

Preliminary Study on the Open Course Design of Geoscience 3D Printing Laboratory in the context of Digital China

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Abstract: Talents with digital knowledge structure and practical ability are the "main force" to realize the construction of digital China. As the core element of subject education, the course is the specific form and effective grasp to achieve the goal of talent training. Based on this, this paper explores the design of the open course of the Geo-science 3D printing laboratory. This course allows students to immerse in the process of solving scientific research problems by integrating the current cutting-edge information technology with their major, and accumulate the knowledge, energy and practical skills needed to participate in the construction of digital China after graduation.

Keywords: Digital; 3D Printing; Open Course Design; Talent Training.

1. Introduction

According to the "Plan for the Overall Layout of Building a Digital China" issued by the Central Committee of the Chinese Communist Party and The State Council in February 2023, tens of thousands of talents with digital knowledge structure and digital practical abilities are urgently needed for the construction of Digital China [1] [2] [3]. As the cradle of talent growth, colleges and universities cultivate compound talents with innovative thinking, innovative abilities, multi-discipline and multi-perspective, which plays an important role in promoting the construction of digital China upon graduation [4] [5].

In the context of Digital China, 3D printing technology has emerged as a leading innovative technology pursued by countries worldwide in fields such as military, medical care, fashion and education. It is a product of multidisciplinary integration, including virtual simulation, 3D mathematical modeling, electromechanical numerical control, etc. However, in the study of Digital Earth, there is a need for further exploration on how to effectively integrate 3D printing technology into scientific research.

The objective of this paper is to investigate the design and execution of an open course for the Geoscience 3D Printing Laboratory that aligns with contemporary demands. The course adopts an interdisciplinary and innovative approach, with a forward-looking curriculum at its core. By integrating cutting-edge information technology with the students' field of study, the course immerses them in a comprehensive process aimed at solving scientific research problems. Through project-driven teaching and research, the course aims to equip students with the essential knowledge and skills required for their contribution to the future construction of Digital China [7].

2. Purposes of Designing an Open Course

This section introduces a new open experimental course designed to tackle various issues found in current courses.

Firstly, traditional practical courses fall behind in terms of technological advancements, failing to keep pace with the rapid development of information technology [8] [9]. Secondly, in today's dynamic industrial landscape, traditional practical courses struggle to replicate real industrial settings, leading to a gap between the knowledge students acquire and its practical application, resulting in limited innovation and entrepreneurial awareness in students [10] [11]. Lastly, existing practical courses often lack research-oriented incentives, preventing students from fully grasping scientific methods and research thinking. Additionally, the fragmented teaching fails to provide students with a comprehensive grasp of project development, spanning from problem identification to delivering effective solutions. In the following discussion, we will analyze these issues and propose improvements in detail.

2.1. Integrating State-of-art Information Technologies

In the current era of rapidly evolving industrial structures and continuous advancements in information technology, university students face a significant challenge: the lack of integration between cutting-edge information technology and their academic knowledge. To tackle this challenge, our laboratory has devised an approach that combines 3D printing technology with existing specialized practical courses. In the modeling phase, we introduce state-of-the-art modeling methods and tools widely utilized by film and gaming companies. During the practical phase, we incorporate 3D printing technology to bring students' design concepts to life in a "what you imagine is what you get" manner. This combination enables us to develop a mentality for continuous learning and innovation thinking. Not only does it equip students with stronger learning and research abilities throughout their academic journey, but it also prepares them to navigate future career changes and challenges more effectively. Moreover, the open nature of the course attracts students from various majors and grade levels to form teams and participate freely. By engaging in this innovative open course, team members not only gain exposure to the latest

research achievements in their respective fields but also acquire cutting-edge information technology, scientific knowledge, and research skills. This integrated approach to learning and practical experience serves as a comprehensive platform for communication and collaboration, where students cultivate their innovative thinking abilities in interdisciplinary fields.

2.2. Embracing Project-Based Teaching

In order for students to better understand the subjects they learn, we typically reserve major core courses for the third and fourth years, while the first and second years focus primarily on foundational theoretical courses. However, this learning model has certain limitations, one of which is that early courses can be tedious and fail to ignite students' interest, leading to a decline in their enthusiasm for learning [12]. To overcome this challenge, we propose the early introduction of projects that address real-world production needs, such as tackling problems found in special education. This approach aims to establish a stronger connection between theoretical knowledge and its practical application, while cultivating students' awareness of innovation and entrepreneurship. By doing so, we aim to stimulate students' initiative and spirit of exploration, enabling them to directly experience the practical implications of their academic knowledge and gradually foster a genuine interest and passion for their field of study.

