Research on the Form of "Four-Steps" Open Project Practical Teaching Activities

Gang Cen(✉), Zeping Yang, Yuefeng Cen, and Zeyu Zheng

Zhejiang University of Science and Technology, Hangzhou, China
gcen@163.com, cyf@zust.edu.cn

Abstract. A "four-steps" open project practice teaching mode is proposed from the perspective of local application-oriented talents cultivation. This mode is constructed for the purpose of improving the comprehensive quality of application-oriented talents, based on the platforms of open innovation and experiments, students' scientific and technological innovation projects, as well as the students' discipline competition, with emphasis on the consolidation and promotion of scientific research results. It is a students' interest-oriented and innovative practical results based mode. Through the forms of "five-autonomies" open project practice teaching, this mode is able to meet the needs of students' personalized practice teaching. In line with the curriculum of professional courses, this mode extends the practical teaching outside the classroom, improves students' scientific and technological innovation ability, and ultimately fosters the education of application-oriented innovative talents.

Keywords: personnel training · "four-steps" · practical teaching · innovative education · construction of teaching environment

1 Introduction

How to improve the education quality of engineering innovation talents has always been the core issue. ZUST (Zhejiang University of Science and Technology) is a provincial university which mainly focuses on cultivating high-level application-oriented talents in China. Exporting high-quality engineering innovative talents is the goal that has been pursued by ZUST [1]. In school teaching, a complete teaching system consists of planned teaching and unplanned teaching. However, the unplanned practical teaching system has failed to fill the vacancy of the high-quality engineering innovation talents. In recent years, although many improvements and gratifying results have been achieved, there are still many areas that can be improved. Systematical improvements of the practical teaching system to increase the output of high-quality engineering innovative talents has become a major issue that schools need to study and solve in the new era [2].

W. Hong and Y. Weng (Eds.): ICCSE 2022, CCIS 1813, pp. 11–21, 2023.
https://doi.org/10.1007/978-981-99-2449-3_2

2 The Overall Idea of "Four-Steps" Open Project Practice Teaching

2.1 Several Pedagogical Issues that This "Four-Steps" is Intended to Address

Local application-oriented undergraduate institutions intend to address the emergence of several teaching the following issues.

The Problem of Whole Process Engineering Practice Environment. Currently, the lack of a systematic engineering practice environment outside the teaching program makes it difficult to meet the diversified, comprehensive, personalized, and maximized growth needs of students. For example, students often lack practical experience and skills related to actual engineering projects, as well as interdisciplinary and cross-disciplinary practice environments, which limits their overall quality improvement. In addition, the lack of effective evaluation methods and systems in the practical teaching process also affects the improvement of the practical effect. Therefore, these undergraduate institutions lack a systematic engineering practice environment to meet the needs of students. Outside the curriculum system, students find it difficult to gain practical experience and skills, especially for future career needs. At the same time, this also makes it difficult for students to apply what they have learned in real life, thereby limiting their abilities and creativity. In addition, the lack of effective transformation mechanisms and achievement display platforms also limits the opportunities for students' practical results to be displayed and applied, thereby reducing their confidence and innovative drive.

Systematic Top-Level Design of Practical Teaching Activities. The practical activities such as open experiments, discipline competitions, science and technology projects, paper publications, and patent applications in undergraduate colleges lack integration, resulting in a lack of synergy and weak overall effect. A systematic top-level design is required to promote the sustainable development of students' innovative ability. To achieve this goal, a comprehensive and unified project-based teaching system that combines open experiments, discipline competitions, science and technology projects, paper publications, and patent applications must be established. The design of this system should comprehensively and sustainably promote the development of students' innovative abilities.

