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Construction and Practice of the First-Class Course of "3D Printing Manufacturing Technology"

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Abstract: Based on the current status of 3D printing courses at Xuchang University, this paper analyzes the pain points and issues that exist in the course. By adopting a reverse thinking approach of "industry-job-major-course", typical thematic modules and experimental projects are constructed based on the knowledge, abilities, and qualities target matrix, which have "advanced" and "innovative" characteristics in student training, and provide a certain degree of challenge. By exploring the ideological and political elements of the course, a student-centered, integrated teaching model of "teaching, learning, and doing" is developed through a blended online and offline teaching approach. A course grading system is also implemented, combining "online and offline blended assessment", "formative evaluation", and "summative evaluation". After four years of practice, the teaching effect of the course has been significantly improved, effectively enhancing the students' 3D printing engineering practical and innovative entrepreneurial abilities.

1. Introduction

2019 was undoubtedly an important year in the history of education in China, as from April to October, the Ministry of Education issued a series of policies implementing the "Double First-Class Plan" for undergraduate programs [1, 2] and courses [3, 4], which marked the beginning of a three-year national and provincial initiative to establish first-class undergraduate programs and courses in various universities across the country. The goal of the "Double First-Class Plan" for undergraduate programs is to strengthen undergraduate education, establish first-class programs, cultivate first-class talents, comprehensively revitalize undergraduate education, and enhance the ability to train talents. The purpose of the "Double First-Class Plan" for courses is to strengthen teachers, improve courses, implement strict management, keep students busy, and achieve practical results. Establishing first-class undergraduate programs is a complex and systematic project, and building first-class courses is an important support for this initiative [5].

3D printing technology, also known as additive manufacturing, is a rapidly developing new digital intelligent manufacturing method in recent years, which is considered one of the world's three major technologies in the 21st century. It subverts the traditional CNC technology based on subtractive manufacturing and enables the personalized customization of any complex parts, which will profoundly impact the future production and lifestyle of human beings. However, the current

establishment of 3D printing-related majors and course systems in domestic universities is still incomplete, unable to meet the demand for innovative and application-oriented talents in the 3D printing manufacturing industry [7,8]. In 2021, the major of mechanical design, manufacturing, and automation at Xuchang University was recognized as a provincial-level first-class undergraduate program construction site. In response to the demand for first-class undergraduate program construction, the 3D printing manufacturing technology course follows the outcome-based education (OBE) educational concept, adopts the overall idea of "industry-post-job-major-course" reverse deduction for teaching content design, and has "high-level" and "innovative" knowledge and ability cultivation of students, with certain "challenge". The course actively carries out blended online and offline teaching to solve the four major pain points in the current course.

2. Objective and Orientation of Course Construction

Xuchang University adheres to the educational orientation of "locality, application, service, and internationalization". In the context of the global strategic planning of "Industry 4.0" and "Made in China 2025", the university is committed to the 3D printing manufacturing industry. Based on the OBE teaching philosophy and guided by innovation-oriented talent cultivation and moral education, the university emphasizes the improvement of students' engineering application and innovation practical abilities, aiming to cultivate high-quality innovative and applied talents that are in line with the university's locality, application, and internationalization education orientation.

Through the study of this course, students will acquire proficiency in three key areas. Firstly, knowledge goals such as mastering the fundamental principles of 3D printing technology, 3D measurement and reverse modelling methodologies, as well as understanding the design and development process of open-source 3D printing systems, along with the selection of appropriate 3D printing materials and process parameters. Secondly, skill goals encompass the ability to operate and maintain 3D printing equipment with precision, analyse and resolve complex engineering problems within the 3D printing arena, adeptly design optimized solutions for intricate engineering problems, independently acquire novel knowledge, and innovate new 3D printing technologies. Lastly, quality goals comprise of deepening ideological and political theories teaching within the course content, embedding the "3D Printing Character Profile" story, fostering a sense of patriotism, cultivating a craftsman's spirit, developing engineering literacy, and inspiring an innovative consciousness. The teaching team's proposed objectives integrate knowledge, skills, and qualities to cultivate innovative applied talents honed in the engineering sphere. These goals aspire to engender individuals with a comprehensive development of "morality, intelligence, physical health, aesthetics, and labour skills".