2.3. Cultivating Interdisciplinary Skills

The emphasis on “open” practical courses is of great significance for cultivating students' interdisciplinary skills. Firstly, the open nature of the course means that the students involved in the course come from different professional backgrounds. For example, students majoring in geoscience and computer science were able to participate in the same project of digitalizing mine specimens, and make full use of their respective expertise to solve the problem of collecting specimens that are difficult to carry during geoscience field studies. Collaboration and interaction across disciplines enable students to view problems from different perspectives and stimulate innovative thinking and problem-solving skills.

Secondly, the open laboratory course provides a platform for students to communicate and share. After participating in the course, students will radiate their growth to the group they are in through their daily interactions, which invisibly improves students' overall learning style and confidence that "I" can also be used.

In addition, the open lab course provides students with the opportunity to explore their own interests and potential. Due to the open nature of the course, students are free to choose laboratory projects of interest and study them in depth. This personalized learning style stimulates students' autonomy and initiative, helps them discover their potential talents, and stimulates innovative thinking and motivation.

3. Open Curriculum

This series of courses is for students of all grades and majors. It is divided into two parts: practical courses of 3D printing technology and the complimentary theoretical course – introduction to 3D printing technologies.

3.1. Practical Sessions of 3D Printing Technology

In project-based practical courses, students can form teams

to complete the projects prepared by the laboratory or design their own projects. During the process, students are familiarized with the whole process of project development, from data acquisition and processing to modeling and printing. Different from the original experimental courses, this course aims to encourage and cultivate students' ability to explore and solve real problems in the society, perceive scientific research bottlenecks in professional fields and solve problems with interdisciplinary thinking. Two examples of specific projects are given below.

3.1.1. DEM Data Modeling of High-resolution Remote Sensing Images

This course aims to lead students to use DEM data from remote sensing images to create 3D terrain modeling and print out tactile map mosaics with provincial administrative divisions for special education. In the modeling process, students will first understand and obtain the ETOPO terrain elevation data issued by the American Geophysical Center, project the standard map issued by the National Bureau of Surveying, Mapping and Geographic Information to the Asian part of the ETOPO data, and complete the preliminary cutting and projection of the model. Next, students will learn and master the use of the standard 3D terrain production software World Machine, and use the Filter factor module to process the most critical perpendicularity of the model to complete the processing of the model in the World Machine. Students then imported the model into ArcMAP for further processing, including loading the Braille names and boundaries of provincial regions, softening sharp edges and corners, and dividing the model into independent models. After the modeling is completed, the model is exported to OBJ format, loaded into the 3D printer supporting software for slicing and printing.

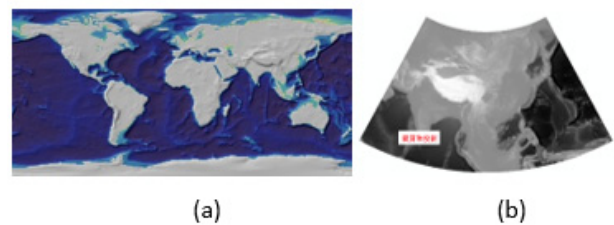


Fig 1. (a) Original DEM data; (b) DEM data after cropping and projecting standard map

After completing this course, students can understand various methods of elevation data acquisition and common processing means, and learn to use GIS and blender+QGIS, worldmachine and other software. Master the conversion between the 3D model file format readable by the modeling software and the printer software, and the printing of the model.

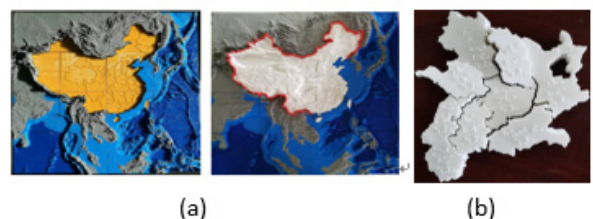


Fig 2. 3d printed teaching AIDS: (a) Before and after the jigsaw puzzle; (b) Braille on the back of the puzzle

3.1.2. Smartphone Snapshot Modeling

In this course, students will master the whole process of collecting a large number of photos of typical geological

phenomena in the field with mobile phones and different angles, and then processing, creating 3D models and printing with Agisoft photoscan. After selecting the target object, following the rules of the minimum overlap rate of adjacent photos, the proportion of the target object in the photo, and the design of the shooting track, enough photos are obtained, which are imported into photoscan software. After the establishment of sparse point cloud and dense point cloud, the dense point cloud is triangulated to form the model. Finally, the generated texture module was used to map the surface of the model, and the generated model was imported into 3Ds Max, blender, magics and other modeling software for post-trimming to obtain the obj format model file, and then imported into the 3D printer slicing and typesetting software, and output printing. The printer used was a full-color Projet 660 Pro from 3D Systems, and the material was gypsum powder.

