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Case study

Exploration and research on reform and practice of graduation design for civil engineering major based on BIM technology and OBE concept

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Abstract: With the continuous development and progress of the construction industry, the requirements for civil engineering professionals are also increasing daily. Building a high-quality ability training model is the top priority in educational reform and development. As an important part of undergraduate teaching in civil engineering, graduation design plays a vital role in cultivating students' comprehensive abilities and innovative spirit. This research combined BIM technology with the OBE concept to conduct reform and practical research on graduation design for civil engineering majors. By analyzing the problems existing in the current graduation design of civil engineering majors, the advantages of BIM technology and the OBE concept and the necessity of combining the two were elaborated. This paper introduced in detail the graduation design reform plan based on BIM technology and the OBE concept, including reform measures in aspects such as design content, guidance methods, and evaluation system. Through actual case analysis and questionnaire survey, the effectiveness of the reform plan was verified and future development was prospected.

Keywords: BIM technology, OBE concept, civil engineering graduation design, reform and practice

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1. Introduction

Higher education is the foundation of a country. Building a high-quality ability training model is the top priority in educational reform and development [1]. Deepening the reform of talent training models requires strengthening the integration of "virtual and real" education and teaching activities [2]. Civil engineering higher education has cultivated a large number of professional outstanding talents, which has promoted the rapid development of the country's modernization drive. With the rapid development of information technology, Building Information Modeling (BIM) technology has been widely used in the field of civil engineering. BIM technology has brought revolutionary changes to the design, construction, and management of civil engineering with its advantages of visualization, coordination, simulation, optimization, and chartability [3,4]. At the same time, the concept of Outcomes-based Education (OBE) has gradually emerged in the field of education, emphasizing student-centered, oriented by expected learning outcomes, and focusing on the cultivation of students' comprehensive abilities [5,6]. In this context, it is of great practical significance to combine BIM technology with the OBE concept to reform the graduation design of civil engineering majors.

This research aims to explore reform plans for graduation design of civil engineering majors based on BIM technology and the OBE concept, improve the quality of graduation design, and cultivate high-quality civil engineering professionals with innovative spirit and practical ability. By introducing BIM technology and the OBE concept, the content and methods of graduation design are optimized to improve students' design level and innovation ability, to improve the quality of graduation design. OBE concept emphasizes student-centered and pays attention to the cultivation of students' comprehensive abilities. In the graduation design, students can not only improve their professional skills by using BIM technology, but also cultivate comprehensive abilities such as teamwork, communication and expression, and problem-solving. With the continuous development of the construction industry, the requirements for civil engineering professionals are becoming higher and higher. Combining BIM technology with the OBE concept to cultivate high-quality talents that meet the development needs of the industry will help improve the employment competitiveness of graduates [7]. Fig. 1 shows the goals, principles, and methods of graduation design reform for civil engineering major based on BMI technology and OBE concept.

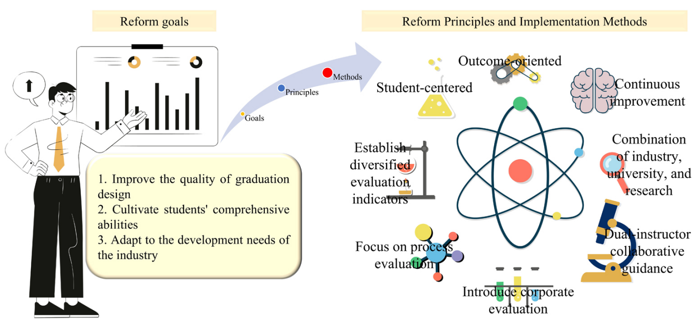

Fig. 1. Goals, principles, and methods of graduation design reform for civil engineering major based on BMI technology and OBE concept

2. Combination of BIM technology and OBE concept

The necessity of combining: (1) Improve the quality of graduation design. BIM technology can provide more advanced design tools and methods for graduation design, and improve design quality, and efficiency. The OBE concept can provide clearer learning goals and evaluation standards for graduation designs, and improve the pertinence and effectiveness of graduation design. (2) Cultivate students' comprehensive abilities. The application of BIM technology requires students to have comprehensive abilities such as teamwork, communication and expression, and problem- solving. The OBE concept emphasizes student-centered and focuses on the cultivation of students' comprehensive abilities. The combination of the two can better cultivate students' comprehensive abilities. (3) Adapt to the development needs of the industry. The construction industry has increasingly high requirements for civil engineering professionals, not only requiring solid professional knowledge, but also requiring skilled BIM technology application ability and comprehensive ability. Combining BIM technology with the OBE concept can better adapt to the development needs of the industry.

The feasibility of combining: (1) Technical feasibility. With the continuous development and popularization of BIM technology, more and more civil engineering professional software supports BIM technology, providing technical support for students to apply it in their graduation design [8]. (2) Teaching feasibility. The OBE concept is becoming more and more widely used in the field of education, and many universities have begun to apply the OBE concept in teaching reform [9–11]. Combining BIM technology with the OBE concept is feasible in teaching. (3) Practical feasibility. Many universities have introduced BIM technology into the teaching of civil engineering and other related majors, and achieved good teaching results [12–14]. Combining BIM technology with the OBE concept is feasible in practice.

In the above aspects, universities such as Southeast University, Nanjing Tech University, Fuzhou University, and Yangtze University have carried out research and practice on graduation design reform for civil engineering majors based on BIM technology [8, 15–18], which reflects the feasibility and applicability of graduation design for civil engineering majors based on BIM technology.

