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Research on the Deep Integration Mode of Theoretical Teaching and Practical Training of Road and Bridge Majors under the Background of Engineering Education Professional Certification

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Abstract

The deepening reform of engineering education and the building of a strong country in engineering education in the new era have put forward new requirements for the cultivation of compound application-oriented talents. On the basis of analyzing the current problems in the teaching mode of China's road and bridge majors, a new teaching mode that deeply integrates the theoretical teaching and "AllTrue" engineering field training of road bridge and river crossing engineering for engineering professional certification was explored. This in-depth integration teaching mode was applied to the major of road, bridge and river crossing engineering of Inner Mongolia Agricultural University, and the training activities were carried out on the infrastructure construction projects of Hai Liu Tu practice base. The practice has proved that this brand-new teaching mode with deep integration of theory and practice has effectively improved the engineering practice ability of students majoring in road bridge and river crossing engineering. It also enhanced the employment competitiveness of graduates and opened up a new situation for graduates' employment.

Keywords

Deep Integration of Theory and Practical Training, "AllTrue" Engineering Field Training, Engineering Education, Construction of Training Base

1. Introduction

Engineering education professional certification refers to the specialized certifi-

cation implemented by professional certification institutions for the engineering professional education offered by higher education institutions, the aim of which is to confirm that engineering graduates meet the established quality standards recognized by the industry (Association, 2022; Xu, Zhao, Zhou, & Li, 2020). With the extensive advancement of engineering education professional accreditation, the China has advanced from the substantial equivalence stage of version 1.0 of "entering the member states of the Washington Accord" to the innovation leader stage of version 2.0 of participating in international governance and contributing to the Chinese program (Wang, 2020). Engineering education in China carries the new responsibility and mission of providing talent and intellectual support for the industrial development of China and the world (Liu, 2019).

At the same time, the proposal of the development strategy of "powering the country with transportation" and the "One Belt, One Road" strategy has put forward clear and specific requirements for the training of road, bridge and river crossing engineering majors in domestic colleges and universities, that is, to cultivate high-level and application-oriented talents with solid professional theoretical basic knowledge, strong application ability and high comprehensive quality, and the cultivation of innovative and practical ability is the top priority. Thus, this development requirement puts forward more comprehensive, higher quality and more international requirements for the talent training of engineering majors in Chinese universities.

Under this background, how to take the opportunity of engineering education certification to promote the reform of the teaching mode of the road and bridge major, strengthen the in-depth integration of theoretical teaching and practical training, and improve the students' comprehensive practical application ability has become one of the urgent problems to be solved in the road and bridge major (Dong et al., 2020). Many educators, experts and scholars in this field have made positive reforms and explorations, and the reform has achieved great results. For example, Huang, Huang, & Xu (2014) re-optimized the theoretical curriculum system and practical teaching system, modularize, integrate and couple theoretical courses and practical courses, so that theory and practice can be seamlessly connected and applied. Zhao (2016) suggested to establish a school enterprise cooperation mechanism and to build a teaching team based on the principle of complementary advantages and mutual benefit between universities and enterprises. Sheng (2011) did research on the application of virtual simulation technology to supplement and strengthen the practical teaching link of road bridge and river crossing project.

Up to now, the reform of the talent training model for road and bridge majors mainly focus on the optimization of curriculum system modules, the cultivation of young teachers' abilities, the cooperation between universities and enterprises, virtual simulation technology, and the addition of college credits (Zhang et al., 2020). There are few studies on the deep integration mode of theoretical teaching and practical training.

On the basis of analyzing the current problems in the teaching mode of China's road and bridge majors, a new teaching mode that deeply integrates the theoretical teaching and "AllTrue" engineering field training of road bridge and river crossing engineering for engineering professional certification is explored. This in-depth integration teaching mode was applied to the major of road, bridge and river crossing engineering of Inner Mongolia Agricultural University, and the training activities are carried out on the infrastructure construction projects of Hai Liu Tu practice base. Through the comprehensive practical operation of the scaled model of road and bridge engineering in the school training base, the theoretical teaching, "AllTrue" project visits, in-class practice and other were organically integrated together.

