

Research on the Construction of Teaching System of Engineering Major in Open Education—Taking the Undergraduate Major in Civil Engineering (Construction Engineering) as an Example

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Abstract: *The full-time engineering major has a relatively mature teaching system, but the open education engineering major is not, especially in the practical teaching process. The article analyzes the overall teaching system and research status of open education both domestically and internationally, proposes the principles and basis for constructing a teaching system for engineering majors in open education. Then, taking the undergraduate major of civil engineering as an example, the characteristics and construction requirements of each element of the open education engineering teaching system were analyzed from four aspects. These four aspects are: closely combining industry needs to develop teaching objectives and design teaching content, designing replicable teaching methods that closely align with learning situations; deepening the construction of online resources and practical platforms to ensure full coverage of teaching support; systematically analyzing and improve teaching evaluation standards, and on the basis of the above, establishing a corrective feedback loop mechanism for the teaching system to improve teaching quality.*

Keywords: *Open Education, Engineering Major, Teaching System Construction, Civil Engineering Undergraduate Major*

1. Introduction

Under the strong trend of deepening the "new engineering construction" in universities, how to further improve the quality of engineering education and teaching in open education is a problem of our research and exploration. It is obviously not feasible to completely follow the educational and teaching ideas of non engineering majors, because the practical teaching process of engineering majors not available in non engineering majors, and practical teaching is an indispensable and important in engineering major teaching,. There is a fundamental difference between the teaching staff and teaching platform required for practical teaching and theoretical teaching. At the same time, the aspect needs to be reasonably connected with the theoretical aspect. The teaching system of open education engineering majors needs to comprehensively consider and highlight the practical teaching aspect to improve students' professional practical abilities.

2. Open education teaching system and its research status

Open education is a form of life-long education, which is extended from the traditional full-time higher education. At present, open education is based on the diploma education of adults, open has broken many restrictions in traditional education, such as fixed study time, place and curriculum, liberated study from classroom restrictions. Learners can access online courses, textbooks and learning resources anytime and anywhere, and learn at their own pace and in accordance with their interests.

Compared with the open education in Britain, America , the open education in China shares the teaching ideas, but there is still a gap in teaching quality, in the teaching system and its implementation the implementation of teaching ideas need to improve and improve. China does not attach enough importance to open education, lacks investment, and lacks systematic management and implementation; Unclear goals and weak guidance; The teaching content does not match professional development and professional positions; Professional teachers lack practical experience in engineering; Lack of practical platforms; The teaching evaluation is not scientific. There is currently a wealth of research on the

teaching system of engineering both domestically and internationally, but there is a lack of clear standards and theoretical framework for the teaching system. The constituent elements of the teaching system are not consistent and there is no authoritative conclusion.

There is relatively more research on the education of engineering majors in full-time universities in China. There are many research results on the teaching system of engineering, especially the practical teaching system of engineering, such as the civil engineering major, which has constructed a practical teaching operation mechanism for school enterprise cooperation resource sharing, mutual benefit, and a practical teaching system for industry education integration and collaborative education [1]; Summary of the Research on the Practice System of Universities from 1998 to 2018: The research on the guarantee and evaluation of practical teaching mainly focuses on the respective professional fields within the school, lacking universal school enterprise cooperation, cross disciplinary joint guarantee and evaluation mechanism research[2].

Overall, China's research on the engineering teaching system either does not conform to the characteristics of open education or does not meet the requirements of new engineering construction, and there are many related studies that focus on the teaching system or a certain aspect of research and propose opinions, without forming sustainable development and finding methods to promote circulation.

3. Principles of construction of teaching system of engineering specialty in open education

3.1 Student-oriented, innovative practice teaching

The concept of open education is to provide more people with equal and universal learning opportunities. The situation of students in open universities in China is different from that of full-time universities. Students in full-time universities have similar ages and learning foundations, while students in open universities have varying ages and knowledge foundations. Building a teaching system must consider students' differences, and teaching methods must implement "individualized teaching". From another perspective, open education in China has relaxed admission conditions and equally strict graduation conditions. Students with good foundations at a young age and those with poor foundations at an older age have the same graduation review. Therefore, we need to do more comprehensive and detailed teaching support services, focusing on individual learning support services, including those for people with disabilities.