Improve the Effectiveness of Practical Teaching. In practical teaching at schools, there are prominent problems such as passive learning and insufficient cultivation of innovation ability, which are also challenges faced by the education sector today. In practical teaching, students are usually passive recipients of knowledge, lacking initiative and creativity, which hinders the effective improvement of their practical and innovative abilities. Therefore, we need to change the

traditional "spoon-feeding" education and realize experiential practical education to improve the effectiveness and quality of practical teaching. Students need to play a more active role and become the main body of practical teaching. Through practical activities, students will gain more practical experience, enhance their innovative thinking ability, improve their practical problem-solving skills, and cultivate teamwork spirit.

2.2 The General Idea of "Four-Steps" Open Project Practice Teaching Activity Form

To solve the above problems and improve the engineering innovation level and practical ability of students in application-oriented undergraduate institutions, the group has proposed a "four-steps" project practice teaching activity, which is based on the CDIO (Conceiving-Designing-Implementing-Operating) as shown in Fig. 1.

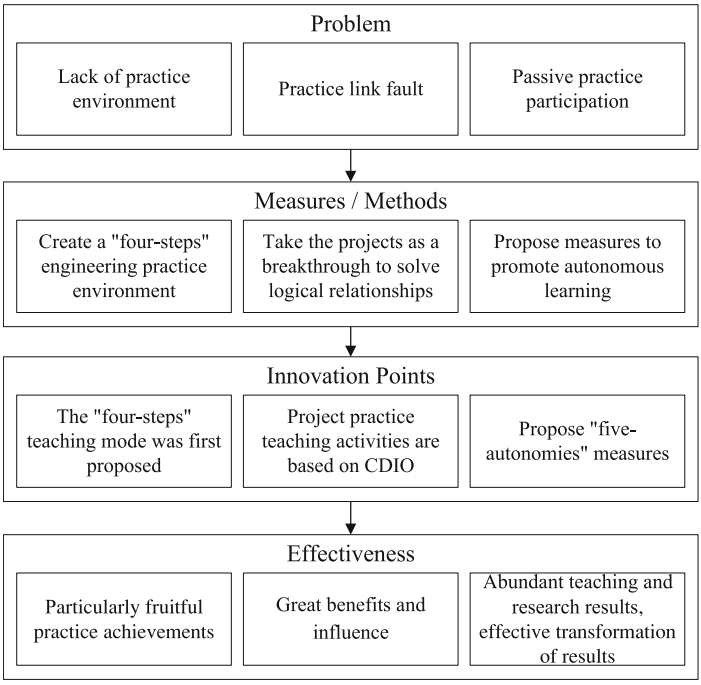

Fig. 1. General idea of the form of project practice activities.

Adopt the CDIO Theory. Create an engineering environment for the "four-steps" open project practice teaching activities. It focuses on solving the problem of lack of engineering practice environment outside the teaching plan, and creates the whole process of "four-steps" engineering environment from the team environment, hardware environment and soft environment.

CDIO upholds the constructivist view of knowledge, emphasizing the active cognitive construction of the subject and the cyclic rise of the carrier, i.e. the cognitive subject is required to develop and apply the product, process and project life cycle from easy to difficult. Based on this idea, and taking into account the structural features and complexity of the project and the characteristics of students in different grades, this paper innovatively takes a project as the main line and hierarchizes the "four-steps" to complement the teaching within the training program. This structure from simple to complex, from validation projects to research projects, facilitates students' targeted project practice, which in turn helps them to gain an integrated learning experience and an overall development of their knowledge and abilities.

Since 2015, we have established an basic innovation practice base named "Blue Space" in the Anji campus which is a sub campus of the university and the place for the first-grade of the undergraduates gathering. As a starting point for project practice it creates a good practice atmosphere, that members help and learn from each other, to effectively improve organizational functions and learning outcomes [3].

Using Project Practice as the Main Line. Based on the characteristics of the new engineering discipline, four modules are proposed: innovation foundation practice, science and technology innovation practice, discipline competition practice and result condensation and promotion practice. All four modules are based on project practice. The projects are from simple to deep, from easy to difficult, and from simple to complicated. With a main project going throughout, students can participate in the practical teaching activities in each stage step by step, and develop innovation in a sustainable way, thus making students have more room for improvement.