2. Problems Existing in the Current Situation of the Teaching Mode of Road and Bridge Majors

As we all know, the major of road bridge and river crossing engineering is an applied discipline with a lot of the professional courses, whereas the practice teaching is also an important part of the whole teaching system and a key link to cultivate the engineering ability and innovation ability of students in this major. Therefore, it is very important to integrate theory and practice teaching in professional teaching. But, according to extensive investigation and research on employment of road and bridge and river crossing engineering majors and follow-up investigation on graduates, it was found that there were many problems in the teaching mode of road and bridge majors, which were manifested by poor integration of theory and practice teaching, incomplete practice teaching system, and weak synergy of education path, etc. And these problems are common in the undergraduate colleges and universities offering this major nationwide, which have seriously restricted the training quality of graduates. These problems are summarized as follows.

2.1. The Practical Teaching System Is Fragmented

There are many professional courses involved in road, bridge and river crossing engineering major, so, the theoretical knowledge is relatively more (Xiang et al., 2022). Most of professional teachers focus on the instillation of knowledge points and while neglect the combination of theory and practice. Also, many colleges and universities have fixed the training location in the classroom, forming a theoretical mechanical classroom teaching mode. This teaching mode enables students to only learn basic and discrete theoretical knowledge, and cannot grasp the knowledge as a whole, let alone apply the knowledge flexibly to practical engineering.

2.2. The Classroom Teaching Focuses on Theory

The existing practical teaching system ignores the integrity, continuity and coupling of the practical teaching system of road and bridge majors, and the

practical teaching activities between courses are not well integrated. At the same time, there is a lack of organic integration of the practice content, and the practice content is fragmented, which result in students only knowing one and not the other, and not understanding the purpose and application of each course. Also, the practice is arranged in a relatively concentrated time period after the end of each course, which contradicts the continuous and long cycle of road and bridge engineering projects. Since students can only participate in part of the construction process, the desired effect cannot be achieved.

2.3. Students Lack the Ability of Autonomous Learning and Lack of Innovative Training

For a long time, the teaching method of road bridge and river crossing engineering has been centered on teachers, so, it is not conducive to the improvement of students' autonomous learning ability and the stimulation of innovation ability. Students are just passively absorbed what the teachers taught them in the classroom. They do not think actively, and cannot form a clear context for the overall situation. They are often confused of exercises after class, and it is impossible to cultivate innovative thinking ability.

2.4. It Is Difficult to Establish an Internship Base, and It Is Difficult to Arrange Post-Job Internships

The location of road bridges and river crossing projects is uncertain, and this construction feature makes students only participate in a small section of the project construction during the practice process, failing to meet the requirements of combining theory and practice. Also, the weak construction of off-campus practice bases has a serious restrictive effect on the development of practical teaching of road bridge and river crossing engineering.

3. Deep Integration Method of Theoretical Teaching and Practical Training

According to extensive interviews with employers of road and bridge and river crossing engineering majors and follow-up investigation on graduates, and also the deep analysis of the problems existed in the teaching process, we put forward the deep integration method of theoretical teaching and practical training, in which a new system of "AllTrue" practical teaching were constructed and the theory and practice teaching integration mode were built.

3.1. Construct a New System of "All-True" Practical Teaching

1) Explore the new model of "AllTrue" engineering simulation practice teaching.

Through the construction of subgrade pavements, bridges, culverts and other scaled engineering simulation structures, and the additional links such as road survey and design, road engineering material composition design, engineering

structure design, highway construction organization and budget, engineering quality acceptance and evaluation, etc, a new system of "AllTrue" practical teaching mode was constructed. It integrated indoor experiments, cognition practice, and professional practice together. All these activities were implemented in two years (third and fourth grades) continuously. Some of the student training scenarios are shown in Figure 1.

2) Organically integrate practical teaching content to solve the fragmentation problem of decentralized practical teaching.

By integrating practical teaching links such as engineering geology practice, survey practice, survey practice, roadbed and pavement practice, and bridge engineering practice, the comprehensive "AllTrue" engineering on-site simulation practice teaching is carried out in the practice teaching base, which took up to 12 weeks. The practice process covers the whole process of surveying, design, construction, and testing, and covers the practical teaching links of all professional courses, so that students' originally relatively fragmented professional knowledge becomes systematic. The students' comprehensive practical application ability has been significantly improved at the same time. The "AllTrue" project on-site training development process is shown in Figure 2.