The aim of engineering specialty is to train advanced technical talents in corresponding engineering fields, pay attention to the combination of theory and practice, pay attention to train the engineering practice ability of students, the comprehensive practice teaching of engineering in open education must be combined with the development of the industry and go deep into enterprises. Engineering projects are often multi-disciplinary integration, practice teaching can not be separated from cross-disciplinary integration and cooperation. The development of engineering technology can not be separated from the cultivation of innovative consciousness and thinking in engineering practice. Therefore, engineering practice teaching is an important part of engineering teaching system.

3.2 Integrate credit mutual recognition with the national full-time higher education system

Drawing on the experience of open education in the UK, the United States, and other countries, it is foreseeable that China's open education and full-time universities will gradually achieve credit mutual recognition. The teaching system of open education should be integrated with the education system of full-time universities. The key now is to improve the quality of education. Only when the teaching quality of open education in the same curriculum reaches or even exceeds the teaching quality of full-time universities can credit mutual recognition be possible. Of course, this requires a national level policy that recognizes that the credits earned by full-time university students in open education are equivalent to the credits earned in the same course at the university. Otherwise, credit exchange would be meaningless, and I believe this is an inevitable trend. Theoretical courses in engineering are easier to achieve credit mutual recognition.

3.3 Future-oriented

With the rapid development of society, the future era is the era of the Internet and big data, open education must adapt to the development of the times, face the future of the Internet and big data,

reshape the concept of digital education resource construction, deepen the service system of digital educational resources and promote the deep integration of digital educational resources and teaching applications.

4. The basis for constructing the teaching system of engineering major in open education

There is no unified standard for the allocation of various elements in the teaching system of engineering majors at the National Open University and its affiliated institutions and teaching points. The current concept of new engineering construction is widely accepted and has been explored for many years. Last year, the general standard for the quality of new engineering talent cultivation in China, the "Engineering Education Certification Standard," was released, laying the foundation for certification in engineering education in China.

4.1 According to the construction requirements of new engineering courses and the certification standards of engineering education

The new engineering concepts can be summarized as: innovation, comprehensiveness, openness, and leadership^[3]. The main goal of the construction of new engineering disciplines can be expressed as: "Actively layout, set up, and build engineering disciplines and majors that serve national strategies, meet industrial needs, and face future development, cultivating and cultivating a group of outstanding engineering and technology talents with innovation and entrepreneurship capabilities, cross-border integration capabilities, and high quality" ^[4]. Whether it is the construction of new engineering courses or other educational and teaching reforms, the achievements of engineering education are basically in a self-evaluation state, and there is no unified certification standard. Based on this, on July 15, 2022, China released the first group standard in the field of talent cultivation quality evaluation in higher education, the "Engineering Education Certification Standard" (T/CEEAA001-2022), which was included in the framework of the national standard system.

The education and teaching parts of the General Standards for Engineering Education Certification in China include: being able to correctly "use" modern tools that are "appropriate" for complex engineering problem characteristics; Being able to apply the basic principles of mathematics, natural sciences, engineering sciences, and related disciplines to identify, express, research literature, and analyze ^[5], should become an important basis for constructing the teaching system of engineering majors.

In short, the construction of an engineering teaching system should be oriented towards new engineering subjects, with the engineering education certification standard (T/CEEAA001-2022) as the basic requirement, and implement the concept of "innovation, comprehensiveness, openness, and leadership".

4.2 According to the characteristics of practical teaching of engineering major in open education

Open education, in a broad sense, is the right of everyone to receive education for life. It means not only the opening to the object of education, but also the opening of educational concept, educational resources and educational process. In the process of high-quality development of open universities, how to realize the high-quality development of personnel training needs to be analyzed one by one from the five elements of personnel training, that is, the training goal, the training subject, the training content, the training process and the evaluation of the training effect, how to develop and form joint forces to jointly promote the high-quality development of personnel training in open universities ^[6]. The practical teaching of engineering specialty is an important part of the teaching system, the practice teaching has the distinct goal, the situation and field of engineering practice, the diversity of practice teaching platform and the complexity of practice teaching evaluation. The teaching of engineering majors aims to achieve the cultivation of ideological and moral character and engineering practical ability. There are no two identical construction projects on the Earth. The construction period is long. The construction process is influenced by the site environment (material, machinery, site), climate, personnel and so on. Unlike a factory producing a product, which can accurately find out the problem and the reason, the object of practical teaching is different students, the effect of practical teaching is affected by many factors, which factors are difficult to accurately locate, the evaluation from the explicit teaching and learning behavior and the achievement can not reflect the effect of practical teaching accurately and comprehensively.