3. Key Problems Solved by the Course

The course team has identified four major pain points in the current course based on the university's mission and professional positioning. These include:

(1) A mismatch between the course's teaching content and the speed of 3D printing technology updates, as well as a disconnected from the skills required in professional positions. To address this, the course objectives, content, teaching methods, and assessment modes have been reconstructed and optimized to align with the pace of new technology development and meet the needs of students' skill development;

(2) A lack of strong subjective initiative on the part of students in participating in course activities, and a lack of challenge in course teaching. To tackle this, a blended online and offline teaching model has been adopted, based on project-based teaching methods. By publishing project tasks online and encouraging student self-study, and using flipped classrooms and exhibitions

offline, students' autonomous learning has been fully mobilized, and their sense of achievement has been enhanced through project challenges;

(3) Insufficient integration of knowledge transmission, skills training, and moral education. This has been addressed by optimizing the offline classroom teaching model, creating realistic work scenarios, and digging deeply into ideological and political elements in the course, truly integrating knowledge transmission, skills training, and moral education. This approach enables students to develop comprehensive engineering capabilities, innovation awareness, and a sense of responsibility;

(4) A singular focus on "knowledge and results" in the assessment method, while ignoring "skills and processes". To solve this, a student-centred, engineering-capability-focused, diversified assessment model has been adopted, combining formative and summative evaluations to construct an evaluation system.

4. Course Design Ideas

The overall design principle of the course is to target the technical requirements of talent development in the domestic 3D printing digital intelligent manufacturing industry. Following the overall design concept of "industry-major-job-post-course" and referring to the national 3D printing industry technical standards, the course is developed based on the technical abilities required for enterprise positions, with the aim of cultivating students' engineering and technical capabilities. The design of the course is based on the achievement of the ability cultivation goals, and project tasks are organized based on the engineering R&D process, forming an integrated teaching mode of "teaching, learning, and doing". Through the joint efforts of industry technical personnel and professional teachers, specific learning contents are determined through professional teacher and enterprise expert research and analysis, work task summary, and course learning objectives clarification. Specifically, this includes three aspects:

(1) Constructing the course learning field based on the vocational work process;

(2) Highlighting the cultivation of engineering application technical abilities;

(3) Focusing on cooperation with industry enterprises to emphasize the applicability, openness, and practicality of the course.

5. Design of Course Content

The course's typical six subject modules and six experimental projects are designed using the reverse reasoning of "industry-post-major-course" and the knowledge objective, ability objective, and quality objective matrix. The six subject modules include: introduction to 3D printing technology, classification and comparison of principles of 3D printing technology, design technology of reverse engineering model for 3D printing, application of 3D printing technology and case analysis, design and development of 3D printing software system, analysis of open source 3D printer and project development. The course's progressive and comprehensive hierarchical relationship ranges from basic knowledge to design applications to system development and dynamically introduces the latest scientific and technological research in the industry, which has a "high-level" and "innovative" quality in student knowledge and quality ability cultivation, and presents a certain "challenge". The university has invested more than 1 million yuan in total to purchase FDM printing equipment, light-curing printing equipment, laser internal adjustment printing equipment, and handheld laser scanners. The teachers in the course group have developed their own clay printing equipment, DLP light-curing printing equipment, micro-drop jet printing equipment, and high-voltage electric field-driven current fluid printing equipment. The integration of existing 3D printing experiments and training equipment has been carried out to make the course

a platform for six printing experimental projects, including 3D printing model building and control software cognition, desktop FDM 3D printing, light-curing SLA 3D printing, handheld laser scanning, and laser internal carving 3D printing.

