Teaching Exploration of 3D Modeling Technology and Visualization under Engineering Education Certification

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Abstract: Engineering education professional certification is an internationally recognized quality assurance system for engineering education, and it is an important foundation for achieving international mutual recognition of engineering education and engineer qualifications. The engineering education professional certification in China is organized and carried out by the China Engineering Education Accreditation Association and the Ministry of Education Centre for Higher Education Teaching Evaluation jointly. It is an important component of the "Five in One" higher education teaching evaluation system. Based on the concept of engineering education professional certification, this paper elaborated on the construction ideas of elective courses to meet engineering education certification, and takes the course of "3D Modeling Technology and Visualization" as an example to construct the teaching objectives, teaching content, basic requirements, teaching methods, assessment methods, and score evaluation methods of this course. This course refines and strengthens each knowledge point, while unleashing the enthusiasm and subjectivity of students, enabling them to apply the latest theoretical knowledge of policies, laws and regulations, standards, guidelines, and technical methods to specific engineering examples, enhancing their engineering analysis ability and deepening their understanding of theoretical knowledge.

Keywords: Higher Education; Engineering Education; Elective Courses; Elective Course; Teaching Methods

1. Introduction

At present, the number of ordinary undergraduate engineering graduates in Chinese universities ranks first in the world, accounting for more than one-third of the world [1]. China has established the world's largest engineering education system. Engineering education has cultivated a large number of scientific and technological innovation talents for China, providing strong support for the formation and development of Chinese complete and independent industrial system. In recent years, under the background of the "New Industrial Revolution", Chinese engineering education has continuously made new breakthroughs, and the professional certification system for engineering education is becoming more perfect [2]. In 2017, Chinese Ministry of Education issued a notice on conducting research and practice in new engineering disciplines (Jiao Gao Si Han [2017] No. 6), launching a plan for the construction of new engineering disciplines, further promoting Chinese engineering education to gradually move from a "engineering education powerhouse" to a "engineering education powerhouse" [3-4]. In the context of the construction of new engineering disciplines and the certification of engineering education majors, how to organically integrate teaching content with engineering education certification is an important task faced by engineering education in universities in the new era [5-6]. This article takes the course "3D Modeling Technology and Visualization" in the field of Spatial Information and Digital Technology as an example to explore and practice the certification of course engineering education.

The course of 3D Modeling Technology and Visualization is an important elective course in the field of Spatial Information and Digital Technology. The course will systematically introduce the basic concepts, theories, and methods related to 3D modeling technology, including 3D modeling basics, basic modeling techniques, surface modeling techniques, materials and textures, lighting and cameras, scene animation techniques, etc. Through the teaching of this course, students will master the basic concepts and principles of 3D modeling technology, master the ability to apply the principles and methods of 3D modeling technology to explain and solve practical problems, and understand the cutting-edge dynamics and development trends of 3D modeling technology. This course focuses particularly on cultivating students' hands-on and practical abilities, laying a foundation for studying professional courses, engaging in professional technical work, and conducting scientific research.

2. Course Objectives

Based on the characteristics and content of the course, the course of 3D modeling technology and visualization can be divided into the following three course objectives.

Course objective 1. Master the basic principles and methods of 3D modeling and possess the ability to use 3ds Max software for 3D modeling, and be able to implement and test 3D engineering projects according to user's needs.

Course objective 2. Students are able to identify, quantify, and analyze the potential impact of the development and application of new products, technologies, and processes in 3D modeling technology on society, health, safety, law, and culture.

Course objective 3. Students are able to track the development status of the 3D modeling field and related industries in a timely manner, and express their own opinions on current hot issues.

The relationship between course objectives and professional graduation requirements is shown in Table 1.

Table 1. Supporting Relationship between Course Objectives and Graduation Requirements and Indicator Points

Course objectives	Graduation requirements	Indicator points
Course objective 1	Design/develop plan capability. Graduates can comprehensively apply the principles, technologies, and methods of computer science and spatial information science to design solutions for complex engineering problems in the field of spatial information and digital technology, and develop spatial information application systems or components that meet specific needs, and demonstrate innovation awareness in the design and development process, considering social, health, safety, legal, cultural, and environmental factors.	Graduates are able to implement, test, and operate spatial information and digital technology engineering projects according to the design plan.
Course objective 2	Engineering and Society. Graduates can conduct reasonable analysis based on the background knowledge of engineering projects in the field of spatial information and digital technology and evaluate the impact of engineering practices and solutions to complex engineering problems in the field of spatial information and digital technology on society, health, safety, law, and culture, and understand the responsibilities they should undertake.	Graduates are familiar with the technical standards, intellectual property rights, industrial policies, and laws and regulations related to the field of spatial information and digital technology, and understand the impact of different social cultures on engineering activities.
Course objective 3	Communication and interpersonal skills. Graduates master basic communication methods and skills, and are able to effectively communicate and exchange with industry peers and the public on complex engineering issues in the field of spatial information and digital technology, including writing reports and design drafts, presenting speeches, clearly expressing or responding to instructions, and possessing a certain international perspective. They are able to communicate and exchange in a cross-cultural context.	Graduates have basic expression skills and are able to accurately express their opinions on professional issues through oral, written, and graphic means, respond to doubts, understand the differences in communication with industry peers and the public, and effectively communicate with them.

