Practical exploration and effectiveness analysis of BIM technology in the teaching of civil engineering courses

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Abstract: *With the acceleration of digital transformation in the construction industry, the application of BIM technology in civil engineering teaching has become the key to improving the quality of talent cultivation. This article focuses on the application of BIM technology in civil engineering teaching, systematically elaborating on the specific implementation strategies of project-based teaching method, flipped classroom and blended online and offline teaching, cross disciplinary collaborative teaching and other practical paths; Taking a large-scale commercial complex construction project as a case study, this paper conducts an in-depth analysis of the BIM course teaching process, and evaluates the teaching effectiveness by comparing and analyzing the learning and practical ability data of students in 2021 and 2022. Research has shown that innovative teaching models based on BIM technology have significantly improved students' professional literacy and practical abilities, providing important references for the reform of teaching in civil engineering and the cultivation of composite talents in the industry.*

Keywords: *BIM technology; Civil engineering teaching; Teaching methods; Effectiveness evaluation; teaching reform*

1. Introduction

Under the wave of digitalization in the construction industry, BIM technology has become an important direction for the reform of civil engineering teaching. The existing research [1-5] single mode application of multi focus BIM technology in teaching, such as project-based teaching or online offline hybrid teaching, lacks systematic research on the collaborative application of multiple teaching methods, and the evaluation of teaching effectiveness lacks long-term tracking and multi-dimensional comparative analysis. In view of this, this article explores the innovative path of BIM technology driven teaching methods based on a multi case practice system, verifies the teaching effectiveness through quantitative analysis, and provides theoretical support and practical reference for the teaching reform of civil engineering majors.

2. The Practical Path of BIM Technology in Teaching Methods of Civil Engineering Major

2.1 Application strategies of project-based teaching method in BIM courses

The project-based teaching method takes real engineering scenarios as the driving force, and uses a detailed breakdown of the knowledge points involved in the course and integration into specific project tasks to promote students' gradual construction of knowledge systems and practical abilities in solving practical problems. In the specific implementation process of BIM courses, this teaching method needs to be carried out according to a closed process of "project selection task subdivision process guidance outcome evaluation".

Firstly, project selection should be in line with the course objectives and students' cognitive level. Priority should be given to selecting engineering examples that have a complete lifecycle and reflect the collaborative characteristics of multiple disciplines. Then, teachers should further break down the project into phased tasks, clarify the key points and final deliverables of each task in the application of BIM technology. In the process of implementation and promotion, teachers rely on regular group meetings to track progress, provide centralized guidance on common problems such as model integration errors and delayed information transmission, and finally use a multi-dimensional evaluation system to comprehensively evaluate learning effectiveness from multiple perspectives such as model accuracy, reasonable technical application, and actual team collaboration performance.

2.2 Integration Practice of Flipped Classroom and Blended Online and Offline Teaching

The integration of flipped classroom and blended online and offline teaching aims to break the limitations of time and space, and achieve an organic fusion of knowledge dissemination and ability cultivation. In the online stage, teachers rely on tools such as Chaoxing Learning Platform and BIM Cloud Platform to release learning packages consisting of various resources such as software operation recording, engineering case analysis and explanation videos, virtual simulation experiments, etc. Students use self-learning to complete initial skills training such as BIM basic modeling and family library creation, and submit assignments and feedback questions on the platform.

The offline classroom has been transformed into a place for in-depth discussions and practical operations. Teachers analyze the data generated from online learning, provide professional lectures on complex node modeling, construction simulation parameter setting, and other difficult topics, and organize groups to conduct research activities on the application of BIM technology in green building energy consumption analysis. In addition, the BIM collaborative platform is used to connect knowledge inside and outside the classroom. Students can access classroom case models for more in-depth design at any time, and teachers can view students' specific operation trajectories in real time through the platform and provide targeted feedback information.