5. Construction of engineering teaching system in open education

The core idea of open education is to provide flexible, autonomous and personalized learning experience to meet the needs and interests of different learners, and to cultivate learners' creativity, critical thinking and problem-solving ability, promote the sustainability and inclusiveness of learning. Whether students, professionals, or other self learners, they can acquire the knowledge and skills they need through open education platforms to achieve personal and professional development.

The professional teaching system refers to a systematic design and optimization of teaching methods and content system. It includes teaching objectives, teaching content, teaching methods, teaching evaluation, and the coordination and cooperation of various links such as teachers, students, and teaching resources. The same applies to the teaching system of open education engineering majors. The construction of various elements of the system mainly includes four aspects: setting teaching objectives and designing teaching content, teaching methods, teaching guarantees, and teaching evaluation. The following will analyze each aspect one by one.

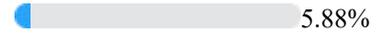
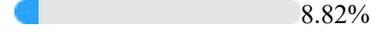
5.1 To formulate teaching objectives and design teaching contents in close connection with the needs of the industry

The core element of the professional teaching system is the teaching objectives. The National Open University has formulated detailed teaching objectives for each major, which have been certified through long-term practice.

The content of teaching refers to the sum of knowledge, skill and behavior experience that the learner needs to study systematically in order to realize the teaching goal. The design of teaching content is based on the general teaching objective and aims at defining the scope and depth of teaching content and revealing the relationship between the various components of learning content, so as to ensure the content validity of teaching optimization, it is the most critical link of teaching design, is the main part of teaching design.

The design of teaching content for engineering majors should closely align with industry needs and refer to textbooks. It has strong practicality, and the teaching design for the practical part is particularly important.

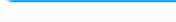
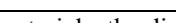
Table 1 The questionnaire feedback enterprise category and proportion

Enterprise Category	subtotal	proportion
Engineering (housing, bridge, municipal, etc.) construction	20	 58.82%
Engineering (housing, bridge, municipal, etc.) design	2	 5.88%
Engineering cost consulting (pre settlement, audit, etc.)	3	 8.82%
Engineering management consulting (bidding agency, construction agency, supervision, project management, etc.)	2	 5.88%
other	7	 20.59%

Civil engineering related enterprises including engineering design, construction, management, consulting, testing and monitoring, semi-finished construction products production, etc. , we have received 34 enterprises' effective feedback, among which 20 enterprises of engineering construction category account for 58.82% (as shown in Table 1) , in fact, civil engineering students in the engineering construction enterprise employment rate is the highest, and the feedback of the enterprise is basically the same. There are large and small feedback enterprises, with state-owned and private enterprises accounting for the majority. According to survey data, out of the seven parameters for talent evaluation by enterprises, the following four parameters were selected, namely "hardworking spirit", "communication skills and interpersonal communication ability", "innovation ability and team cooperation spirit", and "registered professional qualification certificate". The highest number of enterprises were 28, 27, 25, and 22, accounting for 82.35%, 79.41%, 73.53%, and 64.71%, respectively (as shown in Table 2). Therefore, when designing teaching content, it is important to incorporate the cultivation of the spirit of hard work, communication and communication skills, innovation, and

cooperation as important components. This is usually the content of ideological and political education in the curriculum. Ideological and moral education should be integrated throughout the entire teaching process, naturally "implanted" in teaching design and implementation, and preaching that is detached from the time and space environment may be counterproductive.

