Application of BIM in the Course of Subgrade Construction Technology

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Abstract. The subgrade construction technology course is a core course of the professional engineering of bridges and bridges in higher vocational colleges. Due to the high professional technical requirements, strong professional practice, wide coverage, and rich professional knowledge content, it has led to the teaching of existing classroom teaching methods. The increased difficulty is not conducive to students’ good understanding of three-dimensional structures and complex construction techniques, and it is difficult to combine teaching and learning closely. In order to better carry out the teaching of subgrade construction technology courses, combined with the application of BIM technology in the teaching of subgrade construction technology courses, according to the actual conditions of school teaching, using BIM technology and guiding students to create various bridge models, innovative teaching methods and methods, Improved students’ interest in learning and enhanced their practical skills.

Keywords: BIM · Subgrade construction technology · Course teaching · Teaching model

1 Introduction

In the field of road construction, the application of BIM technology is becoming increasingly mature in foreign countries, and it has also set off a wave of BIM technology application in China. However, how to combine BIM technology and concepts with the teaching of roadbed construction technology courses, how to improve the teaching effect and efficiency of roadbed construction technology courses, and promote the transformation of the education world are far-reaching topics worthy of joint discussion and research by the education and road industry [1]. Taking the teaching reform of subgrade construction technology course as an example, the feasibility of applying BIM technology and its superiority compared with traditional teaching methods are explored. The subgrade construction technology course is a core and backbone professional course for vocational students majoring in road and bridge engineering technology. It mainly studies the construction methods, construction technology, and construction organization and management of bridges. The subgrade construction technology is complex
and updated quickly, the environment is difficult, the engineering volume is large, and the content is important, which places high requirements on the teaching of subgrade construction technology courses. The subgrade construction course of our college has gone through the teaching method reform of “construction drawing as carrier”, and the teaching reform and practice of subgrade construction technology course with the goal of establishing network course has accumulated rich teaching materials and resources, with a strong foundation [2]. On this basis, in order to further solve the problems of the implementation of construction drawing teaching in the course of bridge construction and the effect and efficiency in the process of construction drawing teaching, BIM Technology is used to further deepen the curriculum reform.

Since 2013, universities such as Tsinghua University, Huazhong University of Science and Technology, Shenyang Jianzhu University, and Sichuan University have established BIM-related institutions. The Shaanxi Railway Engineering Vocational and Technical College also established the BIM Technology Application Center in 2013. It can be seen that universities have also attached importance to the research and application of BIM technology. With the establishment of BIM technology research institutions, the strengthening of talent teams, and the application of engineering projects, it will surely guide the teaching reform in the process of talent training.

2 Design of Teaching Methods for Subgrade Construction Technology Course

2.1 Making the Teaching Implementation Plan of Subgrade Construction Technology Course

Based on a complete set of construction drawings under construction, a 1:1 three-dimensional entity model is built according to the actual size of the construction drawings by using Revit and other software. The model can not only combine the whole typical project together, but also can be divided into parts, enriched the teaching materials, enriched the teaching means, and achieved the synchronous update of the teaching content and the specific construction technology and construction process on the construction site.

Integrate the course structure of subgrade construction technology, integrate the original foundation engineering course and subgrade construction technology course into one course. Extend the class time of the original subgrade construction technology course, and add the content of bridge foundation construction in class time based on the original teaching content [3]. Following the natural sequence of subgrade construction, we first start with the construction of the road foundation and gradually transition to the pavement abutment. Finally, we talk about the content of the upper main beam and the pavement. This improves the logic of the subgrade construction technology course from the perspective of construction. And good engineering connection issues are conducive to improving students’ logical training of project construction.

