

Reconstructing and Implementing Science Education Courses for Preservice Teachers Based on 3D Printing Technology

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ABSTRACT

In the context of new era educational demands, science education for Preservice teachers has certain limitations. This paper explores a classroom reconstruction path using the “3D Modeling and Printing” course as an example. Starting from the educational value of 3D printing technology and the training needs of Preservice teachers, and combining constructivist theory, Challenge-Based Learning (CBL), and the TPACK framework, we design a three-stage CBL-like task chain of “technology mastery → scientific application → teaching innovation”, and build a “three-ring nested” course framework. Through action research, closed-loop optimization is achieved. This paper also elaborates on course design and implementation, including the design of the three-stage task chain and teaching cases, and analyzes teaching effectiveness. The aim is to rejuvenate the curriculum ecosystem of technology-related courses in normal universities. It provides a new model and a replicable template for cultivating high-quality science education teachers and meeting the demand for cross-disciplinary practical abilities. This will promote educational innovation.

Introduction

As global educational technology advances rapidly, traditional teaching methods can no longer meet the diverse educational demands. UNESCO's “Education 2030 Framework” advocates STEM education integration internationally. In the US, STEAM education promotes cross-disciplinary innovation through Project-Based Learning (PBL). In China, the Ministry of Education and 17 other departments issued the “Opinions on Strengthening Science Education in the New Era for Primary and Secondary Schools”, which calls for improving the sci-

ence curriculum system and teaching methods^[1].

However, there are still limitations in the science education of normal university students. Existing studies mostly focus on the technical operation level, lacking deep integration with teaching design and educational scenarios. There is no systematic training program for all Preservice teachers. Therefore, this paper takes the “3D Modeling and Printing” course as an example to explore the path of classroom reconstruction. It fully utilizes the educational value of this technology to promote the development of science education towards cross-disciplinary integration and technological innovation.

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1 The Educational Value of 3D Printing Technology and the Training Needs of Preservice teachers

1.1 Innovative Applications of 3D Printing Technology in Subject Teaching

Practical teaching is crucial in normal education for teacher preparation. 3D printing technology offers new avenues for practical teaching. Preservice teachers can design and produce various teaching models and learning tools, simulate experimental scenarios, and make experimental equipment. This not only reduces teaching and experimental costs but also enhances the practicality of teaching^[2].

For instance, in science teaching, teachers can create biological structure models to help students understand complex biological systems. In mathematics teaching, geometric shapes can be printed to strengthen students' spatial thinking. In Chinese teaching, story scene models can be printed to enhance classroom fun.

1.2 The Important Role of 3D Printing Technology in Cross-disciplinary Education

3D printing technology has significant advantages in cross-disciplinary education. By designing comprehensive projects and implementing them with this technology, deep integration of multiple disciplines can be promoted. For example, when designing an "ancient architectural model", students can combine historical knowledge with engineering design to create an intuitive model of the architectural structure. Such cross-disciplinary projects require students to apply their knowledge to solve real-world problems, cultivating innovative thinking and practical abilities.

1.3 3D Printing Technology's High Alignment with Personalized Education Needs

Modern education emphasizes the implementation of personalized teaching. 3D printing technology aligns well with this need. Teachers can customize teaching models and learning tools based on students' learning progress and interests, effectively achieving differentiated teaching. For example, for students who are slower to learn, teachers can design simple 3D printed teaching aids to help them grasp basic knowledge. For advanced students, more challenging projects can be designed to inspire their creativity.

2 Theoretical Foundations and Research Framework

2.1 Theoretical Support

Constructivist learning theory stresses "learning by doing" for knowledge construction, offering a basis for step-by-step task design. It argues that learners build new knowledge on their existing foundation through exploration and practice^[3]. In mastering 3D printing technology, Preservice teachers can gradually acquire relevant skills and apply them to teaching practice by completing a series of tasks.

The Challenge-Based Learning (CBL) model promotes high-order ability development through real-world problem-solving^[4]. It meets the practical ability training needs of Preservice teachers. In 3D printing courses, setting challenging tasks can stimulate students' interest and enthusiasm, encouraging them to apply their knowledge to solve real-world problems. This enhances their practical and innovative thinking abilities.

The TPACK framework emphasizes that teachers should have technical knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), and their integration (TPACK)^[5]. In 3D printing-related normal education course design, a three-dimensional evaluation system can be built based on the TPACK framework. This ensures that Preservice teachers can use technological tools and achieve educational transformation.

2.2 Research Framework Design

Based on these theories, this study reconstructs the curriculum system into a three-stage task chain of "technology mastery → scientific application → teaching innovation". Using action research, closed-loop optimization of teaching is achieved, forming a "three-ring nested" course framework:

1. Inner Ring (Technology Layer): Focuses on the proficiency of 3D modeling and printing skills. The main goal is to enable students to skillfully master the basic operation of 3D modeling software and 3D printing equipment.

2. Middle Ring (Science Layer): Emphasizes cross-disciplinary knowledge verification and logical integration. After students have acquired certain technological skills, their knowledge of subjects is combined with what they have learned for cross-disciplinary knowledge verification and logical integration.

3. Outer Ring (Teaching Layer): Promotes the transformation of technological achievements into teaching

resources. The ultimate goal is to transform technological achievements into practical teaching resources for application in teaching practice.