Table 2 Questionnaire feedback enterprises on the selection of talent parameters

Personnel parameters	Subtotal	Proportion
educational background	20	 58.82%
Registered practice qualification	22	 64.71%
Skill level	21	 61.76%
occupational requirements	19	 55.88%
Communication skills and interpersonal skills	27	 79.41%
Hardworking spirit	28	 82.35%
Innovation ability and teamwork spirit	25	 73.53%

Besides the traditional written carrier such as teaching materials, the digitization of teaching content has become the main form, digital carrier should be rich and varied, easy for students to accept and absorb, such as Word document, PPT document, JPG, MP4, etc. .

Open education takes distance education as its main form, courses are divided into compulsory courses and elective courses, practical courses have different directions and different contents, and the courses related to majors in elective courses are very extensive, as long as the credit requirements are met, students can choose any of the courses to study. Taking the comprehensive practice of civil engineering as an example, professional teachers provide practical teaching items, qualification conditions for selecting courses and professional teaching objectives, and list them for students to choose, for example, if a graduate student chooses a concrete structure design, a steel structure design, or a hybrid structure design, he or she can also choose to do a graduation thesis, among them the graduation thesis also has the structure theory, the construction technology, the project management, the cost consultation and so on many aspects (as shown in Table 3) .

Table 3 List of the comprehensive practical graduation design courses for civil engineering majors

Module	Course name	Credit	Nature	Practice qualification conditions	Practice time	Practical projects	Direction
Comprehensive practice	Graduation project (Civil Engineering)	8	Compulsory	Complete all courses specified in the teaching plan (i.e. specified credits)	Not less than 10 weeks	Structure Design	Design of concrete structures
							Design Of Steel Structure
							Hybrid structure design
						Graduation thesis	Structural theory
							Construction Technology
							engineering management
						other	Engineering measurement and pricing
	Preparation of engineering construction organization design documents						

5.2 Designing replicable teaching methods in close connection with the learning situation

The obvious feature of open education teaching is that students mainly learn independently, and

teachers provide learning guidance and assistance. Generally, the number of hours for teacher guidance and assistance in learning is approximately one-third of the total class hours. Guidance is mostly conducted online in the form of live or recorded broadcasts. Live classes not only need to allow students to interact during guidance, but also must ensure that students can replay at any time and repeatedly. Obviously, this is a typical remote education with the advantages of not being limited by time and space. Teachers usually first solve common problems, and then consider the needs of individual students. However, professional courses have a relatively small number of students. Teachers should fully understand the different starting points and difficulties in autonomous learning for different students in different learning environments, understand the diversity of teaching objects and their learning environments, and be more responsible for solving the problem of how to learn. Students can use various channels such as the National Open University online platform, QQ, WeChat, and phone to raise questions to their guidance teachers during their autonomous learning process. The guidance teachers can answer questions in a timely manner, or conduct real-time interactive analysis to solve problems.

The practical teaching of open education engineering majors cannot entirely adopt network remote teaching, and the key points of "new engineering" construction, such as innovation and entrepreneurship ability and cross-border integration ability, should be implemented and reflected in the comprehensive practical stage. The comprehensive practice of civil engineering adopts the "school professional guidance teacher+on-site practice guidance master" model, which is a "double mentor system". The professional guidance teacher is mainly a guide, and the on-site guidance master is mainly a hands-on guidance and coordination. The innovation and entrepreneurship awareness and ability are consolidated and deepened in the practical stage. Among the teaching methods adopted by the supervisor, "problem oriented" and "project teaching method" are the most common and effective methods.

5.3 Further develop online resources and practice platforms to provide full coverage for teaching and learning

The construction of practice platform and the construction of online course resources, the teaching guarantee of open education includes hardware guarantee and software guarantee, the field and equipment of practice teaching and the teachers with rich professional practice experience are the indispensable guarantee to ensure the development of teaching. Taking the civil engineering major as an example, the hardware support for practical teaching in civil engineering includes professional computer rooms and their equipment, professional laboratories and their equipment, comprehensive practice platforms, etc. It is not easy for schools to have a stable comprehensive practice platform. High quality assurance for the development of comprehensive practice must be ensured, and the construction of practice platforms must be systematically expanded to provide more practical content for students to choose from, and improve the management system for practical teaching.