The course incorporates the "3D Printing Character Profile" story, delving deep into the ideological and political elements of moral education to cultivate students' character, and collects, organizes, and produces over 500 online teaching resources such as animations, videos, and micro-courses, as well as over 20 engineering case studies, 4 sets of test question banks, and 10 interactive topics. By organizing and integrating existing 3D printing experimental and training equipment, a comprehensive 3D printing training platform has been provided for offline courses. The "Personalized Innovative Design Product 3D Printing Production" open experiment project has been actively carried out to help students participate in various subject competitions and graduation designs.

6. Organization, Implementation and Assessment of Course Teaching

In response to the practical nature of the course, a real project-based approach is adopted, organizing the teaching content and activities according to actual logical relationships. The course also actively promotes blended learning and flipped classroom teaching reforms, constructing a comprehensive online and offline mixed teaching system consisting of multimedia classrooms, online learning platforms, and open laboratories. Through a progressive teaching method that starts with teacher-led instruction, moves on to guided student self-learning, and culminates in independent student completion of project objectives, a student-centred, integrated teaching model is established, effectively addressing the issue of low student engagement and insufficient course challenge.

The teaching process is as follows: before class (online), the course content resources and project tasks are distributed in advance through the Learning Platform, so that students learn and complete self-study and assessments online. During class (offline), based on the student's learning performance, the teacher provides explanations for key knowledge points and corrects questions. The teacher demonstrates and operates the printing equipment based on real project tasks, guiding students to independently complete project tasks to enhance the innovation and challenge of classroom teaching. After class (offline), student groups design 3D models and 3D print in the open laboratory according to the project tasks, summarize and report on their projects. The reflections and experiences are written based on the "3D Printing Character Profile" story.

To cater to the strong engineering practicality of the course, a blended assessment system is adopted, which integrates online and offline assessments and combines formative and summative evaluations. The online assessment includes video learning, quizzes, assignments, project tasks, and interactive communication, while the offline assessment includes practical skill tests, thematic presentations, and science and technology product design and production. This effectively addresses the pain points of a single evaluation method for course assessment, which only values "knowledge and results" while neglecting "skills and processes".

7. Course Features and Innovation

The course features a combination of knowledge dissemination and skill training, integration of innovative capabilities and engineering literacy, as well as a blend of online autonomous learning and offline student development teaching, in the context of the development of new engineering disciplines and first-class professional construction. The course is designed to deliver the knowledge of 3D Printing Manufacturing Technology based on the talent needs of the industry and the characteristics of applied universities and majors.

Teaching reforms and innovations:

(1) Course design philosophy: Based on the national 3D printing industry standards and the technical requirements of enterprise job positions, the course objectives for student engineering and technical abilities are established to achieve a restructured course design.

(2) Teaching modes and methods: Given the strong practical application of the course, real project tasks are used to organize teaching content and activities according to their actual logical relationships. Teaching is conducted through a blended online and offline approach, and through methods and means such as a flipped classroom, to create an integrated teaching model of "teaching, learning, and doing", truly achieving the integration of theory and practice.

(3) Ideological and political theories teaching in all courses: The ideological and political elements contained in the course content are thoroughly excavated, and the "3D Printing Personnel Profile" story is condensed and reasonably integrated into the teaching process, highlighting the organic integration of knowledge, skills, and qualities to emphasize the function of character-building education.

(4) Course assessment: Diverse formative assessment modes are adopted, combined with course objectives and requirements, to reinforce the diverse assessment methods such as comprehensive skills tests, technological design works, and project topic reports, which are oriented towards evaluating students' abilities and qualities. The assessment combines formative and summative evaluation methods.

(5) Evaluation feedback: An improved teaching evaluation feedback mechanism has been established, which effectively and continuously improves the course and further enhances students' engineering abilities and innovative spirit, supporting their graduation design and various disciplines competitions, and making their abilities stronger.