3. Teaching Content and Basic Requirements

According to the training objectives of this major and the characteristics of this course, the teaching content is divided into 24-hour theoretical teaching and 24-hour experimental teaching.

Theoretical teaching mainly includes six parts, and the first part is the 4-hour foundation of 3D modeling, which includes that (1) Overview of 3D modeling technology (2) Introduction to 3ds Max software (3) Project workflow (4) Editing methods for objects (5) File management methods. Its basic requirements include that (1) Understand the current development status of 3D modeling (2) Familiar with the working interface of 3ds Max software (3) Understand the workflow of creating projects using software (4) Proficient in editing methods for objects, including selection, grouping, copying, array, and basic transformations (5) Master the methods of file management in 3ds Max. This teaching content supports course objectives 1, course objectives 2 and course objectives 3. The second part is a 4-hour basic modeling technique, and its teaching content includes that (1) Modeling of basic objects (2) Modeling of 3D object modifiers (3) Modeling of 2D graphics (4) Composite modeling technology. Its basic requirements include that (1)Students are proficient in using standard primitives to create models and modify parameters (2)Students master the basic methods of 3D object modifier modeling and are proficient in using modifier commands such as bend, taper, twist, FFD, shell, and mesh smoothing (3)Students are proficient in the creation and modification methods of splines (4)Students can master the basic methods of 2D graphic modeling and proficiently use modifier commands such as extrusion, turning, chamfering, and chamfering profiles (5)Students can master the modeling methods of composite objects, mainly including Boolean, super Boolean, shape merging, and lofting. This teaching content supports course objectives 1. The third part is surface modeling for 4 hours, and its teaching content includes that (1) Types of surface modeling (2) Mesh modeling (3) Polygonal modeling (4) Surface slice modeling (5) NURBS modeling. Its basic requirements include that (1) Understand the types and methods of surface modeling (2) Students can proficiently master the basic methods of polygon modeling and master editing commands at the vertex, edge, boundary, polygon, and element sub object levels (3) Understand the methods of mesh modeling, patch modeling, and NURBS modeling. This teaching content supports course objectives 1 and course objectives 2. The fourth part is about materials and textures for four hours, and its teaching content includes that (1) material editor (2) Material type (3) Map channels and map types (4) Creating and calling material libraries (5) Configure external file paths and use resource collectors. Its basic requirements include that (1)Understand the concepts of materials and textures (2) Proficient in using the material editor (3) Proficient in the basic application of standard materials and multi-dimensional sub object materials (4)Understand various texture channels and types (5)Master the basic application of UVW mapping coordinates (6)Master the method of creating and calling material libraries (7)Understand the methods of configuring external file paths and using resource collectors. This teaching content supports course objectives 1 and course objectives 2. The fifth part covers 4-hour lighting and camera technology, and its teaching content includes that (1) Create lighting and arrange lighting reasonably (2) Parameter adjustment of lighting and the relationship between lighting (3) Camera creation and parameter adjustment (4) Installation of cameras in the scene. Its basic requirements include that (1) Master the basic methods of lighting distribution (2) Master the parameter adjustment of lighting and the relationship between lighting (3) Familiarize the characteristics of the camera (4) Master the installation method of cameras in the scene. This teaching content supports course objectives 1. The sixth part is a 4-hour scene animation technique, and its teaching content includes that (1) Key-frame animation (2) Time configuration (3) Curve editor (4) Constraint animation. Its basic requirements include that (1) Understand the production ideas of animation and master basic knowledge of animation rules (2) Master the basic methods of creating 3D animations using key-point animation modes (3) Master the production methods of curve editor animation and constraint animation. This teaching content supports course objectives 1 and course objectives 2.