Plan the training of nuclear occupation ability based on BIM technology for subgrade construction technology course construction drawing reading. As one of the main tasks of the subgrade construction technology course is to train students’ ability to read
construction drawings, only after reading the construction drawings can they understand the structure of the construction drawings accurately, and then they can guide the site construction according to the construction drawings and accurately convert the drawings and structures Engineering in kind. Combined with the inspiration of German action-oriented teaching method, according to the actual and objective conditions of our institute, in the implementation of the bridge construction teaching reform organization, our overall plan is based on the construction drawing reading ability and construction ability training ideas:

First, members of the subgrade construction technology course reform team are familiar with a set of typical subgrade drawings, follow the learning rules from simple to complex, and from single to holistic, and use the development and training project of the complete construction drawing in use. According to the actual size of the drawing, a three-dimensional solid model of 1:1 is built using revit. When modeling, there are not only the overall structural effect diagram, but also the detailed steel bar layout diagrams of various parts.

Second, based on the familiar drawings and the ability to establish subgrade model, train students to learn to use Revit and other modeling software, so that students can skillfully view the established model and drawings at the same time, and carry out comparative analysis, so that students gradually have the ability to accurately create three-dimensional BIM drawing according to the construction drawing, and can achieve in the training process Goal of proficiency [4]. The calculation of reinforcement beam quantity in subgrade stage is shown in Fig. 1.

Third, according to the needs of specific teaching situations, after each big situation is completed. Select a construction detail of a typical drawing to guide students to use Revit to accurately build the solid model of each component of the bridge according to the size. Because in the process of model making, it is necessary to strictly refer to the construction drawings, accurately model, and operate the computer room. On the one hand, it improves the students’ ability to solve problems by hands. On the other hand, the model established is visible, and it is easy to check whether the students can really accurately understand the construction drawings. In the course of subgrade construction technology, some teaching situations, such as pile cap, pier, abutment and main beam, are repeated in the teaching practice, so as to improve the students’ reading ability of construction drawings [5].

Strengthen the construction of equipment for the training conditions of roadmap construction technology courses, purchase high-end computers with independent graphics cards that meet the needs of 3D modeling, and establish professional computer rooms and 3D printers equipped with 3D modeling software. Students who have a good level of modeling can allow them to print their work and affix their own information cards as a reward. A circle of cabinets is provided around the computer room. The cabinets store eleven sets of construction drawings prepared for our learning environment. Each set of drawings is 50 copies. It is equipped with various design and construction specifications for roadbeds, construction manuals, and 10 copies of each specification or manual. Equipped with a calculator, drawing tools, and cropping gadgets of 50 copies each for easy reference.
2.2 Establishing a Teaching Model for Subgrade Construction Technology Courses

The basic structure of the teaching model of subgrade construction technology course based on BIM Technology is mainly a whole teaching model of subgrade construction technology course, which is composed of students as the main body, students’ learning activities in the classroom as a small structural unit, with the basic theory of independent learning proposed by social cognitive school and Zimmerman as the axis.
The teaching model is mainly composed of three levels, that is, the basic attainment level—the knowledge promotion level—the inquiry expansion level (as shown in Fig. 3) [6]. Students’ autonomous learning in the classroom is performed in the order shown in the figure. In order to reach the level of inquiry development, students need to first reach the level of knowledge improvement, and knowledge improvement requires students to learn the various advanced rules required by the level of inquiry. For these advanced rules, students must reach the basic achievement level, that is, learn to identify and firmly grasp the specific concepts, rules and definitions (Fig. 2).

![Diagram of Teaching Model](image)