8. Course Evaluation and Effectiveness

As of now, four cohorts of students have used the course resources, with a cumulative total of over 700 users. Especially during the past three years of the pandemic, blended online and offline teaching has been widely used and well-received by students. This course has received excellent results in internal supervision and student evaluations in recent years, ranking in the top 10% of the whole university. The teaching resources of the course have been shared and evaluated by peer professionals and industrial enterprises, with significant feedback results. The classroom participation has significantly improved, and students have a high satisfaction rate with the course teaching, with an increasing number of students enrolling every year. Students' feedback indicates that the course content is detailed and comprehensive, and it effectively consolidates their knowledge. The teaching arrangement is careful and thoughtful, and teaching materials are abundant and comprehensive, which enhances their engineering application ability, innovation practice ability, and self-learning ability. According to peer teachers, "The course has abundant teaching resources, innovative and comprehensive knowledge content, remarkable teaching effect, and can provide demonstration and high-quality sharing teaching resources for domestic 3D printing courses, as well as practical teaching references for domestic 3D printing technology course teachers." According to 3D printing companies, "The course meets the talent demand for the current 3D printing digital intelligent manufacturing industry, coincides with the needs of talent cultivation for 3D printing product technology development and application promotion, and has good application promotion value." The course effectively supported students to win over 50 awards in various subject competitions, complete over 30 3D printing graduation design topics, and apply for and obtain 4 patents. Course team members have completed two teaching and research projects and won one university-level teaching achievement award, and published five teaching and

research papers. The course was selected as the first batch of characteristic course construction projects for transformation and development, the first batch of demonstration application-oriented course construction projects, and the first-class undergraduate course construction projects in Xuchang University, and has passed the university's acceptance smoothly.

9. Conclusion

(1) The teaching objectives proposed by the course team, which integrate knowledge, skills, and qualities, aim to cultivate new innovative applied talents in the field of engineering with comprehensive development in morality, intelligence, physical health, aesthetics, and labor skills.

(2) The design of the course is based on the achievement of the ability cultivation goals, and project tasks are organized based on the engineering R&D process, forming an integrated teaching mode of "teaching, learning, and doing".

(3) The course's typical six subject modules and six experimental projects are designed using the reverse reasoning of "industry-post-major-course" and the knowledge objective, ability objective, and quality objective matrix.

(4) The course also actively promotes blended learning and flipped classroom teaching reforms, constructing a comprehensive online and offline mixed teaching system consisting of multimedia classrooms, online learning platforms, and open laboratories.

(5) The teaching effect of the course has been significantly improved, effectively enhancing the students' 3D printing engineering practical and innovative entrepreneurial abilities.

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References

[1] Ministry of education. Opinions of the Ministry of education on the implementation of first-class undergraduate course construction (J.G. [2019] No.8) [J]. Bulletin of the State Council of the people's Republic of China, 2020 (5): 57-62.

[2] Wang Jianhua. Reflections on the construction of first-class undergraduate majors - also on the "Double First-Class Plan". (2019) Chongqing higher education research, 4, 122-128.

[3] Wu Yan. Building a "Golden Course" in China. (2018) China University Teaching. 12, 4-9.

[4] Li Zhiyi. My Opinion on "Easy-A Courses" and "Golden Courses". (2018) China University Teaching. 12m 24-29.

[5] Zhang Hongwei, Jiang Mingxia, Lan Liqiong. The essence of first-class course construction: ideological and academic. (2020) China University Teaching.12, 36-41.

[6] Fu Yu, Hao Liping, Hou Liyuan, et al. 3D printing technology and its enlightenment to mechanical teaching. (2015) Journal of Inner Mongolia Radio & TV University.1, 101-104.

[7] Chao Yanpu. Exploration and Practice of Innovative Design and Manufacturing of 3D Printing. (2017) China Modern Educational Equipment. 7, 60-62.

[8] Wang Yueji, Cheng Shali, Liu Jinglu, et al. Research on the Reform of Blended Teaching Mode of "3D Printing" Engineering Training Course. (2018) the Science Education Article Collects .10, 65-66.