Experimental teaching mainly includes 7 experimental projects. Experiment Project 1 is a 2-hour introduction to 3D software basics, and its experimental content includes that (1) Interface settings of 3ds Max software, unit settings, and preference settings, etc (2) Basic operations of 3ds Max software: object creation, control of objects, selection of objects, dual tools, position and angle capture, object crowding, frozen objects, hidden and isolated objects, etc (3) Copy group: transform copy, array copy, path array, and mirror array (4)File saving and merging in 3ds Max. Its basic requirements include that (1) Familiar with the interface of 3ds Max software (2) Proficient in the basic operations of 3ds Max software (3) Master various methods of object replication (4) Master the management methods of 3ds Max files. This experimental project supports course objective 1. Experiment Project 2 is a 4-hour three-dimensional basic modeling project, which includes that (1) Editor configuration (2) Common 3D editing commands (3)2D graphic creation, editing splines, and 2D editing (4) Common Composite Object Modeling: Boolean, Shape Merge, and Lofting. Its basic requirements include that (1) Master the method of editor configuration (2) Master commonly used 3D editing commands (3) Master the basic methods of creating and editing 2D graphics (4) Master common composite object modeling methods. This experimental project supports course objective 1. Experiment Project 3 is a 4-hour 3D surface modeling project, which includes mesh modeling, polygon modeling, patch modeling, and NURBS modeling. Its basic requirements include that (1) Understand mesh modeling, patch modeling, and NURBS modeling (2) Master the methods of polygon modeling and proficiently use commonly used editing commands at various sub object levels. This experimental project supports course objective 1 and course objective 2. Experiment Project 4 is a 4-hour material and texture experiment, which includes that (1) The setting of standard materials and their basic properties (2) Settings for multidimensional subobject materials (3) Use of UVW mapping and UVW unfolding modifier. Its basic requirements include that (1) Proficient in using the material editor (2) Understand various texture channels and types (3) Master the method of setting up standard materials and multi-dimensional sub object materials (4) Master the usage of UVW mapping and UVW unfolding modifier. This experimental project supports course objective 1 and course objective 2. Experiment Project 5 is a 4-hour light and camera experiment, which includes that (1) The use of standard lighting, photometric lighting, and daylight systems (2) The use of target cameras and free cameras (3) Development and implementation of lighting and camera deployment plans. Its basic requirements include that (1) Master the ability to create lighting and cameras, and be proficient in setting lighting and camera parameters (2) Master the development and implementation methods of lighting and camera deployment plans. This experimental project supports course objective 1 and course objective 2. Experiment Project 6 is a 2-hour 3D scene animation production, which includes the production of keyframe animation, curve editor animation, and constraint animation. Its basic requirements include that (1) Understand the principles of animation production (2) Understanding the ideas of 3D animation design (3) Master the skills of 3D basic animation production. This experimental project supports course objective 1 and course objective 2. Experiment project 7 is a 4-hour comprehensive 3D modeling experiment, which involves the comprehensive application of basic modeling techniques, surface modeling, materials and textures, lighting and cameras to complete the production of 3D scenes. The basic requirement is to master the basic modeling, surface modeling, materials and textures, lighting and camera techniques for creating 3D scenes. This experimental project supports course objective 1 and course objective 2.

4. Teaching Method

This course mainly focuses on classroom teaching and student hands-on operations. Combining the content of classroom teaching, course experiments and homework are arranged to deepen the understanding and recognition of theoretical teaching content and cultivate engineering practical abilities [7-8]. Moreover, classroom discussions can enhance the learning atmosphere, making students interested and fully involved in classroom learning, improving the overall learning atmosphere of the class, and enhancing the effectiveness of classroom teaching. The relationship between the course objectives and the four teaching stages of classroom teaching, homework, discussions, and experiments is shown in Table 2.

Table 2. Course Objectives and Teaching Processes

Course objectives	Teaching processes			
	Classroomteaching	Homework	Discussion	Experiment
Course objective 1	✓	✓		✓
Course objective 2	✓		✓	✓
Course objective 3	✓		✓	

5. Assessment Method and Score Evaluation Method

5.1 Assessment Methods and Specific Requirements

This course comprehensively evaluates students' mastery of the core knowledge of the course through regular assessments, experimental assessments, and final exam, as well as their ability to apply 3D modeling technology and visualization related knowledge to solve complex spatial information engineering problems. The assessment method fully covers three course objectives, comprehensively reflecting the supporting relationship between the course and the achievement of graduation requirements in this major. The assessment results can serve as the basis for evaluating the achievement of course objectives.

Based on the evaluation of student process assessment and final exam, the course grades are formed, and the weights of each part are as follows.

Process assessment (weight 50%). The process assessment mainly includes three parts (daily homework completion, participation in teaching activities, and experimental assessment) as follows.

(1) Daily homework completion (weight 10%). The teacher evaluates the homework and gives a grade based on its correctness, conscientiousness, and standardization [9].

(2) Participation in teaching activities (weight 10%). It mainly assesses students' classroom performance and homework, as well as their questioning and communication both inside and outside of class [10].