We take project practice as a breakthrough to build a logical relationship between the activities of the "four-steps" project teaching, and focus on solving the problem of broken practical teaching links.

Measures of "Five-Autonomies" are Proposed. "Five-autonomies" means practice content autonomy, choosing partners autonomy, choosing mentors autonomy, practice time autonomy, and practice project management autonomy [4].

Practice content autonomy means that the source of practice content can be students' own themes, teachers' research projects, discipline competition projects, enterprise demand projects, etc. Choosing partners autonomy means that members of the practice study group can come from different grades and different campuses. Choosing instructors autonomy means that teachers from

different disciplinary backgrounds are available for students to choose as project monitors. Practice time autonomy means that students can choose the starting and ending time of practice according to their own situation, spanning from one to several semesters. Practice project management autonomy means that students manage practice bases and projects independently, making project implementation more convenient and effective [5,6].

The measures of "five-autonomies" focus on solving the problem of passive learning in practice, allowing students to participate in basic practice, science and technology practice or disciplinary competitions that interest them, giving them a sense of control over their own learning and promoting a practice paradigm that aims at their personalized development.

3 Construction of "Four-Steps" Open Project Practice Teaching Activity Model

3.1 Logical Relations of Activity Forms

Based on CDIO, according to the structure characteristics of the project, the complexity and the characteristics of the students in different grades of schools, with the integration of the open experiment teaching, extracurricular science and technology innovation project achievements of study and practice, college students competition, and achievement condensed promotion, we established an activity patterns and theoretical system named "four-steps". That is, the relatively independent four modules are organically integrated to form a project-based, interrelated and hierarchical practical teaching activity system, as shown in Fig. 2.

3.2 "Four-Steps" Open Project Practice Teaching Activity Format

Basic Project Practice. The purpose of basic project practice is to familiarize students with the "four-steps" activity model. This approach allows students to participate in the "four-steps" process in a progressive and hierarchical manner, starting with simpler projects and gradually moving on to more complex ones. The ultimate goal is to develop students' innovative abilities and provide them with practical experience that they can use in their future careers.

To achieve this goal, it is important to provide students with a supportive learning environment that encourages active engagement and experimentation. One way to do this is through basic training seminars, which can provide students with the foundational knowledge and skills they need to start working on their own projects. In addition, visits to innovation bases and exposure to the practical achievements of senior students can help spark students' interest in project-based learning and motivate them to take on more challenging projects.

Specific implementation: Through publicity and mobilization, organizing visits to innovation bases such as "Blue Space", observing the practical achievements of seniors, and attending the meeting of outstanding seniors, we can guide

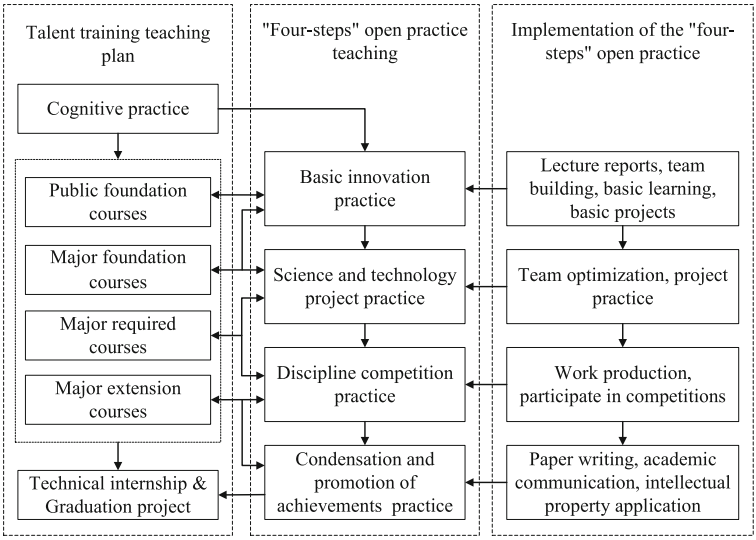

Fig. 2. The logical relationship between the forms of "four-steps" open practical teaching activities.

students to understand CDIO and stimulate their interest in the project practice. Through basic training seminars, students can try to start some small projects and form teams to practice basic projects. In this stage, students mainly practice in innovation bases such as "Blue Space".