**Fig. 2.** Structure of teaching model of subgrade construction technology course

The main part of the teaching model of subgrade construction technology course includes three closed main loops. The first one is to determine the learning objectives, stimulate learning motivation, recall the existing knowledge in the mind, self-study textbooks, basic standards, consolidate basic exercises, students’ self summary, and students’ self-evaluation. The first loop is designed for the whole class. The main content of learning is the basic concepts, laws, axioms and other declarative knowledge in the textbook. The second main loop consists of determining learning objectives, stimulating learning motivation, recalling the existing knowledge in the mind, self-study teaching materials, improving knowledge, consolidating knowledge practice, learning self summary and self-evaluation of students. This loop is mainly designed for middle-level and above students with certain foundation. The main content of learning is to learn advanced rules such as mathematical thoughts, methods and strategies on the basis of understanding the basic concepts, laws, axioms and other declarative knowledge. The third main loop is composed of determining learning goals, motivating learning, recalling existing knowledge in the mind, self-study textbooks, exploring and expanding, consolidating
and expanding exercises, student self-summary, and student self-evaluation [7]. This
loop is mainly for students with good academic performance, quick thinking and dili-
gent thinking. The main content of learning is to transfer the knowledge from textbooks
to real life to solve problems, so as to develop students’ innovative thinking, expand
students’ horizons, The purpose of solving real life problems.

Each level of learning includes three closed sub loops. The first sub loop consists
of determining learning objectives, stimulating learning motivation, recalling existing
knowledge in the mind, self-study textbooks, self-study inspection, standard practice
consolidation, students’ self summary, students’ self-evaluation and other links. This sub
loop shows that students can achieve the goal by reading and understanding the content
of the textbook and completing the basic standard exercises correctly after setting the
learning goal. In this smooth situation, students can independently complete the contents
of reading materials, internalize basic knowledge, and complete the after-school basic
standard exercises. Teachers can patrol in the classroom and do a good job in guiding
and maintaining classroom discipline. The second sub loop adds collective discussion on
the basis of the first sub loop, which indicates that students encounter certain obstacles
when they read and understand the content of the textbook independently, but these
obstacles in the process of self-study can be solved through collective discussion. Such
collective discussion is mainly carried out among learning groups, so teachers only
maintain classroom discipline and guide students’ learning. Self study textbooks are
mainly completed by students themselves or through collective discussion within the
learning group, and students master the autonomy of learning [8]. The third sub-loop
adds teachers to explain this link on the basis of the second sub-loop. It shows that after
self-study materials and group discussions in the study group, there is still a certain
amount of knowledge understanding and internalization problems that have not been
resolved. At this time, teachers need to give lectures. Teachers’ lectures help students
remove learning obstacles and complete self-study tasks. Achieve self-study goals. Of
course, if after the teacher’s lecture, there are still a small number of students who are
unable to complete the task of self-study materials, the teacher must find out the reason
why the students’ learning is blocked, or re-teach or stop teaching.

The specific implementation steps of the teaching model of subgrade construction
technology course are as follows:

Step1: Determine teaching objectives

(1) The content of the basic teaching materials and the judgment standard to achieve
the learning objectives;
(2) Tips on the specific learning behaviors of each link in the process of students’
learning activities;
(3) Consolidate exercises.

Step2: Motivate learning

Students are not always passive in the process of stimulating the learning motivation.
They need to psychologically imply that they want to learn the content of this lesson
and can learn from each other. The group members in the group should encourage each other to ensure that they and their group Efficient completion of learning tasks.

Step3: Let students recall what they have in mind

In the process of students’ independent recall of existing knowledge, teachers can use language, gesture or other means to situationally restore the abstract text knowledge, so that students can have a sense of immersive experience in the process of knowledge extraction, which is more helpful for students to quickly form a road map into a certain “knowledge area” in their minds, and successfully reach the destination.

Step4: Guide students’ self-study ability

Students’ self-directed learning can’t just start with textbooks. Teachers need to remind students to adopt a combination of self-directed learning and free discussion in groups so that they can learn more knowledge in one lesson. And when the self-learning classroom teaching was first tried in the second grade, teachers needed to guide students to learn together instead of letting students learn freely, so that they could learn more systematic and solid basic knowledge.

