain the clustering algorithm and the reinforcement learning algorithm in machine learning, as well as the divide and conquer algorithm in the traditional algorithm, the mathematical theory utilizes the matrix analysis theory and statistics theory, and the performance optimization utilizes the heterogeneous computing technology in the parallel distributed computing technology, and so on. Through the analysis and realization of such comprehensive instances, it can cultivate students' comprehensive evaluation ability and solving complex problem ability.

B. Constructing a Multi-dimensional Cultivating Mode

1) Providing multi-dimensional cutting-edge technology and the latest literature guidance

In view of the lack of cutting-edge and the inability to timely reflect the latest research results of the discipline in courses content, need to provide multi-dimensional courses research guidance according to the student's professional research fields. In the course learning process, provide graduate students with cutting-edge technologies and the latest papers related to the field, guide them to learn the latest cutting-edge technologies and the latest papers related to the field, and instruct them to access the latest cutting-edge technologies and the latest professional field-oriented literature online, for example, guide them to access the latest deep learning

technologies through the network, learn the latest deep networks, guide them to access the latest professional field direction top journals and conference literature online, guide them to read the latest cutting-edge papers, and cultivate their self-learning ability and peruse ability of scientific research papers.

2) Providing multi-dimensional scientific research thinking guidance

In combination with graduate students' research fields, guide them to participate in research projects, aim at the forefront of science and technology, and conduct scientific research. According to the research direction of them and in combination with the research projects in the laboratory, by guiding them to study the latest cutting-edge papers, where are required to summarize and analyze the papers they read. In this process, teachers guide them to find problems and learn to think independently. In this way, they are trained to analyze problems and think independently, actively find problems, and deeply analyze problems. For the problems found and the research direction, teachers guide students to conduct research direction and relevant questions problems investigate and survey, summarize research progress of related issues, summarize challenging issues, define issues, conduct method research based on issues, conduct experimental verification, and output scientific research results, and participate in innovative projects, etc. In this way, can cultivate their abilities to think independently, find problem abilities actively, analyze problem abilities in-depth, and solve problem abilities creatively.

3) Constructing multi-dimensional research-oriented teaching model

In the teaching process, through the combination of courses and cutting-edge technology and the combination of multiple courses conduct multi-dimensional teaching implementation. Combined with scientific research, teaching and research are combined. High-level course teaching needs to combine scientific research, transform scientific research resources into teaching resources, make full use of the scientific research achievements of the discipline and laboratory, bring scientific research into the classroom, and this way students can master the cross-course scientific research knowledge structure. It is the basis of cultivating students' innovative thinking and potential.

4) Advocating multi-dimensional fusion of science and education

In the process of student training, in addition to the combination of multi-dimensional course teaching and multi-dimensional scientific research, we also need to attach importance to encouraging students to actively participate in scientific research and innovation practice activities and scientific competitions. Thus, cultivating students' research and innovation practice abilities. Participating in scientific research and innovation activities is an important aspect of students' innovation abilities training.

5) Forming a multi-dimensional cultivating mode

Through the organic combination of multi-dimensional course teaching, multi-dimensional scientific research

combination, multi-dimensional research-oriented teaching and science education fusion, we have built a multi-dimensional cultivation model for graduate students which can carry out comprehensive scientific research diathesis cultivation and personalized training. Thus, it can improve the abilities and level of graduate students' cultivation.

IV. PRACTICE AND SUGGESTIONS

A. Practice

1) Multi-dimensional course teaching practice

In the courses of algorithm design and analysis, machine learning, and parallel distributed processing, we combine cutting-edge deep learning technology and cutting-edge big data cloud computing technology, and we combine multiple courses to fusion. In this way, this multi-dimensional course teaching broadens students' cutting-edge technology vision, stimulates students' interest in professional learning, cultivates students' innovative thinking and ability, and expands students' knowledge structure and scientific research vision.

2) Multi-dimensional scientific research combination practice

In the process of multi-dimensional course teaching practice, we combine multi-dimensional scientific research and guide students to learn the latest deep learning technology, big data technology, and parallel distribution technology through the network combined with the knowledge of the courses they have learned, and instruct students to read the latest top journals and conference papers in the fields of artificial intelligence and computer vision, such as *TPAIM*, *IJCV*, *TIP*, *NeurIPS*, *CVPR*, and *ICCV*, etc., through reading high-quality papers, guide students to find problems, put forward problems, define problems, propose methods, implement methods and verify experiments. So as to cultivate students' ability to analyse problems and think independently, and cultivate students' ability to solve problems creatively.

3) Multi-dimensional research-oriented teaching and science education fusion practice

Based on multi-dimensional course teaching and multi-dimensional scientific research combination, we conducted multi-dimensional research-oriented teaching and science education fusion practicing, which transformed the scientific research projects and achievements resources of the laboratory into teaching resources and encouraged students to actively participate in scientific research innovation practice activities and scientific competitions, such as modeling competitions and innovation competitions. Students mastered the structure of scientific research knowledge of cross-course. These can cultivate students' innovative thinking and potential and cultivate students' abilities of scientific research innovation and practice.