2.3 Cross disciplinary collaborative teaching organization based on BIM platform

Based on the BIM platform, cross disciplinary collaborative teaching is carried out by simulating the full process of multi disciplinary collaboration in engineering construction, in order to cultivate students' systematic engineering thinking and communication and coordination abilities; Before conducting teaching, it is necessary to form a teaching team composed of teachers specializing in architecture, structure, water supply and drainage, electrical engineering, and other related fields; After the team is formed, a collaborative teaching outline and task allocation book should be jointly developed; In the process of promoting teaching, students from various majors use professional

software such as Revit and MagiCAD to construct relevant models according to the specific requirements of the task book, and regularly integrate and perform collision detection on the models using collaborative platforms such as BIM 360; When dealing with collision problems, students from various majors discuss solutions based on relevant regulations and engineering practice experience. For example, structural majors can adjust the height of beams to avoid water supply and drainage pipelines, while equipment majors can optimize pipeline routing to avoid conflicts with structural load-bearing walls; The teacher team plays a similar role as a project consultant in this process, guiding students to weigh the pros and cons of various solutions from the perspective of the overall project, and ensuring that collaborative teaching results meet functional and economic requirements.

2.4 Implementation of Practical Training and Operation Training of Engineering Software Tools

The BIM practical training session focuses on the gradually progressive training mode of "theory simulation practice", aiming to build a clear skill improvement system. In the basic training stage, by completing the standard case content in the BIM software operation manual, students can master the Revit family parameter setting Basic functions such as Navisworks construction simulation critical path analysis are introduced in the simulation training stage, which includes simplified engineering projects provided by enterprises. Students are required to complete all process operations from model construction to construction progress simulation, and virtual inspection work is implemented through the BIM quality and safety management platform. In the practical training stage, students are directly connected to real engineering projects, allowing them to participate in the practical application of BIM technology in complex deep foundation pit support design, large-scale steel structure hoisting simulation and other scenarios under the joint guidance of enterprise engineers and teachers. In order to ensure good training results, the school has specially established a BIM training base, equipped with high-performance graphic workstations, VR immersive experience equipment and other hardware facilities. A BIM training management system has also been developed to realize the full process data of student training under the joint guidance of enterprise engineers and teachers. Directional recording and intelligent analysis.

3. Evaluation and Analysis of the Effectiveness of BIM Course Teaching

3.1 Case Overview

This evaluation of the teaching effectiveness of BIM courses focuses on the 2021 and 2022 students majoring in civil engineering at a certain university. Among them, 120 students in the 2021 class used traditional teaching methods, while 130 students in the 2022 class participated in innovative teaching practices based on BIM technology, using "a large-scale commercial complex construction project" as the main teaching case. It involves multiple professional fields such as architecture, structure, water supply and drainage, and electrical engineering, with complex spatial surface shapes, dense and staggered mechanical and electrical pipeline layouts, and strict construction period restrictions, covering the entire life cycle of engineering construction from planning, design, construction to operation and maintenance. It is in line with the teaching goal of cultivating students' comprehensive application ability in BIM courses.

3.2 Implementation Process of BIM Course Teaching

Under the innovative teaching mode fully implemented in the stage of carrying out teaching activities, in terms of project-based teaching methods, teachers divide the 2022 students into 26 groups of 5 to 6 people according to the characteristics of project tasks, and arrange each group to be responsible for building BIM models and collaborating on different professional modules. For example, in the pipeline comprehensive optimization task of a commercial complex project, water supply and drainage majors use MagiCAD software to build water supply and drainage pipeline models, and carefully mark relevant parameters such as pipe diameter and slope. Electrical majors use Revit Electrical module to create electrical pipeline models and plan cable tray paths, while structural majors do detailed design work on structural models; At the weekly group meetings organized by the teacher, if a group encounters a conflict between the elevation of structural beams and water supply and drainage pipes during model integration, the teacher will guide students to solve the problem by reducing the height of beams, adjusting the direction of pipes, and other methods based on building codes and construction experience. At the same time, targeted guidance will be given in terms of model accuracy and collaborative efficiency, and the exchange of relevant experience between groups will be advocated. For example, some groups will share tips on using BIM software collision detection function to quickly locate problems and promote common progress among all students.

In the new learning ecosystem created by the close integration of flipped classroom and blended online and offline teaching, teachers will publish various learning materials on the Chaoxing Learning Platform, such as advanced BIM software operation tutorials, detailed interpretation videos of commercial complex BIM application cases, etc., and assign homework tasks such as complex building model construction and special family library development. After students complete the self-learning process, they submit their homework results. When teachers correct their homework, they notice that some students have created irregular building curtain wall families and have errors in parameter settings, so they record specialized Q&A videos to explain and explain; In offline classrooms, teachers conduct in-depth analysis of complex scenarios such as construction machinery selection and site layout in construction simulations based on data information generated from online learning, combined with actual engineering project cases. They organize students to conduct research activities around the theme of "Application of BIM Technology in Energy Consumption Analysis of Green Buildings in Commercial Complex". Students use the establishment of energy consumption analysis models to compare energy consumption data of different design schemes and propose optimization suggestions, effectively cultivating their own innovative thinking ability and teamwork ability in this process.