As shown in Fig. 2, the research and practice of graduation design reform of Yangtze University based on BIM in civil engineering majors was analyzed as a typical case. To better integrate BIM technology into the graduation design of undergraduate civil engineering majors, Professor Wensheng Li [18] took the graduation design reform of the 2016 grade Civil Engineering Excellence Pilot Class of Yangtze University as an example, and combined the OBE concept to select the final graduation design topic based on the actual project under construction on the campus, and the civil engineering graduation design titled "Virtual Construction of a University Student Dormitory Building Based on BIM Technology" was carried out (Fig. 2). The overall task requirements of the graduation design: Comprehensively used the core knowledge of the three major groups of design, construction, and management included in the civil engineering profession, and used the latest BIM digitalization and multi-professional collaborative technology to simulate the project from scheme optimization, engineering design, cost management, and construction organization design to the entire process of construction links such as 5D project management. The design content was divided into six professional modules: Architectural design module, structural design module, electromechanical modeling module, measurement and pricing module, construction organization module, and project management module.

Regarding forming BIM instructors [18]: The guidance teachers for graduation design have been changed from the previous single-instructor system to a BIM instructor group. The members of the instructor group are mainly from the civil engineering majors, and teachers from related majors such as architecture, equipment, and engineering management will be added as needed. The requirement is that they are "dual-qualified" teachers with rich theoretical teaching and engineering practical experience. Regarding forming student design teams [18]: By leveraging the collaborative design concept of BIM, the graduation design model is promoted that is mainly based on civil engineering and involves multiple disciplines working together. The above helps students broaden their knowledge of civil engineering horizontally and deepen their overall understanding of the entire process and all aspects of engineering construction. Through the formulation of a scientific and reasonable workflow and phased plan, the reform of civil engineering graduation design based on BIM technology was achieved (Fig. 2).

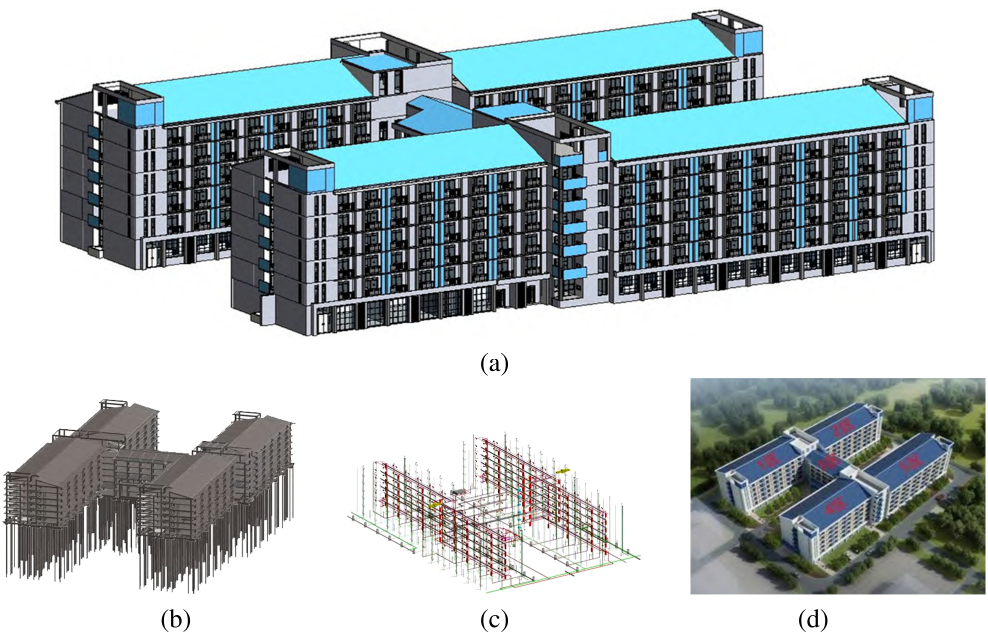

Fig. 2. Citation case (Yangtze University): Virtual construction of a college student dormitory building based on BIM technology (3D model drawings) [18]: (a) Revit architecture, (b) Revit structure, (c) Revit MEP (d) Render effect

3. Analysis on the current situation of graduation design for civil engineering majors

3.1. Problems existing in current graduation design

Presently, the topics for graduation designs for civil engineering majors are often outdated and lack innovation and practicality. The design content is out of touch with the actual project, and students cannot be exposed to the problems and challenges in the actual project during the graduation design. It is difficult to improve their ability to solve practical problems. During the graduation design process, students often only focus on the application of professional knowledge, while neglecting the cultivation of comprehensive abilities such as teamwork, communication and expression, and problem-solving. This makes it difficult for students to adapt to the needs of practical work after graduation. At present, the guidance method for graduation design is mainly for teachers to guide students to complete design tasks. This kind of guidance method is relatively simple and lacks personalized guidance. Teachers are often unable to meet the needs of every student, which affects students' learning effectiveness. At present, the evaluation system of graduation designs mainly evaluates students based on their design results and paper quality. This evaluation system is not perfect enough to comprehensively evaluate students' learning outcomes. For example, it is difficult for students to effectively evaluate their comprehensive abilities such as teamwork ability, communication and expression ability, and problem-solving abilities during the graduation design process.