3.2. Build a Teaching Model That Integrates Theory and Practice in Depth

1) Adopt the modular theory teaching method to solve the problem of integration of theory and practice.

(a) (b)

(c) (d)

Figure 1. Practice training site. (a) Binding main beam reinforcement; (b) Prefab site construction; (c) Field lectures by experts; (d) Field line selection & measurement.

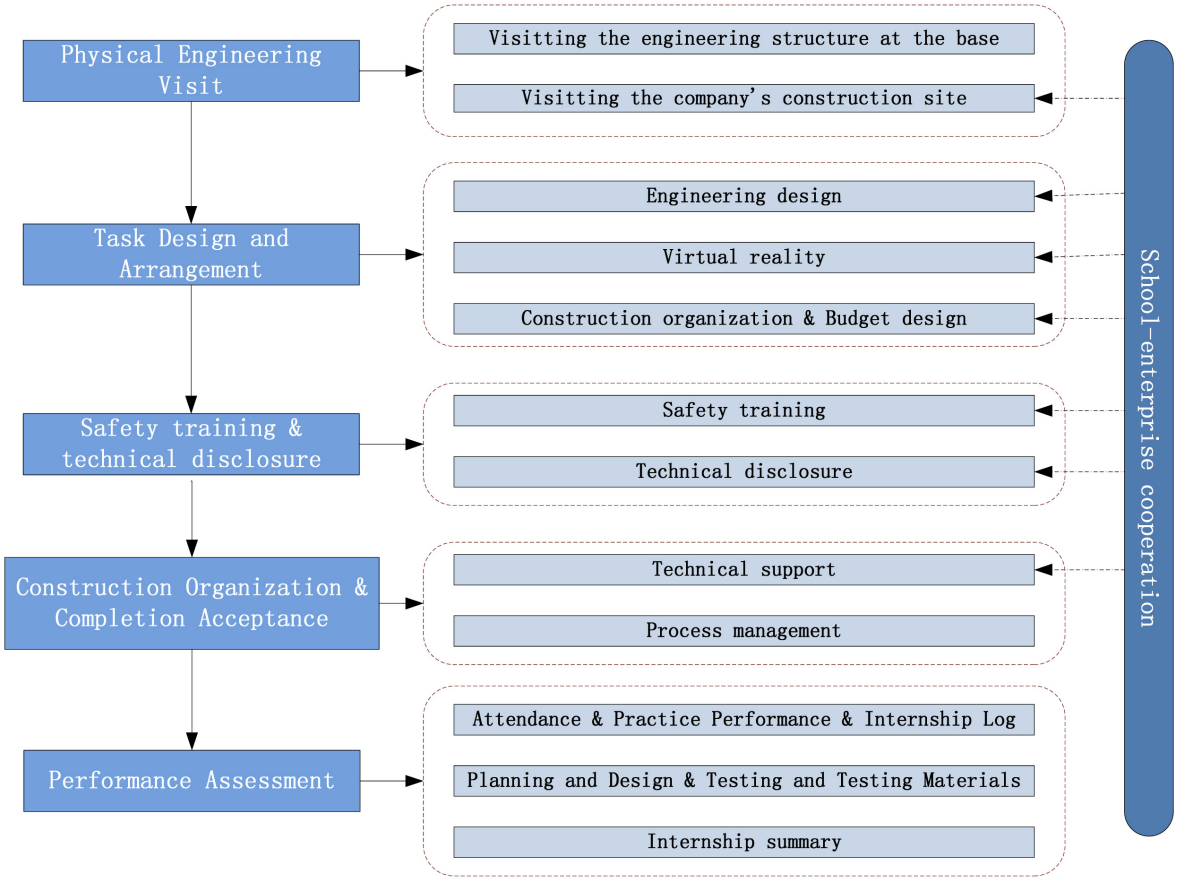

Figure 2. "AllTrue" project on-site training development process.