We carried out practices based on the multi-dimensional cultivating mode. In this manner, on the one hand, it broadens and deepens students' professional knowledge learning of courses; on the other hand, it

improves students' scientific research diathesis and comprehensive abilities through multi-dimensional combination of teaching and research and fusion of science and education; students' ability to study high-level literature, conduct scientific research and research innovation practice are significantly improved; students' professional knowledge and scientific research abilities are solid and strong. we direct 11 postgraduate students in two grades who have published papers or have been accepted papers 10 papers in total, all of these papers have been published in above category C designated by CCF, and two graduate students made oral reports at the conferences. Nine people times won the prize in the mathematical modeling contest and three graduate students won the prize in the artificial intelligence innovation contest. So verified the effectiveness of the proposed mode. The follow-up will be carried out on a large scale based on previous experience.

B. Suggestions

1) Starting from the formulation of the talent-cultivating program

The multi-dimensional cultivating mode requires cooperation between multiple courses and multiple teachers. It requires full research and discussion when formulating the postgraduate cultivating program, and requires to design of relevant course and course content around the talent cultivating objectives. It's better to divide these set courses into several relevant course groups. Different course groups can relate with different field directions, and teachers of relevant courses should cooperate with each other.

2) Designing frontier instances of different course groups

In the process of multi-dimensional cultivating, in order to cultivate students' scientific research thinking and solving complex problem ability, each course group needs to design at least one cutting-edge instance related to each course of this course group. The instance includes at least one content of each course in the course group. On the one hand, it can let students see that a complex problem can not be solved by one course, on the other hand. It also enables students to understand that our scientific research needs a solid professional foundation and knowledge, as well as the ability to analyze and solve problems.

3) Course instructors with certain cutting-edge technology and scientific research ability

Because the course needs to combine cutting-edge technology and scientific research achievements, the course teachers need to have certain cutting-edge technology and scientific research ability. It is better to teach with instances from their own scientific research achievements, and it is easier for students to accept practical and specific problems.

V. CONCLUSION

This paper proposes a multi-dimensional postgraduate cultivating model, explores the cultivating model of mutual promotion between the course teaching process and the cultivation of scientific research thinking, and introduces the specific contents of the cultivating model that include the problem analysis-oriented teaching in course teaching; the combination with cutting-edge technology in course teaching; the combination of multiple courses in course teaching; multi-dimensional course teaching; providing multi-dimensional cutting-edge technology and latest literature guidance; providing multi-dimensional scientific research thinking guidance; constructing multi-dimensional research-oriented teaching model; advocating multi-dimensional fusion of science and education and forming a multi-dimensional cultivating mode. In this way, the provision of multi-dimensional course research guidance according to the direction of postgraduates' professional fields, and in combination with the direction of postgraduates' research fields to guide postgraduates to participate in research projects, to guide postgraduates to aim at the forefront of science and technology, conduct scientific research, participate in innovative projects and scientific competitions, to stimulate their interest in professional learning, and cultivate their innovative thinking and abilities, cultivate their analyzing and solving problem abilities, cultivate their scientific research thinking and solving complex problem abilities, and improve postgraduates' comprehensive diathesis. And also verified the effectiveness of the proposed model through practice. Finally, some relevant suggestions are given.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Suping Wu conducted the research, student supervising and course teaching; Xueming Wang conducted student supervising; Jinfeng Liu conducted student supervising and course teaching; all authors had approved the final version.

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REFERENCES

[1] J. W. Win, "Computational thinking," *Communications of the ACM*, vol. 49, no. 3, pp. 33–35, 2006.
[2] G. Chen, L. Li, and R. Dong, "Towards computational thinking 2.0," *China University Education*, vol. 4, no. 4, pp. 24–30, 2020.
[3] L. Deng, D. Zhan, and X. Jiang, "The value exploration and practice of computational thinking ability cultivation in the new engineering education," *Research on Higher Engineering Education*, no. 2, pp. 49–53, 2020.
[4] Y. Yang, Y. Lu, and C. Wu, "Discussion on the cultivation mode of postgraduate innovation ability under the background of interdisciplinary," *Education and Teaching Forum*, no. 33, pp. 69–70, 2018.
[5] X. Liu, "Research on the interdisciplinary cultivating mode of graduate students in research universities," thesis, Zhejiang University, Hangzhou, 2018.

[6] Y. Xie and S. Wu, "Cultivation of the innovation ability of graduate students in local universities based on interdisciplinary," *University Education*, no. 5, pp. 161–163, 2019.

[7] J. Hu, "Three problems in the cultivation of top talents in basic disciplines," *Journal of Jishou University (Social Science Edition)*, no. 2, pp. 64–67, 2020.

[8] H. Rosdianto and C. Teeka, "The improvement of students' problem-solving skills through 5E learning model," *JPI*, vol. 8, no. 2, pp. 235–243, 2020.

[9] P. Parrado-Martínez and S. Sánchez-Andújar, "Development of competences in postgraduate studies of finance: A Project-Based Learning (PBL) case study," *International Review of Economics Education*, vol. 35, 100192, 2020.

[10] T. Niu, "Research on the ability of graduate students to solve scientific research problems and its influencing factors," thesis, East China Normal University, 2019.

[11] University of Waterloo, Teaching problem-solving skills [EB/OL], November 28, 2018.

[12] J. Y. Kim, D. S. Choi, C. S. Sung, *et al.*, "The role of problem solving ability on innovative behaviour and opportunity recognition in university students," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 4, no. 1, p. 4, 2018.