3.2. Analysis of the causes of the problems

At present, the teaching model of civil engineering is still relatively traditional, focusing on the transfer of knowledge and neglecting the cultivation of students' dominant position and innovative ability. In graduation designs, students often only passively accept teachers' guidance and lack the motivation to learn independently and innovate. Civil engineering is a highly practical major that requires students to have strong practical abilities. However, at present, the practical teaching link of civil engineering majors is relatively weak, and students lack opportunities to exercise in practical engineering. This makes it difficult for students to combine theoretical knowledge with practical engineering in their graduation design, which affects the quality of the graduation design. Among the teachers majoring in civil engineering, some teachers lack practical engineering experience and are difficult to provide effective guidance to students in graduation designs. At the same time, the knowledge structure and ability level of the teaching team also need to be continuously updated and improved to meet the development needs of the construction industry. Teaching resources for civil engineering include laboratory equipment, books and materials, software, etc. At present, some colleges and universities have insufficient teaching resources to meet students' needs in graduation designs, which affects students' application of BIM technology.

4. Graduation design reform plan based on BIM technology and OBE concept

4.1. Goals and principles of reform

To cultivate high-quality civil engineering professionals with innovative spirit and practical ability, the graduation design of civil engineering majors has been reformed by introducing BIM technology and the OBE concept. Specific goals include: (1) Improve the quality of graduation designs and make students' design results more in line with actual engineering needs. (2) Cultivate students' comprehensive abilities, including teamwork, communication and expression, problem-solving, and other abilities. (3) Enhance students' awareness of innovation and practical ability, so that students can skillfully apply BIM technology to solve practical engineering problems. (4) Establish a scientific and reasonable evaluation system to comprehensively evaluate students' learning outcomes.

Reform principles: (1) Student-centered. Give full play to students' main role, pay attention to students' learning needs and development potential, and provide students with personalized guidance and support. (2) Outcome- oriented. Clarify the learning outcomes that students should achieve in the graduation design, and reverse design the teaching process to ensure that students can achieve the expected learning goals. (3) Continuous improvement. Establish a teaching quality feedback mechanism, continuously improve teaching methods and teaching content, and improve teaching quality. (4) Combination of industry, university, and research. Strengthen cooperation with enterprises and introduce practical engineering cases so that students can be exposed to practical engineering problems and challenges in graduation designs and improve students' practical and innovative abilities.

4.2. Reform of graduation design content

Design project options to introduce BIM technology. Select design projects with a practical engineering background, such as multi-storey buildings, bridge engineering, underground space development, etc. Students are required to use BIM technology for three-dimensional modeling, structural analysis, construction simulation, etc. Improve students' practical and innovative abilities through the design of actual projects. Combine actual engineering cases to highlight result-oriented. Integrate actual engineering cases into the graduation design to allow students to understand the problems and solutions in actual engineering. Guided by the achievement requirements of actual projects, clarify the tasks and goals of graduation design, so that students' design results can be more in line with actual needs. Increase the content of comprehensive ability training. In the graduation design, add content to cultivate comprehensive abilities such as teamwork, communication and expression, and problem-solving. For example, students are required to form a team to complete design tasks and cultivate students' teamwork ability.

Students are required to conduct design reports to cultivate students' communication and expression skills. Students are required to solve problems encountered in design and cultivate students' problem-solving abilities.

4.3. Reform of guidance methods

Collaborative guidance from multiple instructors. Establish a guidance team composed of professional teachers, corporate engineers, and BIM technical experts to provide comprehensive guidance to students. Professional teachers are responsible for imparting theoretical knowledge and guiding design methods, corporate engineers are responsible for sharing practical engineering experience and cultivating practical capabilities, and BIM technical experts are responsible for training and application guidance of BIM technology. BIM technical training and guidance go through the entire process. Before the graduation design begins, BIM technical training courses will be provided for students to allow students to master the basic operation and application methods of BIM software. During the graduation design process, guidance teachers should provide students with timely guidance and support on BIM technology to help students solve technical problems. Personalized guidance. Pay attention to the learning needs and development potential of each student and provide personalized guidance and support to students. For students with strong learning ability, more independent design space can be given. For students with weak learning ability, more guidance and help can be given.

4.4. Evaluation system reform

Establish diversified evaluation indicators. Establish a diversified evaluation indicator system including the quality of design results, teamwork ability, communication and expression ability, problem-solving ability, innovative spirit, etc. to comprehensively evaluate students' learning outcomes. Focus on process evaluation. Strengthen the supervision and management of the graduation design process and pay attention to process evaluation. Regularly check students' design progress and quality, provide timely feedback to students, and help students improve their design plans. Introduce corporate evaluation. Invite corporate engineers to participate in the evaluation of graduation designs and evaluate students' design results from a practical engineering perspective. The results of enterprise evaluation can be used as an important part of students' graduation design scores.

5. Reform practice and effect analysis

5.1. Implementation process

Implementation process: (1) Before the graduation design starts, students will be provided with BIM technology training and the OBE concept, so that students can understand the advantages and application methods of BIM technology and the OBE concept. (2) Select design projects with a practical engineering background, such as high-rise buildings, bridge engineering, underground space development, etc., and require students to use BIM technology for 3D modeling, structural analysis, construction simulation, etc. (3) Establish a guidance team composed of professional teachers, corporate engineers, and BIM technical experts to provide comprehensive guidance to students. (4) During the graduation design process, strengthen the process evaluation of students, regularly check students' design progress and quality, provide timely feedback to students, and help students improve their design plans. (5) Invite corporate engineers to participate in the evaluation of graduation designs and evaluate students' design results from a practical engineering perspective.