In order to adapt to the "AllTrue" engineering simulation practice teaching mode, the theoretical teaching is divided into five teaching modules: survey and design, structural design, construction organization, engineering quality inspection, and innovation and improvement, as is shown in **Figure 3**. In the implementation process of the "AllTrue" engineering on-site simulation practice teaching mode, the theoretical teaching content were modularized to adapt to the practical teaching system, and the problem of disconnection between theory and practice is solved. A series of high-quality courses have been created in the process, which supports the integration of theory and practice.

2) Create a series of high-quality courses to support the integration and improvement of theory and practice.

In order to meet the needs of practical teaching mode and theoretical teaching mode reform and support the deep integration of theory and practical teaching, a certain number of high-quality courses have been created, in which the teaching contents and teaching method were explored. Ecological road related courses such as "Highway Environment and Landscape Design" have been added to highlight the characteristics and advantages of road bridge and river crossing engineering majors in agriculture and forestry colleges. The details of these High-quality courses are shown in **Table 1**.

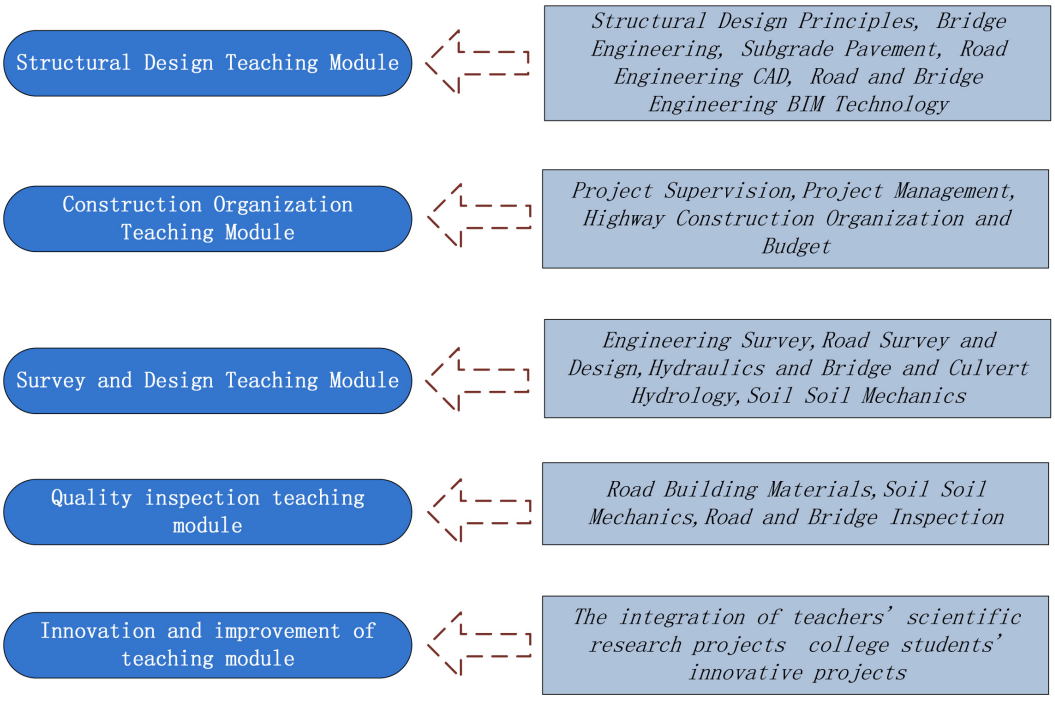

Figure 3. Division of teaching modules.

Table 1. High-quality courses.

serial number	Course Title	Course level
1	Soil and Soil Mechanics	First-class courses in Inner Mongolia Autonomous Region
2	road building materials	First-class courses in Inner Mongolia Autonomous Region
3	Subgrade Pavement Engineering	First-class courses in Inner Mongolia Autonomous Region
4	Road Engineer	First-class courses in Inner Mongolia Autonomous Region
5	bridge engineering	School-level first-class courses
6	Highway construction organization and budget	School-level first-class courses

3.3. Construct a "All-True" Practical Teaching System to Cultivate Morality and Cultivate People

In the implementation process of the "AllTrue "engineering on-site simulation practice teaching mode, the ideological and political elements of the course are effectively integrated, which greatly improved the students' awareness of team-work, stimulates the students' craftsmanship, developed the quality of hard work, and cultivated the engineering quality to meet the future needs creates a sense of innovation. The details are shown in **Figure 4**.