Step5: Self study examination

After learning the contents of the textbook independently, students should do exercises according to the passing exercises given by the teacher or the exercises at the back of the textbook and compare them with the true answers given by the teacher, calculate the accuracy rate or the degree of understanding and application, and feed back the comparison results in time. Members of the group urge each other to check whether their learning objectives have been achieved? What is the correct rate of exercises? What are the obstacles to learning goals? What are the difficulties of the poor students in the group. In the process of checking whether the exercises are right or wrong, the teacher can invite the students with good, poor and middle grades to write their solutions on the blackboard, and check whether their solutions are correct together with the whole class. In this way, the teacher can not only understand the students’ autonomous learning in the class, but also facilitate the discussion among the whole class Mistakes in the process of doing the questions.

Step6: Organize discussions

The discussion among the members of the group can begin with the solution of the exercises of a certain classmate in the group, or start with the important and difficult points of study given by the teacher in this class. The discussion about this lesson between the students in the whole class can be started under the guidance of the teacher around the solution process of the practice questions shown by several students on the blackboard. How can a student comment on a student’s problem-solving process? Where is it calculated? Can also point out the reasons and crux of a student’s error proneness? And ask students with strong language organization skills and agile thinking to lead the
classmates to make a summary, so that the students in the class know exactly what is learned in this lesson and where they are in this chapter. Why is it important? Where is the difficulty? How to overcome it? and many more.

Step 7: Key lectures by teachers

In the form of students’ own control of learning progress, Depends mainly on students to succeed, Not through machines and other technical means. “Group teaching complemented by the frequent feedback and individual corrective help required by each student”. It is the essence of learning. Bloom’s mastery of learning is based on a new perspective on students, he thinks “Almost all people can learn what one can learn in the world by providing proper conditions of the past and the present”. This is in line with the promotion of new curriculum reform in China “Commonness + individuality” Cultivated spirit is consistent, That is to say, in the stage of basic compliance, Require each student to meet standards “Mastery Learning”. The basic implementation procedure of teaching is: Analysis of teaching materials - reorganization of teaching materials - Design of “unit feedback - correction procedure” - final evaluation. However, in the classroom teaching situation of autonomous learning, the main task of teachers is to use the “feedback correction procedure” repeatedly and frequently for the students who fail to reach the standard, so that each student can finally complete the learning task at the basic standard stage.

2.3 Realization of Courses in Subgrade Construction Technology

According to the three-level structure of teaching model, the realization of subgrade construction technology course teaching also presents three-level auxiliary structure, namely three-level auxiliary teaching cycle. The first loop is to attract students’ attention, inform students of learning goals, present stimulating materials, provide learning guidance, lead basic exercise questions, provide homework-specific feedback, evaluate homework, teacher summary, and evaluate student knowledge and skills. The second loop is to attract attention, inform students’ objectives, present stimulus materials, provide learning guidance, lead out ability improvement exercises, provide correct feedback on assignments, evaluate assignments, teachers’ summary, evaluate student processes and methods, etc. [9]. The third loop is to draw attention, inform students of goals, present stimulating materials, provide study guidance, lead inquiry and exploration exercises, provide correct feedback for assignments, evaluate assignments, teacher summary, and evaluate students’ attitudes and values. The teaching implementation process of subgrade construction technology course is shown in Fig. 3.

The implementation steps of the roadbed construction technology course are as follows:

Step 1: Attract attention

At the beginning of the class, students should be given stronger and more novel stimuli, help students to condense various other thinking activities before class, and let students’ attention be directed to the classroom quickly.
Fig. 3. Flow chart of subgrade construction technology teaching implementation

Step2: Inform students of goals

The purpose of the teacher to inform the students’ learning objectives is to establish an expectation of the behavior obtained as a result of the learning. It is the main role that learners have in anticipating learning outcomes, enabling them to match their behavior with the type of “correct” behavior they expect. Therefore, reinforcement in the form of information feedback has a further role in confirming learners’ expectations.

Step3: Present stimulus material

In the course of the roadbed construction technology course, advance arrangements must be made for the nature, method, and appropriate time of presenting the stimulating materials. It is important to choose the right time to present the stimulating materials. Generally, a stimulating learning material will be presented before the students learn autonomously, in order to stimulate the students’ curiosity, or present a class when students encounter difficulties in the process of autonomous learning Supplementary materials to help students overcome difficulties, or give a type of extended or supplementary learning materials after learning to deepen students’ knowledge of this type of knowledge.