3 Course Design and Implementation

3.1 Design of Three-Stage Challenge-Based Task Chain

3.1.1 Technology Mastery Stage

Basic modeling tasks are used to strengthen software operation skills. For example, using easy-to-learn software like TinkerCAD or 3D One, students are required to complete the design and printing of simple models. Students need to master the basic operation process of 3D printers, including equipment debugging, material selection, and printing parameter settings. Specific practice tasks are arranged, such as gear modeling and support structure optimization, to familiarize students with operation processes and skills. Meanwhile, a micro-project-driven approach is adopted, involving students in life-creative model printing projects. Combined with operation manuals and video resource libraries, abundant learning resources are provided to train basic skills and strengthen engineering thinking.

3.1.2 Scientific Application Stage

Embedding a scientific verification link, scientific inquiry tasks are set. Teaching models and learning tools of diverse types are designed in combination with the characteristics of disciplines. Students are required to revise model designs in line with subject knowledge and write analytical reports. On the basis of the existing curriculum framework, the resource linkage channels of related disciplines such as biology and geography are connected. For example, biology teachers can guide students in revising model structures based on cell anatomy principles. Geography teachers can guide students in making planetariums of the Earth, Moon, and Sun to verify the accuracy of orbital parameters. By forming a cross-domain mentor group of “science education + specialized disciplines + IT teaching”, multi-disciplinary guidance and support are provided for students. This systematically improves the scientific rigor and teaching suitability of teaching aids.

3.1.3 Teaching Innovation Stage

Complete the development and suitability verification of teaching resources. Specific lesson plans are designed to closely integrate 3D printing technology with teaching content. A feedback mechanism between “technology-science” is established to ensure technological achievements can be accurately transformed into teaching-compatible

resources. Relying on the “University-Primary School Collaborative Platform”, trials are conducted in real-world teaching scenarios. Close cooperation is established with primary school teachers to jointly develop lesson plans that meet the new curriculum standards for primary schools. Joint trials are carried out. Classroom observation data is collected to optimize teaching resources and enhance the compatibility between teaching aid development and classroom teaching needs. A three-dimensional evaluation scale—covering technology, scientific logic, and educational suitability—is used to comprehensively assess learning outcomes for curriculum improvement.

4 Teaching Case Design and Theoretical Value

4.1 Case 1: Development of Animated Teaching Aids for Chinese Idioms

This case aims to develop teaching aids for primary school Chinese idiom stories to enhance preservice teachers’ future students’ understanding and interest in idioms. First, the meanings, usages, and backgrounds of idiom stories are analyzed. Then, role-joint models are designed for 3D printing to perform actions in story scenes. Finally, trials are conducted in actual classroom settings. Feedback from students and teachers is collected to optimize the teaching aids.

This case validates the integration logic of “technology-subject-pedagogy” in the TPACK framework. By applying 3D printing technology to Chinese teaching, it shows how technology can combine with subject knowledge and pedagogy to create effective teaching resources. This integration improves teaching fun and intuitiveness, offering a better learning experience and enhancing teaching effectiveness.

4.2 Case 2: Making and Comparing Animal and Plant Cell Models

Based on the knowledge of animal and plant cell structures, this case uses 3D modeling software to design models of animal and plant cells and print them as teaching aids. Teachers guide students in selecting appropriate geometric shapes to represent different cell structures, such as spheres for the cell nucleus and ellipsoids for mitochondria. These structures are combined in the correct proportion and positional relationship to form complete models of animal and plant cells. During the design process, students are encouraged to be creative, adding colors or textures to different cell structures for easier distinction and observation. Finally, students use the models to compare and analyze the differences in cell structures, filling in tables, drawing diagrams, and discussing.

This case follows the CBL theory. Tasks progress from knowledge learning to model design and production, and then to comparative analysis, gradually enhancing students' scientific thinking and inquiry abilities. It also aligns with constructivist learning theory. Through hands-on practice and thinking, students construct and improve their knowledge system.

4.3 Teaching Effectiveness Analysis

4.3.1 Student Ability Development

Through the above curriculum design and teaching cases, students can achieve step-by-step development in “technological proficiency → scientific inquiry ability → teaching transformation ability”. In terms of technological proficiency, students become skilled in 3D modeling and printing technologies, independently completing various model design and production tasks. In scientific inquiry ability, students learn to use subject knowledge to scientifically verify and analyze models, cultivating rigorous scientific thinking and inquiry skills. In teaching transformation ability, students can transform technological achievements into practical teaching resources and apply and optimize them in real teaching scenarios, enhancing teaching practice and innovation abilities.

4.3.2 Curriculum Ecosystem Optimization

Through cross-disciplinary task design, the traditional isolation of technology-related courses can be broken. This promotes the construction of a STEAM curriculum cluster. This cross-disciplinary curriculum model integrates teaching resources and methods from different disciplines, offering students a richer and more diverse learning experience^[6]. It also provides teachers with more opportunities for teaching innovation, promoting their professional development and curriculum reform. Moreover, the collaborative mechanism between universities and primary schools will be further deepened, facilitating the sharing and optimal allocation of educational resources and providing a strong guarantee for improving educational quality.

5 Conclusions and Prospects

Led by the “classroom transformation”, this study reconstructs the curriculum ecosystem of technology-related courses in normal universities. It addresses the issue of insufficient integration of “technology-science-education” in preservice teacher training. A feasible solution is offered, providing a new model for cultivating science education teachers. In response to the “cross-disciplinary practical ability” requirement in the “Compulsory Educa-

tion Science Curriculum Standards”, it offers a replicable curriculum template for training new-type teachers who “understand technological principles and can teach science with technology”.

In the future, the three-stage task chain mode of “technology mastery → scientific application → teaching innovation” can be extended to more courses to promote sustained educational innovation. The university-primary school collaboration mechanism can be further deepened to ensure research results are directly applied to real-world teaching, providing strong support for educational development.

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