5.2. Problems and solutions in practice

Students' difficulty in mastering BIM technology. Some students have certain difficulties in mastering BIM technology. In response to this problem, instructors have increased training time and guidance on BIM technology, while encouraging students to communicate and learn from each other. Conflict handling in teamwork. In the process of teamwork, conflicts and differences may arise between students. Instructors should understand the situation in a timely manner, coordinate and resolve conflicts, and guide students to establish a sense of teamwork. The issue of unification of standards for enterprise evaluation. There may be differences in evaluation standards between corporate engineers and school teachers. To solve this problem, before evaluation, corporate engineers and school teachers were organized to communicate and exchange to unify evaluation standards.

5.3. Practical effect and evaluation

5.3.1. Classroom teaching

The BIM course textbooks use the excellent textbook "BIM Applications: Revit Architectural Case Tutorial (Second edition)" edited by Lingjie Chen and others and published by Peking University Press [19]. Combined with the example of the teaching building project, using the information technology teaching platform of the School of Civil Engineering and Architecture of Anhui University of Science and Technology, the comprehensive teaching model of "knowledge content explanation + multimedia demonstration teaching + practical operation of computer examples + group innovation drills + discussion and answering analysis" is mainly used to fully embody the OBE teaching concept, to achieve the teaching effect of students learning while doing, learning with thought, and thinking innovatively [20].

As shown in Fig. 3, during the classroom teaching process, the practical case (Drawing of teaching building floors) was integrated, BIM's visualization function was used to optimize design solutions, and students were trained to work collaboratively to better solve key problems, which not only improved students' ability to use BIM technology, but also strengthened their teamwork and problem-solving capabilities to effectively achieve OBE teaching goals.

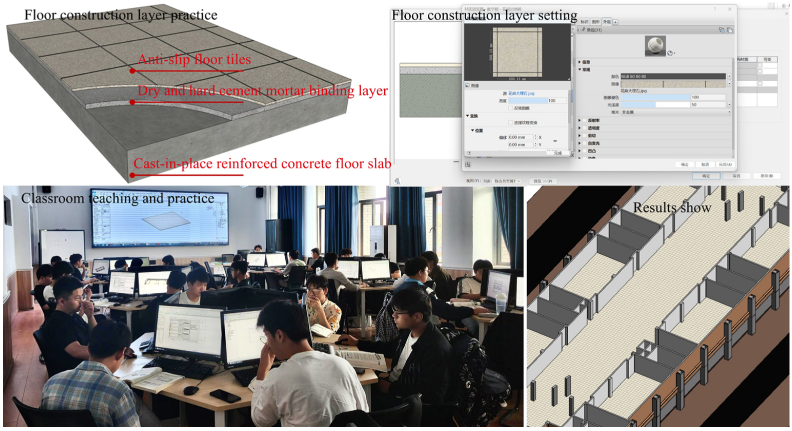

Fig. 3. Drawing of the actual cases integrated in daily teaching course activities (Drawing of teaching building floors)

During the Revit architectural design example guidance process, the dual- instructor co-guidance model of "university teacher + enterprise engineer" was adopted to carry out case teaching at each drawing stage of the teaching building project. Here are examples of the staircase, handrail, and, ramp designs:

In Revit, stairs, handrails, and ramps all belong to system families. The three commands, "Handrails", "Ramp", and "Stair", are all located in the stair ramp panel. As a part of stairs and ramps, the railings are automatically generated when drawing stairs or ramps. Under the dual- instructor co-guidance model of "university teacher + corporate engineer", students were helped to better master the key knowledge points of the stair, handrail, and ramp designs (Table 1).

Table 1. Capability goals and knowledge points for stair, handrail, and ramp designs

Capability goals	**Knowledge points**
Master the drawing and editing methods of stairs in Revit	Stair components: stairs, platforms, support components, and handrails
	Sketch stairs
	The stairs end at the kick surfaces
Master the drawing and editing methods of railings and handrails in Revit	Top handrails
	Handrail structures
	Handrail positions
	Heights of platform railings and stair railings
Master the drawing and editing methods of ramps in Revit|	Edit the properties of the ramps
	Draw the ramps

Taking the drawing of the slab staircases as an example, the enterprise engineers provided key parameter information in combination with the actual engineering situation: After the calculation of the evacuation width, it was determined that the evacuation width of the staircase was 1850 mm (one of the size types). Both the steps and rest platforms of the staircases were 120 mm thick cast-in-place reinforced concrete, and the risers and treads were faced with 50 mm thick marble.

Follow the stair drawing steps taught by university teachers: (1) Copy and create the stair type; (2) Set the type parameters (calculation rules, stair type, platform type, treads and risers); (3) Set the instance parameters (stair width, top and bottom constraints, number of risers required, actual tread depth); (4) Draw the stairs; (5) Open a hole in the stairwell. As shown in Fig. 4, the stairs that comply with national specifications and meet functional requirements can be drawn.

Fig. 4. Revit renderings of stairs, handrails, and ramps

As shown in Fig. 5, BIM teaching clarified the learning results-oriented training goal of civil engineering talents and established a BIM course teaching evaluation system based on the OBE concept [20]. The BIM course teaching evaluation system was mainly divided into two stages: Process evaluation and conclusive evaluation. The process evaluation included the first phase of teaching content (score accounting for 15%), the second phase of teaching content (score accounting for 20%), the third phase of teaching content (score accounting for 15%), and the final exam of teaching content (score accounting for 50%). The conclusive evaluation was a comprehensive score of the process evaluation of teaching content. By building the above diversified comprehensive evaluation system, scientific evaluation of students' learning effectiveness can be achieved.