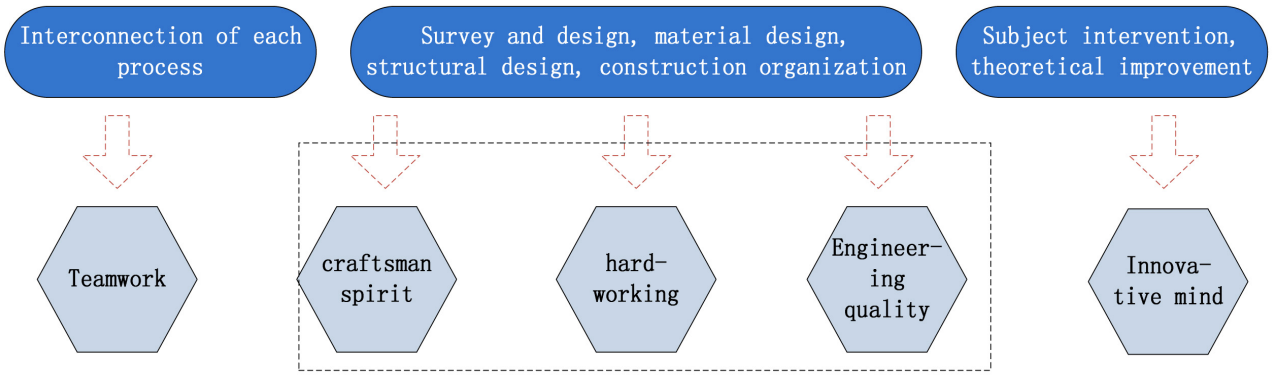

Figure 4. Ideological and political education integration.

4. Achievements and Their Promotion and Application Effects

4.1. A Complete Theoretical and Practical Teaching System Has Been Formed

A practical teaching system with "AllTrue" engineering simulation and engineering practice was built since the implementation of the teaching mode, which integrated of practical teaching and theory. There are 14 professional courses involving the integration of teaching links, exceeding professional core courses 80%.

4.2. Students Received Effective Engineering Training and Were Highly Rated by Employers

Since the implementation of the new teaching mode, more than 600 students have benefited accumulatively. Through the engineering simulation practice of this project, the students have deeply studied and mastered the content involved in the engineering construction process, exercised the ability to bear hardships and stand hard work, teamwork, and positive thinking when encountering problems and cultivated strong engineering construction quality. This achievement is equivalent to bringing the company's pre-job training for employees to the school learning stage in advance, and the employer's evaluation of the students' comprehensive ability is very high.

4.3. The Employment Rate and Employment Correlation Have Increased Significantly

The employment rate and employment correlation of undergraduates in this major have improved since the implementation of the results, and the data has changed more significantly after 2018. The detailed data are shown in the Figure 5. As is shown in Figure 5(a), the enrolment rate increased from 7% to 20%, which means that the new teaching mode improved the learning ability of the students. Also, the employment rate of both stated-owned enterprises& institutions and others enjoyed a substantial growth, and the employment relevance rate reached 100% in 2020 and 2021, which is shown in Figure 5(b).