5.4 Systematic analysis and improvement of teaching evaluation criteria

The evaluation of Teachers' teaching is difficult to be refined. The general evaluation indexes include teaching thoughts, teaching abilities and strategies, teaching effects and so on. It is extremely important to highlight the evaluation of teachers' teaching process and scientifically formulate evaluation rules. The teaching process of open education teachers mainly refers to the process of remote network teaching. National and local open universities have established a relatively mature evaluation system for the process of remote network teaching. The usual practice is that the daily teaching quality supervision and management department analyzes problems and provides timely feedback to teachers through remote listening and evaluation classes. The teaching process of engineering majors cannot be copied from the above practices. Teaching evaluation should prioritize practical teaching, and practical teaching must be combined online and offline, with a focus on online and offline teaching. To achieve ideal practical results, the evaluation of the practical process should not only stay on the paper results of practice, nor should there be requirements for the teaching process of practice without supervision or process evaluation. The process of practical teaching can be decomposed into teaching design, teaching organization, teaching summary, and one-on-one individual guidance and assistance for each centralized guidance or Q&A session. The school's teaching quality supervision department conducts real-time on-site inspections of the practical teaching process and promptly communicates and provides feedback to the practical guidance teachers. Due to the diversity of practical projects, the methods and methods of practical teaching process in civil engineering majors

vary greatly, and the practical environment varies greatly, We should start from the basics, refine indicators by category, and continuously optimize them in practice.

In addition to the evaluation of teachers by schools, the evaluation of teachers by students and third parties is also an integral part of teacher evaluation, such as the evaluation of teachers by civil engineering cooperative enterprises.

The evaluation of Students' learning effect is based on their behavior and achievement, and the evaluation of learning behavior includes self-evaluation and other evaluation, it includes the number of times of attending class, the time of attending class, the number of times of self-study on the Internet, the time of self-study, the number of effective interaction, the number of times of completing homework and scores after class, and other learning behavior data, the self-evaluation and the other-evaluation echo and support each other. The data of the other-evaluation is the basic basis of the self-evaluation, can reflect the level of students' mastery of knowledge. There is another important part in the evaluation of the learning effect of engineering students, that is, the evaluation of the practice links, the practice part of his evaluation includes practice task, practice preparation, practice attendance, the completion of the practice task, on-site master evaluation and other multivariate data.

In the teaching process, the prohibited behavior or phenomenon, such as violating the law of education and teaching, should be used as the evaluation of the bottom line of the teaching system, the negative list includes acts of violating teachers' ethics, teachers forgetting to attend classes, cheating, and students' complaints.

6. Create the mechanism of corrective feedback in teaching system

The construction of each element of the teaching system must have a process from scratch, from poor to good, from low quality to high quality, it needs to be corrected and improved in the process of teaching system construction. Teaching system is a whole, the construction of each element must develop in harmony, any one factor, a link or even a detail of the short board may cause the decline of teaching results, has an obvious“Bucket effect”. The evaluation of teaching results must follow the principle of objective science, establish a multi-evaluation system of teaching results, evaluation elements of information, data, try to reduce artificial interference.

The evaluation of the teaching system includes the evaluation of the elements of the system and the degree of coordination among the elements, it can be evaluated from three aspects: professional teachers and teaching quality, teaching guarantee and students' learning effect. Teaching quality mainly refers to the quality of teaching process, which is essentially the evaluation of teachers and teaching security. Education and teaching are different from factory production. Factory production has fixed assembly lines, strict error limits, and precise product standards, while the object of education and teaching is people. Through education and teaching, people's knowledge level, ability level, and overall quality are improved. There is no precise standard, but there is a clear direction. Education and teaching evaluation must always set standards in the direction of cultivating students' correct worldview and outlook on life, learning technology, and knowledge, that is, positive standards, as well as bottom line standards such as inaction, intentional or unintentional instillation of negative ideas, and ignorance. Evaluation should not rely on a small amount of data, but need big data as a basis.

The evaluation of the teaching system and the revision and improvement of the teaching system should form a sustainable feedback cycle. The detailed list of evaluation should give feedback to those who are being evaluated, at the same time, it puts forward suggestions and suggestions on the problems in the actual operation of the evaluation standards, which in turn feed back to the evaluators, forming a corrective feedback cycle (as shown in Figure 1) , so as to realize the continuous improvement of the teaching quality.