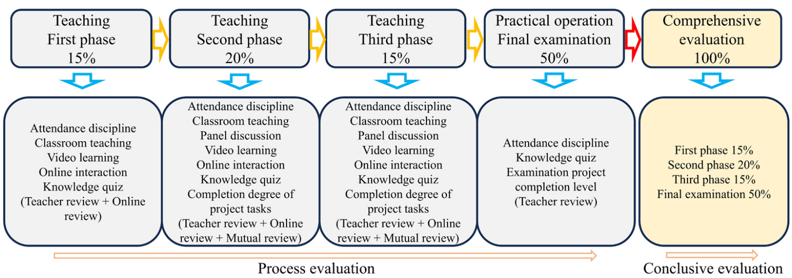

Fig. 5. BIM course teaching evaluation system based on the OBE concept [20]

In terms of classroom teaching assessment, by adopting the BIM course teaching evaluation system based on the OBE concept, the distribution of students (38 students in the class) modeling scores and comprehensive scores at the end of the term was further obtained (Fig. 6). It can be seen from Fig. 6 that the average achievement rate of this course is 85.45%, and the highest achievement rate is 98% [20]. The analysis of the achievement rate reflects that the vast majority of students have a good grasp of the basic knowledge of BIM technical principles and applications, and have achieved the teaching purpose.

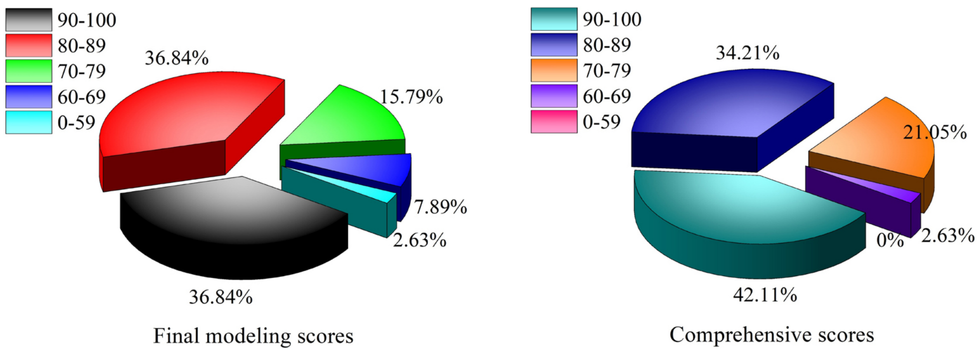

Fig. 6. Analysis of students' scores in practical building models

5.3.2. Graduation design

In terms of graduation design, through the display of a student's design result (see Fig. 7), it can be seen that students have greatly improved their use of BIM technology, solved practical engineering problems, and achieved course objectives. The design results are more in line with actual needs and are highly innovative and practical.

Course objectives:

Objective 1: Be able to use the basic theory and professional knowledge of engineering design and related specifications, atlas, and manuals to optimize the design of the scheme.

Objective 2: Be familiar with the general laws and methods of engineering design, and have the ability to accurately calculate engineering structure design or prepare construction organization design.

Objective 3: Have the ability to select graduation design topics, test design, data analysis, etc., and be able to use engineering design software to model and verify complex engineering problems.

Objective 4: Have awareness of sustainable development such as selecting new energy-saving and environmentally friendly materials, energy conservation, and water conservation, and green construction.

Objective 5: Be able to effectively express the content of graduation design orally or in writing, and have good communication and communication skills.

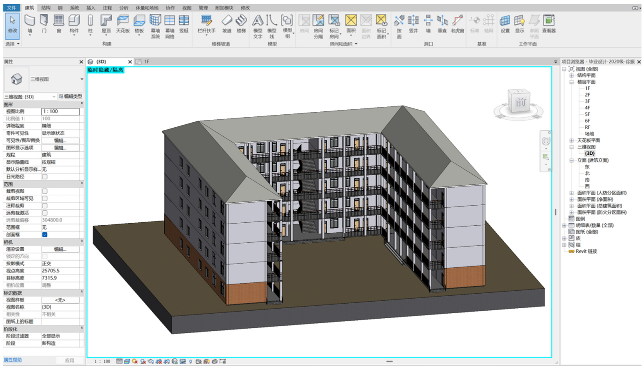

Fig. 7. Graduation design case (3D model drawing)

It should be noted that to provide a scientific, objective, and reasonable evaluation of graduation designs, the BIM graduation design evaluation system based on the OBE concept has been established. As shown in Fig. 8, scoring standards for the scores of the completion degree of the above five training goals have been formulated from three aspects: Guidance teachers (Instructor) (score accounting for 30%), review teachers (score accounting for 30%), and graduation defense performance (score accounting for 40%).

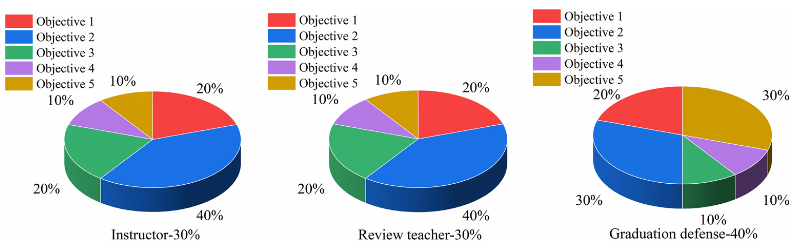

Fig. 8. Evaluation score standard for graduation design process based on the OBE concept

5.3.3. Feedback and evaluation from students and teachers

To more objectively evaluate the reform and practice effect of civil engineering graduation design based on BIM technology and the OBE concept, real feedback from students and teachers was obtained through questionnaires (Figs. 9 and 10). As can be seen from Figs. 9 and 10, relatively speaking, students and teachers spoke highly of the reformed graduation design. Students believe that through graduation design, they not only improve professional knowledge and skills, but also cultivate comprehensive abilities such as teamwork, communication, and expression. Teachers believe that the reformed graduation design is closer to the actual project and will help improve students' practical ability and innovative spirit. Compared with traditional graduation designs, graduation designs based on BIM technology and the OBE concept have been greatly improved in terms of design content, guidance methods, and evaluation systems. Students' comprehensive abilities and innovative spirit have been better cultivated, and the quality of graduation design has been significantly improved.