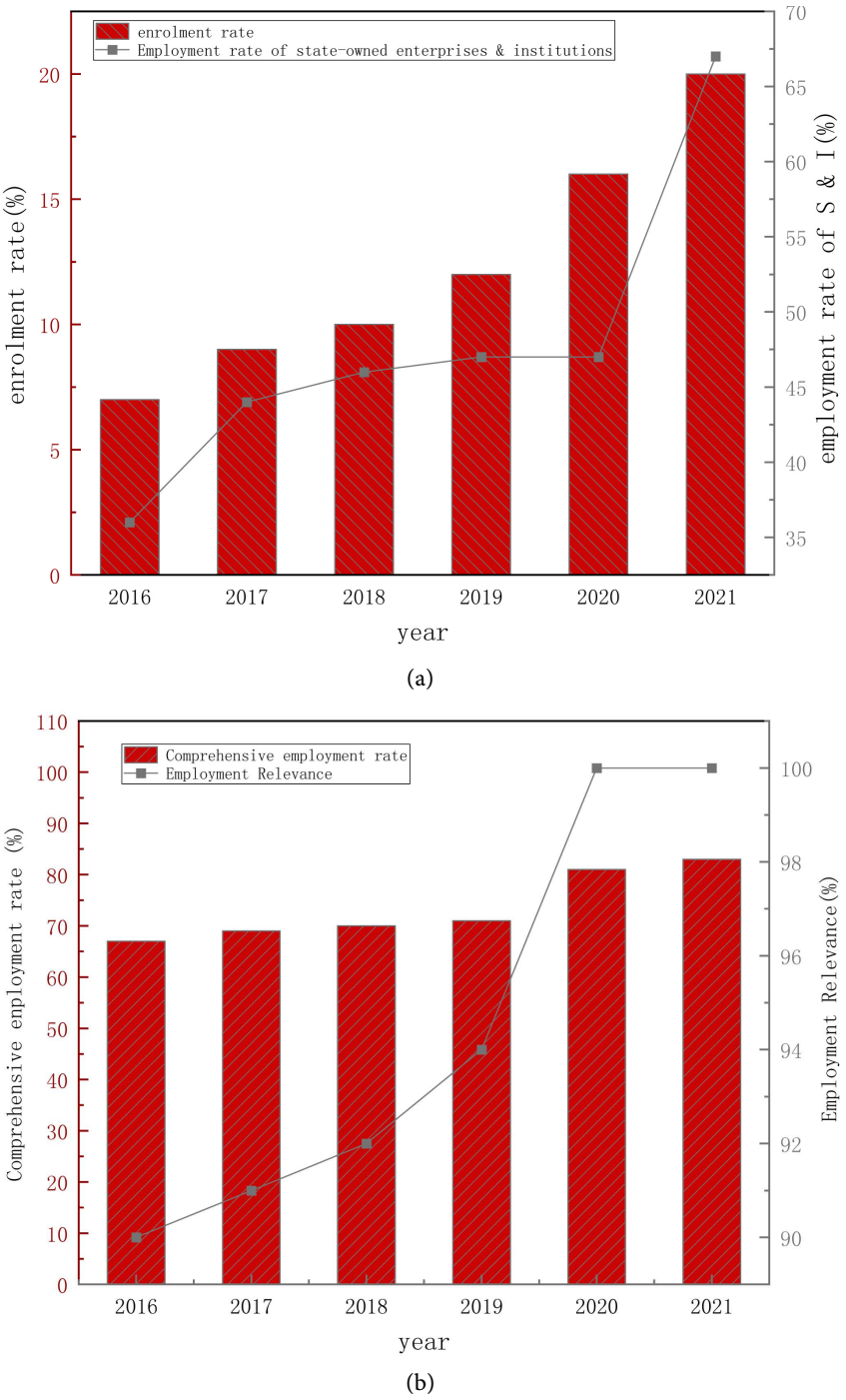

Figure 5. Employment rate and employment correlation. (a) Enrolment rate and employment rate of S & I; (b) Comprehensive employment rate & employment relevance.

4.4. The Theoretical Teaching and Practical Guidance Ability of Teachers Has Been Steadily Improved, and the Strength of the Teaching Team Has Been Gradually Improved

This achievement provides a platform for teachers, especially young teachers, to go deep into the production line, and the comprehensive practical ability of teachers has been greatly improved. All teachers have industry qualification cer-

tificates such as construction engineers' certificate, supervision engineers' certificate, and inspection engineers' certificate, which lays the foundation for the establishment of a double-qualified teaching team.