Step4: Provide learning guidance

According to the different levels of students’ autonomous learning, teachers should give corresponding learning guidance, that is, at the level of basic standards, teachers
should give “master learning” teaching guidance; at the level of knowledge and ability improvement, teachers should give “scaffolding” teaching guidance; at the level of exploration and expansion, teachers should give “insight learning” teaching guidance.

Step 5: Elicit a practice question

Depending on the level of student’s autonomous learning, teachers need to draw different consolidation exercises. At the basic achievement level, students should present basic practice questions that consolidate their knowledge so that they can form a good knowledge structure. In the knowledge promotion level, teachers will give students some more difficult questions than the basic achievement level exercises to improve students’ hands-on ability and once again consolidate the knowledge of the basic achievement level. At the level of inquiry development, the teacher will give practice exercises with fixedness and flexibility to achieve the ability to train students to comprehensively use knowledge in the first two levels of learning.

Step 6: Provide correct feedback on the job

After finishing some exercises, the students will determine whether the answers of some exercises are correct or not through the discussion and comparison between groups, so the teacher must do one thing is to tell the students whether the answers of each exercise they have done are correct or not. But this does not mean that teachers must use the words “right”, “wrong”, “right” or “incorrect” [10–13]. In the classroom, teachers can show whether the exercises are correct or not through follow-up teaching, or use other subtle tips such as nodding, smiling or scanning to show whether the exercises are correct or not. Many times, the exercises in the basic standard level have been learned by students in their early life, so it is unnecessary to explain all the exercises in detail at this time.

Step 7: Teacher’s assessment and assignment

Homework assessment is an important way for teachers and students to interact. Positive homework assessment can help students understand themselves, build confidence, and narrow the distance between teachers and students. Therefore, we need to give more encouragement to students’ homework evaluation. Make the evaluation warm and effective: We must pay attention to the development of students’ personality and the cultivation of students’ willpower. Teachers should make full use of the link of homework evaluation, while guiding students to learn mathematical knowledge, even if it nourishes the students’ hearts, organically infiltrate learning interests, learning attitudes, and the cultivation of good learning habits; timely adjust student learning through homework evaluation, Guide them to learn self-analysis, self-appreciation, constantly improve themselves, and grow up healthily.
Step 8: Teacher summary and evaluation

At the end of a class, teachers need to make a summary of what they have learned in this class, so that students can form a logical vein of knowledge in their heads, which is not only convenient for memory storage, but also can optimize the knowledge structure of students, and easy to recall and extract when they are used in the future. The evaluation of teachers should be comprehensive, but also focus on the students’ learning process, including “knowledge and skills”, “process and method”, “emotional attitude and values”, etc. But especially for the students who encounter obstacles or difficulties in the learning process, teachers should especially explain the methods used to solve the problems, or the creative way of thinking. And the students who have successfully solved difficult problems are praised and affirmed, and all students are set an example to encourage them to learn and improve themselves.

3 Case Analysis

3.1 Pilot Arrangements

According to the specific teaching arrangements, pilot projects were conducted in the subgrade construction courses of the 2013 and 2014 grades of subgrade construction technology. There are 12 classes in this major. Three classes were selected for the pilot. Three teachers led a pilot class and an ordinary class, each with about 45 students. At the end of the semester, through the comparative analysis of the final exam results, the traditional subgrade construction technology course teaching method and the BIM-based subgrade construction technology course teaching method were used to collect the experimental classes and non-experimental classes from the average score and the question type score for analysis.

3.2 Data Analysis

According to the arrangement of the pilot project, the collected final score data of students are sorted out and the following results are obtained.