Based on the BIM platform, cross disciplinary collaborative teaching work is progressing in an orderly manner, which is manifested in the careful development of teaching outlines and task allocation related documents by a teaching team composed of multiple professional teachers; Taking the teaching of a commercial complex project as an example, students from various majors first complete the construction of their own professional models, and then use the BIM 360 collaborative platform to implement integration and collision detection operations. During this process, if a collision is detected between the ventilation ducts and structural beams in a certain area, students from the structural and HVAC majors will jointly discuss and explore, and finally determine a solution to properly solve the problem by locally reducing the height of the beams and optimizing the cross-sectional size of the ventilation ducts. The teacher team closely monitors the various stages of student discussion and decision-making throughout the process, actively guiding students to comprehensively weigh the

advantages and disadvantages of different solutions from multiple aspects such as project cost, construction difficulty, and functional use, in order to cultivate students' global awareness and decision-making ability.

The practical training process strictly follows the "theory simulation practical" training mode. In the basic training stage, students master basic functions such as Revit family parametric driving and Navisworks construction progress 4D simulation by completing hotel building standard cases in the BIM software operation manual; Entering the simulation training phase, a simplified commercial complex project provided by the enterprise is introduced. Students are required to complete the entire process operation from site modeling, building structure design to construction progress simulation. They also use the BIM quality and safety management platform to conduct virtual inspections. For example, in a certain simulation project, students discover safety hazards such as inadequate protective measures for reserved openings in the basement ceiling; In the practical training stage, students participate in actual commercial complex projects with the guidance and assistance of enterprise engineers and teachers, using BIM technology to compare and select deep foundation pit support schemes and simulate large-span steel structure hoisting. For example, in a certain project, BIM simulation is used to optimize the steel structure hoisting sequence, successfully shortening the construction period by 10 days. The BIM training base established by the school is equipped with high-performance graphic workstations, VR equipment, and training management systems, providing solid and powerful support for practical teaching.

3.3 Comparative data analysis of students' learning ability and practical ability improvement

Comparing the learning and practical abilities of students from two grades in a multidimensional manner to comprehensively measure teaching outcomes. In terms of learning ability, the course exam covers BIM technology principles, advanced software operations, and comprehensive project applications. The average score of the 2022 students' course exam reached 87.2 points, which is significantly higher than the 73.1 points of the 2021 students; From the perspective of classroom performance, the frequency of innovative viewpoints proposed by 2022 students during group discussions has increased by 40% compared to 2021, the number of proactive questions has increased by 50%, and the scores obtained from classroom interactions have increased by 35%; In terms of the quality of homework completion, the BIM models submitted by students in the 2022 class are more outstanding in detail processing and technological application innovation, with 48% of excellent assignments, compared to only 20% in the 2021 class.

In the practical ability evaluation stage, according to feedback from enterprise internships, the 2022 students were able to quickly use BIM technology to complete complex model creation and pipeline comprehensive optimization tasks in their internship positions. The average practical ability score was 90.2 points, a significant improvement from the 76.5 points of the 2021 students. Taking the practical achievements of the commercial complex project they participated in as an example, the 2022 student team used BIM technology to implement pipeline comprehensive optimization, reducing collision points by 85%, saving 20 days of construction time and reducing costs by about 1.5 million yuan. In the construction progress simulation process, the optimized construction plan shortened the overall project duration by 18%, while the 2021 students were not significantly improved when participating in similar projects under the influence of traditional teaching mode.

4. conclusion

In summary, this article constructs a multidimensional teaching system such as project-based learning, blended learning, and cross disciplinary collaboration, and verifies the significant effectiveness of BIM technology in civil engineering teaching through practical cases, effectively enhancing students' practical and innovative abilities. However, the integration of teaching resources and the long-term evaluation mechanism still need to be improved. Future research can focus on the integration of BIM technology and emerging technologies, continuously optimize teaching modes, and cultivate higher quality professional talents for the industry.

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