(3) Experimental assessment (weight 30%). This section mainly tests the practical ability of students to apply theory to practice. This section mainly assesses the production ability of 3D models, the ability to assign materials and textures based on the characteristics of 3D models, the ability to lay out lighting and cameras, and the production ability of 3D scene animations. Students can design and write experimental reports based on the experimental questions and objectives proposed by the teacher, combining theoretical principles, to provide the experimental process and analysis of the experimental results.

Final exam (weight 50%). On the basis of assessing students' mastery of basic knowledge, the focus is on assessing their ability to apply theoretical knowledge and solve complex engineering problems related to 3D modeling engineering. The final exam adopts a closed-book examination format, and the main exam question types can be multiple-choice questions, true/false questions, fill in the blank questions, noun explanations, short answer questions, and essay questions.

5.2 Score Evaluation Method

The process assessment score consists of three parts (daily homework score, participation in teaching activities score, and experimental assessment score). The corresponding scoring standards are shown in Table 3-5.

Table 3. Scoring Criteria for Daily Homework Grades

Score / Observation points	90-100	70-89	60-69	0-59	Final score
Completion status (Weight 10%)	Complete all tasks on time	Complete all tasks with a delay	Final on-time partial completion	Delayed partial completion	
Accuracy (Weight 70%)	Accurate	Basic accuracy	Moderate inaccurate	Inaccurate	
Normalization (Weight 20%)	Normalization	Basic normalization	Moderate normalization	Nonstandard	

Table 4. Scoring Criteria for Participating in Teaching Activities

Observation points \ Score	90-100	70-89	60-69	0-59	Final score
Mutual evaluation of homeworks (Weight 50%)	Students are able to complete the mutual evaluation of homeworks on time, seriously, and meticulously, and can correct errors in homeworks and provide feedback.	Students are able to complete the mutual evaluation of homeworks on time and in a more serious and meticulous manner, and provide appropriate homework remarks.	Students are able to complete the mutual evaluation of homeworks on time and provide homework ratings.	Students are unable to provide the mutual evaluation of homeworks on time.	
Classroom questioning (Weight 25%)	Students are able to actively and correctly answer questions.	Students are able to answer most questions correctly.	Students are able to answer a small number of questions.	Students cannot answer questions.	
Extracurricular communication (Weight 25%)	Students are able to frequently communicate with teachers on relevant issues.	Students occasionally communicate with teachers on relevant issues.	Students rarely communicate with teachers on related issues.	Students never communicate with teachers about related issues.	

Table 5. Scoring Criteria for Experimental Scores

Observation points \ Score	90-100	70-89	60-69	0-59	Final score
Basic theory (Weight 20%)	Students are very clear about the theoretical knowledge required for experiments.	Students are clear about the theoretical knowledge required for experiments.	Students have a basic understanding of the theoretical knowledge required for the experiment.	Students are not clear about the theoretical knowledge required for the experiment.	
Selection and analysis of experimental plans(Weight 40%)	Students are able to access relevant information and choose experimental plans that are very scientific and reasonable, and analyze correctly.	Students are able to access relevant information and choose experimental plans, and analyze correctly.	Students are able to access relevant information and choose a basic reasonable experimental plan, but the analysis is not entirely correct.	Students are able to access relevant information, but their chosen experimental plan is unreasonable and their analysis is incorrect.	
Analysis and summary of experimental results(Weight 30%)	The experimental data, results, analysis, and summary are complete and accurate.	The experimental data, results, analysis, and summary are basically complete and accurate.	The experimental data, results, analysis, and summary are partially complete and accurate.	The experimental data, results, analysis, and summary are incomplete and inaccurate.	
Quality of experimental report(Weight 10%)	The experimental report is standardized and complete.	The experimental report is generally standardized and complete.	The experimental report is standardized but incomplete.	The experimental report is not standardized and incomplete.	

The final exam is designed based on the course objectives and assessment requirements, to comprehensively examine students' mastery of course related knowledge, as well as their ability to apply and solve complex engineering problems comprehensively. The design of test questions should ensure that exam scores can be used to evaluate the achievement of course objectives. Each exam question should meet the institutional requirements of Henan

University of Technology for exam proposition in terms of difficulty, coverage, and repetition rate over the years, and provide corresponding reference answers and scoring standards.
The weights of course assessment methods in course objectives is shown in Table 6.

Table 6. Weights of Assessment Methods in Course Objective Evaluation

Course objectives	Assessment method/weight
Course objective 1	Final examination/50%
	Process assessment/50%
Course objective 2	Final examination/50%
	Process assessment/50%
Course objective 3	Final examination/50%
	Process assessment/50%

6. Conclusions

Under the background of engineering education professional certification, based on the concept of engineering education professional certification, this paper explores the elective course of 3D Modeling Technology and Visualization in the field of Spatial Information and Digital Technology. The course objectives, teaching content and requirements, teaching methods, assessment methods, and grade evaluation methods are provided.

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