Science and Technology Project Practice. The purpose of science and technology project practice is to optimize the team structure and customize the project practice content according to individual interests and strengths. By engaging in innovation project practice, students can enhance their abilities in research, collaboration, design, development, and cooperation.

To achieve this goal, it is necessary to establish a comprehensive system for science and technology project practice that includes project topic selection, project proposal writing, project implementation, and project evaluation. In order to optimize the team structure, students can form teams based on their individual interests and strengths, and can be guided by teachers and industry experts.

During the project practice process, students should be encouraged to think creatively and independently, and to communicate and collaborate effectively with team members. They should also learn to solve practical problems and apply theoretical knowledge to real-world situations.

Specific implementation: With the help of innovative practice bases such as "Blue Space", students can apply for science and technology innovation projects, reorganize or optimize project practice teams, or participate in teachers' research projects. Driven by innovation projects, students further improve their design,

development and collaboration skills. The outstanding students can help guide the junior students in this stage, and they can learn from each other to promote the rapid growth of the team.

Discipline Competition Practice. The purpose of the discipline competition practice is to enhance the quality of work and showcase the practical achievements of students based on their mastery of some professional knowledge. This practice is aimed at improving the students' abilities in project management, document writing, speech expression, and more. It also serves as a platform for students to learn from each other and exchange ideas, as well as to promote healthy competition among peers. In this stage, students are encouraged to participate in various discipline competitions and challenge themselves to continuously improve their skills and knowledge in their chosen field of study. Through such competitions, they can also gain valuable experience in teamwork, communication, and problem-solving. The discipline competition practice is an essential component of the comprehensive project practice system and plays a significant role in the cultivation of innovative and practical talents.

Specific implementation: To enhance the practical experience of students and promote their innovation ability, it is crucial to complete the practical part of the discipline competition with the help of innovation bases. The innovation bases provide students with necessary resources, equipment and mentors to carry out their projects. Moreover, students can access a real-world environment to test their innovations and apply theoretical knowledge into practical activities. To achieve the above objectives, students need to select key issues or technologies in the project research results and create or improve them. They can then participate in national or provincial university competitions to showcase their innovative ideas and achievements. During the competition, students have the opportunity to exchange ideas with peers and experts from different universities and disciplines, which can broaden their horizons and stimulate their creativity. Through this combination of competition and learning, students can improve their project management ability, competition ability, and speech and expression ability. They can also gain confidence in their own innovative ideas and learn from the experience of others to enhance their future projects.

Condensation and Promotion of Achievements Practice. The purpose of the condensation and promotion of achievements practice is to improve the ability of writing papers, intellectual property rights application, public speaking and academic communication.

Specific implementation: Summarize and refine the results of the previous project practice, write papers or declare intellectual property rights. Students can choose to attend relevant academic conferences for learning and exchange. Summarize the experience of participating in the "four-steps" activities and guide other students to carry out project practice activities. There is no limitation on the venue for the whole practice process.

4 Implementation of the "Four-Steps" Open Project Practice

4.1 Environment Guarantee

In the process of "four-steps" project practice, we need to mobilize, organize and manage, and provide a good practice environment. It mainly includes the hardware environment and software environment [7]. The hardware environment is that we provide a place for all students to practice independently, the necessary common equipment and instruments, etc. The software environment includes software learning materials, design and development systems and application tools needed for practice. In addition to this, we need all mentors and enthusiastic seniors to be available as assistant mentors.

4.2 Specific Implementation

These four stages have a clear progression from easy to difficult, and from simple to complex, starting with validation projects and moving towards research projects. The stages are not only designed in a logical sequence but are also highly correlated, providing students with a complementary learning experience to the training plan, thereby promoting the integration of knowledge and the comprehensive development of their abilities.