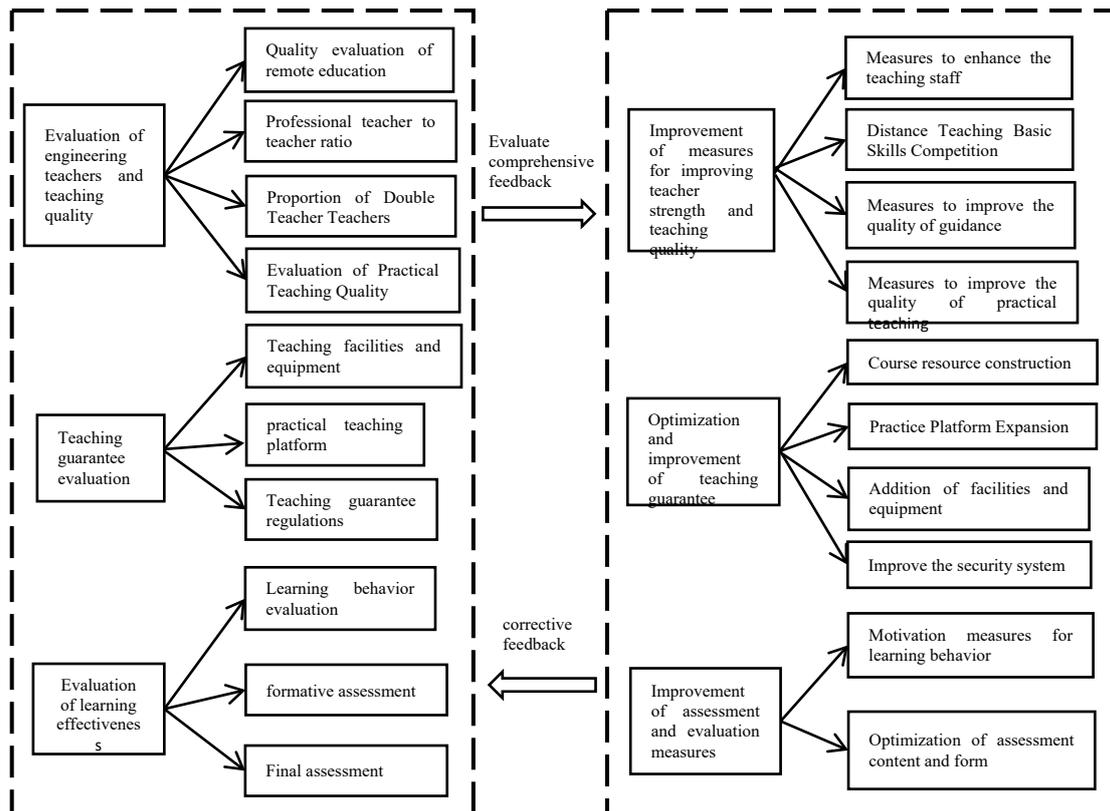


Figure 1 Corrective Feedback Loop of Engineering Teaching System

The corrective feedback cycle needs to be continuously guided and maintained in order to develop and promote healthily. The practice link of engineering teaching system in open education is the key, it is very important that the quality of the coordination among the factors in the practice teaching can be reflected by the evaluation, through the evaluation, correction, implementation, re-evaluation, re-correction of such a spiraling quality improvement process to improve the teaching system. Because the location, structure and environment of the project are different, the practice of civil engineering is more challenging than that of other engineering majors.

7. Conclusion

The teaching system of open education engineering majors should fully absorb successful experiences both domestically and internationally, eliminate falsehood and preserve truth, and improve the development mechanism of various elements of the teaching system from coarse to fine. We should face the future, innovate practical teaching, and establish credit mutual recognition. Based on the requirements of new engineering construction, engineering education certification standards, and the characteristics of open education, we should start from setting teaching objectives, optimizing teaching content design, innovating teaching methods, improving teaching guarantees, and conducting diversified data based teaching evaluations. We should construct an engineering professional teaching system, create a corrective feedback loop mechanism, and promote a virtuous cycle of the teaching system, Improve the quality of engineering education and teaching in open education.

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