4.5. The Radiation Demonstration Effect Is Good, and the Research Results Are Popularized and Applied in the Majors of Roads, Bridges and River Crossings in Colleges and Universities inside and outside the Inner Mongolia Autonomous Region

The achievements of this project are centered on talent cultivation, combined with the concept of new engineering, the concept of engineering education certification, and the characteristics of regional talent needs, and have formed a series of innovations in practical teaching methods, integration of theory and practical teaching, practical teaching feedback on theoretical teaching, and professional characteristics condensation. The results have a very important reference significance for the majors of road bridge and river crossing engineering in similar colleges and universities. It has a guiding role in the construction of professional characteristics and curriculum system. The promotion effect is good in many colleges and universities.

5. Improvement Measures in Future

With the continuous development of road construction technology in China, new materials, new processes and new technologies are used in highway construction. Therefore, more attention should be paid to the introduction of this achievement in the subsequent application and promotion process and the teaching content should be timely updated. For example, the BIM technology can be used in the construction organization module and the NDT technology can be applied in the detection module. In addition, in order to improve the teaching system, excellent textbooks should be compiled on the basis of high-quality courses and first-class courses in the follow-up construction process. Last but not the least, the achievements should be combined with the requirements of engineering education certification in the follow-up promotion and optimization process, and it should be combined effectively with the program adjustment, syllabus preparation and other education and teaching work.

6. Conclusion

In the context of deepening the reform of engineering education and building a strong country in engineering education, the cultivation of compound application technical talents with "highlighting compound application and engineering ability" has important value and significance. The practice of the deep integration mode of theoretical teaching and practical training of road and bridge majors has proved that the reform measures of "full truth" engineering on-site simulation practice teaching have not only effectively improved the engineering practice ability of students majoring in road, bridge and river crossing engineer-

ing, but also enhanced the employment competitiveness of graduates and opened up a new situation for graduates' employment.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Association, C. E. E. A. (2022). *Engineering Education Accreditation Criteria* (Vol. T/CEEAA 001-2022).

Dong, L. C., Cheng, J. D., Huang, X. X., & Yang, Y. J. (2020). Research on Teaching Reform of Road Bridge and River-Crossing Engineering under Professional Certification Standard. *Jiangsu Science & Technology Information, 21,* 66-68.

Huang, M. S., Huang, M., & Xu, F. (2014). Research on the Optimization of Practical Teaching System of Road Bridge and River Crossing Engineering Specialty in Local Universities. *Journal of Yangtze University, 11,* 111-114.

Liu, T. (2019). Research on Teaching Reform of Modern Control Theory under Engineering Education Professional Certification. In *The 2019 Chinese Control and Decision Conference (CCDC)* (pp. 1243-1245). IEEE. https://doi.org/10.1109/CCDC.2019.8833275

Sheng, H. Y. (2011). Exploration and Practice of the Talents Training Mode of School enterprise Cooperation and Combination of Work and Learning—Taking the Major of Traffic Road and Bridge Engineering as an Example. *Transportation Vocational Education, No. 3,* 7-8.

Wang, F. (2020). A Comparative Study of Chinese and American Engineering Education Professional Certification Standards. In *The International Conference on Education, Economics and Information Management (ICEEIM 2019)* (pp. 25-31). Atlantis Press. https://doi.org/10.2991/assehr.k.200401.008

Xiang, C. S., Qiao, X. et al. (2022). Teaching Reform Research and Practice of Professional Introduction Course Based on the Concept of Engineering Education Accreditation: An Example of Introduction to Road, Bridge and River-Crossing Engineering. *Journal of Architectural Education in Institutions of Higher Learning, 31,* 7.

Xu, D., Zhao, Y., Zhou, X., & Li, N. (2020). Research on Innovative Personnel Training System of Measurement and Control Specialty under the Background of Engineering Education Professional Certification. *Open Journal of Social Sciences, 8,* 205-216. https://doi.org/10.4236/jss.2020.83018

Zhang, H. Z., Liu, W. D. et al. (2020). Optimization of Training Goals and Graduation Requirements for Road Bridges and Crossing River Engineering Majors for Engineering Education Accreditation: Taking Shenyang Jianzhu University as an Example. *Journal of Shenyang Jianzhu University: Social Science, No. 5,* 6.

Zhao, J. (2016). Research on the Teaching Mode of the Traffic Design Course with the Combination of Theory and Practice. *Education Teaching Forum, No. 12,* 128-130.