By completing these four stages, students can not only acquire practical skills and knowledge in engineering but also develop problem-solving abilities, creativity, and critical thinking skills. Furthermore, they will gain valuable experience in project management, teamwork, and communication.

4.3 Implementation Cases

Take the "Panda" project practice team as an example, they participated in some small practice activities in the "Blue Space" innovation base practice, and applied for a school level science and technology innovation project to study website design with the theme of "Web-based campus information publishing platform". On the basis of this project, they applied for the national project: "AI-based global tourism detection and dispatching system". After completing the project practice, they entered the third level of project practice. They improved the results of the project and completed works such as "Impression of West Lake" and "Meet West Lake". By participating in the provincial and national university discipline competitions, they achieved the excellent results of second prize in national and provincial competitions. Finally, these works and application techniques are condensed into papers and software publications. The project practice flow of the team is shown in Fig. 3. The main line of the whole team is the "Territorial Tourism Management System", around which the four stages of the "four-steps" process are implemented to achieve a high degree of integration between theory and practice [8].

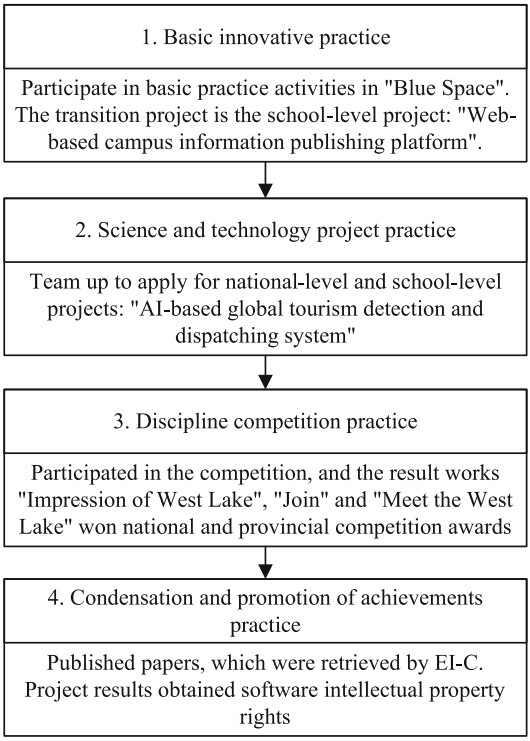

Fig. 3. The case of "four-steps".

5 The Effectiveness of "Four-Steps" Open Project Practice Teaching Activities for Talent Cultivation

5.1 Practice Achievements of Students in Project Practice Teaching

Students have made rich achievements in scientific and technological innovation, discipline competitions and condensation and promotion of achievements. With the establishment of "Blue Space", teachers and students on multiple campuses can communicate better. The open project practice teaching activity has more full vitality and has achieved remarkable results [9].

From 2015 until 2021, 253 practice projects have been initiated by students who have participated in practice activities in "Blue Space", including 26 national-level projects, 56 provincial-level projects, 171 university-level projects, and more than 10 teacher research projects and independent design projects. Students won 319 awards in discipline competitions, including 63 national-level awards, 149 provincial-level awards and 107 university-level awards. They have written and published 87 academic papers, applied for and obtained 15 intellectual property rights of invention patents and 20 intellectual property rights of software works.

Most of the papers written by them have been exchanged in many international and domestic academic conferences and domestic academic journals. There are 4 papers which were evaluated as excellent papers, and 29 papers have been retrieved by SCI and EI.

5.2 High-Quality Personnel Training, Great Benefits and Influence

In terms of breadth, more than 1,000 students of science and engineering majors of the university participated in these teaching activities, which have remarkable results and wide a range of benefits.

In terms of depth, the personal ability of the students who participated in the practice has been greatly improved. 13 students won the "Baosteel Scholarship", "The Excellent Students of ZUST" and the highest award in ZUST named "Outstanding Student", which show the students' elegance. Some postgraduate students who have participated in the whole process of project practice teaching have obtained many achievements. And they have obvious advantages in practical ability, design ability, cooperation ability.