It can be seen from Fig. 4 that the average scores of the subgrade construction technology courses in the pilot classes are 15.8 points higher than those in the non-pilot classes, which is 24.2% higher than the same period last year. In addition, from the perspective of question type, there is no significant difference between the scores of blank filling questions in pilot class and non pilot class. The average score of sample questions in pilot class is 7.9 points higher than that in non pilot class, 32.1% higher than that in the same period last year, and the average score of map reading questions in pilot class is 11.2 points higher than that in non pilot class, 46.3% higher than that in the same period last year. It is because filling in the blanks is mainly based on memorization assessment content, and the application of BIM technology is not very obvious to improve students’ memorization content, but the average score of case analysis questions and picture recognition problems is obviously improved, especially the picture recognition problems. The range reached 46.3%. This shows that the application of BIM technology
in the teaching process of subgrade construction technology can significantly improve students’ understanding of subgrade structure and construction process, and further enhance students’ ability to identify drawings and optimize construction plans.

![Diagram](image1)

**Fig. 4.** Statistics of final exam scores of 2013 students

![Diagram](image2)

**Fig. 5.** 2014 statistics of final examination results of students

It can be seen from Fig. 5 that the average scores of the subgrade construction technology courses for the 2014 pilot classes are 22.1 points higher than the non-pilot classes, 33.4% higher than the same period last year and 11 percentage points higher than the 2013 class. The scores of fill-in-the-blank questions in the 2014 pilot class and
non-pilot classes are not much different from those in the 2013 class; the average score of the case questions in the 2014 pilot class is 11.9 points higher than that of the non-pilot class, which is 52.7% higher than that of the previous year, and 20 higher than that of 2013 Multiple percentage points; the average score of the picture recognition questions for the 2014 pilot class was 13.3 points higher than that of the non-pilot class, which was 52.8% higher than the same period of the previous year, which was 6 percentage points higher than the 2013 class. The main task is to fill in the blank. There are many assessment contents relying on memory. The application of BIM Technology is not obvious to improve students’ memory content, but the average scores of case analysis questions and map reading questions are obviously improved, especially map reading questions.

| Final grade of 2013 | Final grade of 2014 |
|-------------------|-------------------|
| 88.2              | 81.2              |
| 11                | 12                |
| 34.5              | 32.5              |
| 38.5              | 35.4              |

**Fig. 6.** Comparison of teaching methods in this article

It can be seen from Fig. 6 and Fig. 7 that compared with 2014 and 2013, the performance improvement of 2013 and 2014 non pilot classes is very limited, and the improvement of teaching effect is not obvious. However, the scores of 2013 and 2014 pilot classes increased significantly, especially the scores of map and case questions in 2014 pilot classes increased significantly. This shows that in the application of BIM technology in the teaching process of subgrade construction technology courses, due to the improvement of teachers’ teaching ability, the continuous improvement of teaching materials and teaching design, and the continuous improvement and updating of teaching equipment, students can significantly improve the students’ The ability to learn further enhances the students’ ability to identify drawings and the preparation and improvement of construction plans, improve their cognition and understanding, and improve the efficiency and effectiveness of learning.
4 Concluding Remarks

This paper studies the application of Bim in the course of subgrade construction technology. After several rounds of reform in the course of subgrade construction technology, certain results have been achieved. How to enrich the core of the course teaching, fundamentally improve the students’ core competence in construction drawing reading, and enhance students’ knowledge level and ability level. The three-dimensional modeling of the whole bridge is carried out by Revit, Dassault and other software, the two-dimensional drawings are transformed into three-dimensional entities, the complex subgrade structure is three-dimensional and visualized, the process logic problems are simplified and clear, the problems of construction drawing reading in the teaching process, the inspection of construction process understanding effect and the teaching effect are difficult to grasp are solved, and the teaching effect is achieved through the pilot. However, the requirements of teaching environment and equipment are high, and the investment in teaching is relatively large. In the process of promotion, each college should consider the use in combination with the actual conditions.

5 Fund Projects

Research on the Application of BIM Technology in the Course Reform of Subgrade Construction and Construction (CJJY201912).

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