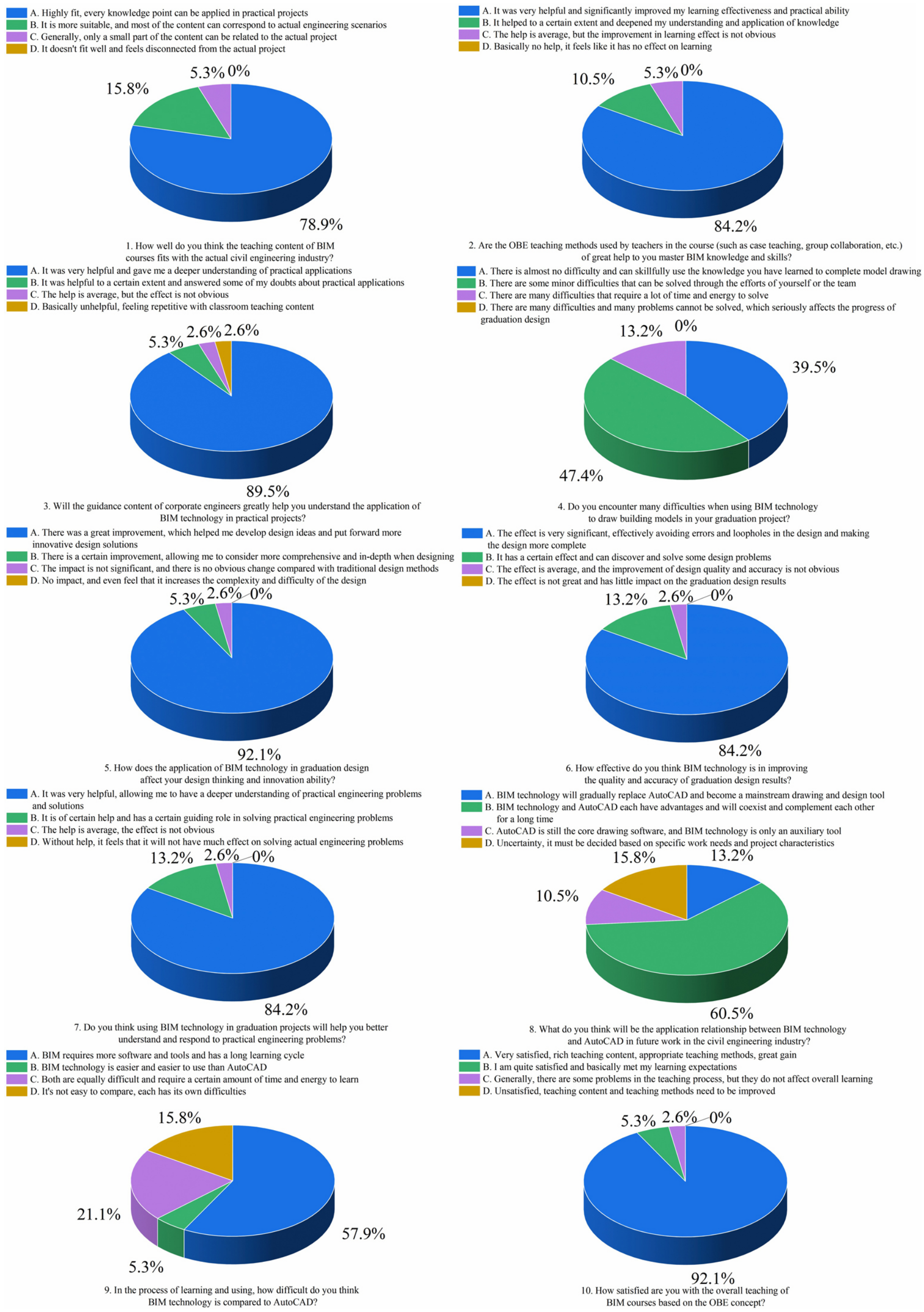

Fig. 9. Feedback and evaluation from students

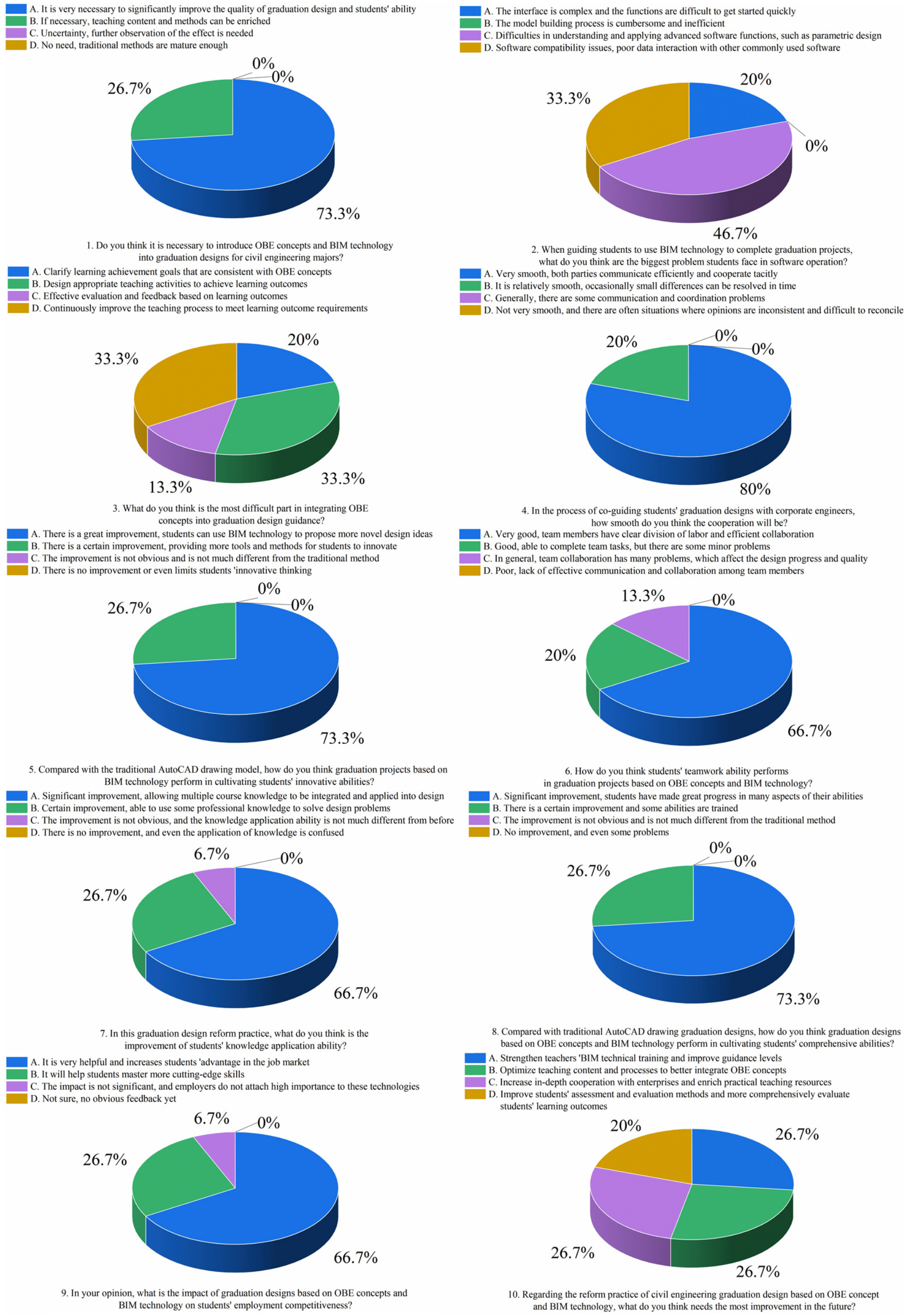

Fig. 10. Feedback and evaluation from teachers

6. Analysis and discussion

6.1. Cost-effectiveness and hardware and software limitations of BIM technology

In the reform practice of civil engineering graduation design based on BIM technology and the OBE concept, although teaching results can be significantly improved and students' ability to collaborate and solve problems can be cultivated, there are still many practical challenges in the implementation process, among which the cost-effectiveness and hardware and software limitations of BIM technology can not be ignored.

(1) Cost-effectiveness analysis

From the cost-effectiveness perspective, introducing BIM technology involves multiple costs. In addition to software purchase costs, hardware update costs cannot be ignored. BIM software operation requires high computer hardware, and old equipment makes it difficult to meet operating needs. Some universities may need to invest money to update computer equipment to ensure the smooth operation of BIM software. However, BIM technology can also bring significant benefits. In terms of teaching, it can provide a more intuitive and realistic project simulation environment, enhance students' interest and participation in learning, help students better understand and master professional knowledge, cultivate students' practical ability and innovative thinking, and provide more professional talents to society. In terms of scientific research, BIM technology can help carry out more in-depth research on building performance analysis, construction process simulation, and other research, and enhance the schools' scientific research level and academic influence. In the long run, by training high-quality talents to adapt to the development of the industry, the reputation and competitiveness of the school can be improved, and more high-quality students and scientific research projects can be attracted.

(2) Hardware and software limitations issues

For universities with weak technological infrastructure, the following solution strategies can be adopted. In terms of software acquisition, universities can negotiate with software suppliers to strive for preferential education policies and obtain software licenses at a lower cost. They can also focus on open-source BIM software. Although these open- source BIM software functions are not as comprehensive as commercial software, they can meet basic teaching needs. In terms of hardware updates, schools can formulate batch update plans to prioritize configuring laboratories and computer rooms related to graduation designs with hardware equipment that meets the requirements. They can also explore cloud desktop technology and run BIM software through cloud servers. Students only need to use ordinary computer terminals can access and use it, reducing reliance on local hardware. In terms of training, schools can encourage teachers to participate in online training courses and obtain relevant certifications, and then teachers on campus can train students. At the same time, they can establish a BIM learning community on campus to promote experience exchange and learning mutual assistance between teachers and students. Through these strategies, universities with weak technical infrastructure can gradually overcome difficulties and smoothly advance the reform practice of civil engineering graduation design based on BIM technology and the OBE concept.