5.3 The Achievement of Symbolic Teaching Reform and Obvious Demonstrative Effect

In addition to writing the research monograph "Research and Exploration on 'Four-Steps' Open Practical Teaching Activities", the research group has also written 25 research papers related to this achievement and won 3 achievement awards at the department level or above. We has established the "'four-steps' project teaching activity results website". The practice results have been promoted and exchanged in the domestic and overseas, and have been highly recognized by peers [10].

6 Conclusion

The "four-steps" teaching model is proposed the first time for the cultivation of application-oriented talents in colleges and universities, which is based on the teaching of planned courses and the design of practical projects in a progressive manner, and these practical projects further feed the professional knowledge. The research and practice of this teaching model has been supported by the Ministry of Education's "Research on Open Practical Teaching in Engineering Education Environment" and other teaching research and reform projects. Through the design, exploration and practice for more than 10 years, the traditional teacher-centered teaching mode has been changed and the student-centered teaching idea has been deeply spread. The "four-steps" project teaching mode provides a novel and effective pathway for the cultivation of engineering application-oriented talents, and is also an important initiative to guide students' scientific and technological innovation and strengthen their practical ability, whose theory and practice are of great significance to high-level application-oriented undergraduate education and teaching reform [11].

Acknowledgment. Thank you for the support of the general planning fund for Humanities and Social Sciences Research of the Ministry of Education (17yja880004) in 2017 and the key project of Teaching Research and Reform of Zhejiang University of Science and Technology "Construction and Practice of a New Generation of Information Technology Innovation Talent Training System based on the College of Artificial Intelligence Industry" (2022-jg15) in 2022.

References

1. Wu, A., Hou, Y., Yang, Q., Hao, J.: Accelerating development and construction of emerging engineering, taking initiative to adapt to and lead the new economy. Res. High. Educ. Eng. (01), 1–9 (2017)
2. Zhang, Y., Fang, H.: From living space to the cultural space: how to implement the modern university academy system. J. High. Educ. **37**(03), 56–61 (2016)
3. Jiang, X., Yu, J., Song, S., Wu, H., Cheng, X.: Innovation and practice on student management and educational pattern under collegiate system - a case study on zust anji campus. J. Zhejiang Univ. Sci. Technol. **28**(02), 153–157+171 (2016)
4. Han, J., Cen, G.: A new environment construction of open project instruction for students' self-management. Res. Explor. Lab. **30**(04), 215–218 (2014)
5. Cen, G., Lin, X., Mo, Y.: Exploration and practice of open-ended practical teaching innovation by 'four steps' - using application-oriented talent cultivation mode of German for reference. J. Zhejiang Univ. Sci. Technol. **27**(05)
6. Cen, G., Wu, S., Jiang, X., Lv, B., Zhu, R., Ding, Z.: Research and exploration on construction management of project practice innovation base based on 'four steps'. Res. Explor. Lab. **40**(07), 244–248 (2021)
7. Chen, J., Zhang, Y., Wei, Y., Hu, J.: Discrimination of the contextual features of top performers in scientific literacy using a machine learning approach. Res. Sci. Educ. **51**(01), 129–158 (2021)
8. Cen, G., Yu, J.: A new environment construction of open project instruction for students' self-management. Res. Explor. Lab. **30**(02), 158–160 (2011)
9. Cen, G.: Teaching research and exploration of open-ended 'four-step' project practice teaching mode in innovative and application-oriented talents training. J. Zhejiang Univ. Sci. Technol. **32**(05), 413–419 (2020)
10. Jiang, X., Zhu, R., Cen, G., Song, S., Li, X., Wang, S.: Design of student affairs management system of 'plam academy' smart campus. J. Zhejiang Univ. Sci. Technol. **32**(02), 139–144 (2020)
11. Cen, G., Lin, X.: Research and exploration of "four steps" open practical teaching activities. China Water&Power Press (2016)