6.2. Potential obstacles and risks in reform and practice

In the practice of civil engineering graduation design reform based on BIM technology and the OBE concept, although this reform has brought many positive prospects, it provides a new path for cultivating professionals who can meet the needs of modern engineering. However, in the implementation process, there are a series of potential obstacles and risks. If it is not paid attention to and properly handled, it will have a negative impact on the smooth progress and final results of the reform.

(1) The resistance of some teachers

Some teachers may be resistant to the graduation design reform led by BIM technology and the OBE concept. On the one hand, some senior professors have long formed traditional teaching models and thinking habits, and are slow to accept new technologies and concepts. They are worried that reforms will disrupt the existing teaching rhythm and increase teaching difficulty and workload. On the other hand, mastering BIM technology requires investing a lot of time and energy in learning and practice, and professors themselves have heavy teaching and scientific research tasks and it is difficult to spare enough time for self-improvement. To reduce this risk, a hierarchical and classified training strategy can be adopted. For young teachers with high acceptance of new technologies, provide in-depth BIM technical training to make them a vanguard force in reform. For senior professors with rich experience but concerns about new technologies, first carry out conceptual training to let them understand the significance and value of reform, and then gradually guide them to participate in technical training. At the same time, an incentive mechanism should be established to link teachers' contributions in the reform with performance evaluation, professional title promotion, etc., to increase teachers' enthusiasm for participating in the reform.

(2) Potential risks of introducing BIM technology

In the process of gradually introducing BIM technology into the curriculum, problems may arise in that the curriculum system is not smoothly connected. If the newly introduced BIM technical content cannot be organically integrated with the original course content, it will lead to confusion in students' knowledge system and poor learning results. At the same time, due to the rapid upgrading of BIM technology, schools may face the risk of teaching content lagging behind industry development. To reduce these risks, schools should organize professional teachers to comprehensively sort out and optimize the curriculum system, formulate scientific and reasonable teaching syllabi, and ensure the organic connection between BIM technology-related content and other courses. In addition, strengthen cooperation with industry enterprises, keep abreast of the latest industry developments and technological development trends, and regularly update teaching content to keep the knowledge students have learned in sync with actual engineering needs.

(3) Long-term follow-up and effect evaluation

To measure the impact of this reform method on teaching effectiveness, students' employability, and performance in actual projects, a long-term tracking mechanism needs to be established. Through return visits to graduates, learn how they use the knowledge and skills they have learned at work, and collect their feedback on the reform of graduation design. At the same time, maintain close contact with employers to understand the performance of graduates in actual work and analyze the impact of reform on students' employment competitiveness and career development. Based on the results of follow-up feedback, the reform plan will be adjusted and improved promptly to continuously improve the quality of teaching.

(4) The relationship between graduation design model and practical project

When using BIM technology for graduation design, how to ensure that the model established is closely related to the actual engineering field is a key issue. If the model is disconnected from the actual engineering, students will not be able to truly master the skills and methods needed in the actual work. To solve this problem, schools should strengthen cooperation with enterprises and introduce practical engineering projects as the source of graduation design topics. Invite corporate engineers to participate in graduation design guidance, so that students can fully understand the needs and specifications of actual projects during the design process. At the same time, students are encouraged to participate in corporate internships, accumulate experience through practical work, and apply what they see and hear during the internship to graduation designs to improve the practicality and authenticity of the model.

The practice of civil engineering graduation design reform based on BIM technology and the OBE concept is of great significance and value, but during the implementation process, it is necessary to fully realize the potential risks and adopt effective response strategies. Solving problems such as teachers' resistance and students' insufficient mastery of technology, establishing a long-term tracking mechanism, and strengthening the connection between models and actual projects, can ensure that the reform achieves the expected results and cultivate more high-quality innovative talents for the civil engineering profession.

7. Conclusions and prospects

7.1. Summary of research results

By combining BIM technology with the OBE concept, this paper conducts reform and practical research on graduation design for civil engineering majors. The research results show that the reformed graduation design has significant advantages in improving students' comprehensive abilities, cultivating innovative spirit, and being close to practical projects. Specifically, it is reflected in the following aspects: (1) Optimize the graduation design content to make the design project more practical engineering background and innovative. (2) Innovative guidance methods, dual-instructor collaborative guidance, and BIM technical training throughout the entire process, improving students' practical ability and problem-solving abilities. (3) Reconstructed the evaluation system, established diversified evaluation indicators, focused on process evaluation and feedback, and improved the scientificity and objectivity of evaluation.

7.2. Shortcomings and prospects of the research

Although the research in this paper has achieved certain results, there are also some shortcomings. The scope of practical objects is small, and the promotion and application of reform plans need further verification. The integration of BIM technology and the OBE concept is not deep enough, and more effective integration methods need to be further explored. Students' graduation design scores need to be further improved. Future research can be carried out from the following aspects: (1) Expand the scope of practical objects, promote and apply the reform plan to more universities and majors, and further verify its effectiveness and feasibility. (2) In-depth study of the integration of BIM technology and the OBE concept, explore more effective teaching methods and evaluation systems, and improve the quality of talent training for civil engineering professionals. (3) Based on the development needs of the industry, it is necessary to combine big data, big models, and big databases, and pay attention to the sustainable principles of civil engineering to continuously update the content and methods of graduation design, and cultivate high-quality civil engineering professionals who meet the needs of social development [21, 22]. In short, the reform of graduation design for civil engineering majors based on BIM technology and the OBE concept is an important research topic. Through continuous exploration and practice, new ideas and methods can be provided for improving the quality of graduation design and talent training levels for civil engineering majors.

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