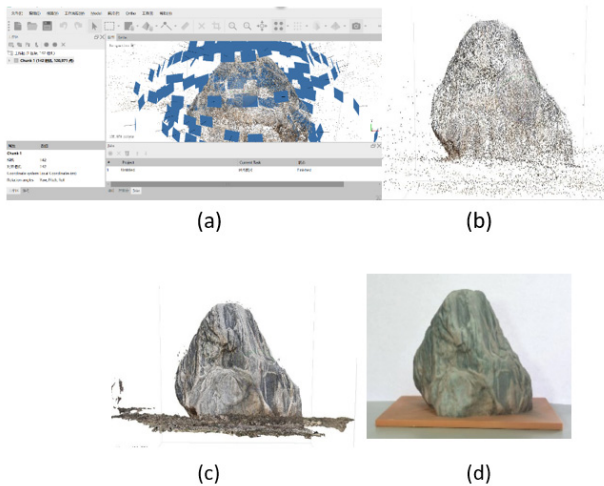


Fig 3. The key steps of the modeling process of snapshot and the 3D printed model.: (a) Align photos with building sparse point clouds (b) Dense point clouds are generated (c) Generate textures from photos; (d) 3D printed model

Compared with other modeling processes, smartphone snapshot modeling has the advantages of convenient acquisition tools, short modeling time and low technical cost. For geological practitioners this modeling method is more suitable for field practice and scientific investigation of the typical geological features encountered in real-time record and collection.

3.2. Introduction to 3D Printing Technologies

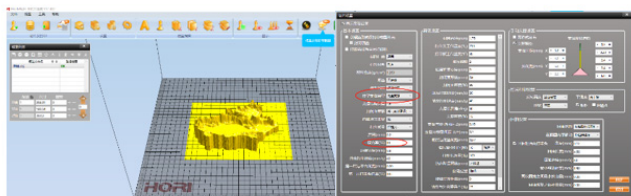


Fig 4. 3D printer supporting software basic operation teaching diagram: slicing

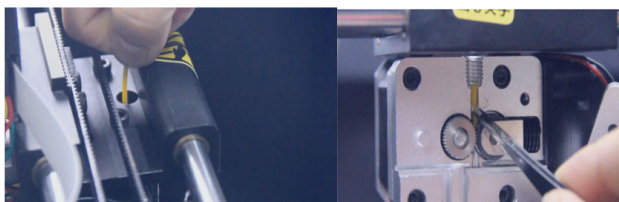


Fig 5. Troubleshooting and repairing

Students usually get a great sense of achievement when they print out 3D models constructed by themselves, which will then stimulate the motivation for self-learning, forming a virtuous cycle. However, in the process of printing, it is inevitable that students will encounter failures of various reasons. Therefore, the introduction to 3D printing is set up to increase students' understanding of the mechanical structure and working principle of the printer, so as to reduce the probability of printing failure, help students quickly solve the problems in practice, and get a satisfactory model entity.

The course focuses on the structure and working principle of FDM printer with cheap consumable materials and wide use, as well as the common operation methods of supporting software such as slicing and adding support.

4. Initial Results



Fig 6. Partial certificates



Fig 7. Some patent certificates and published articles

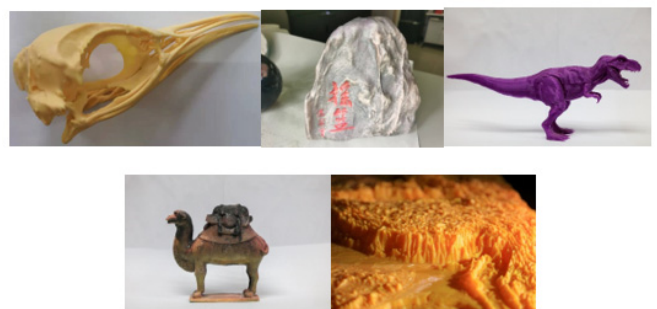


Fig 8. Partial printed product

Through the open course learning, the students' interest in actively participating in the entrepreneurship and innovation project has increased, especially the use of professional knowledge to solve the problems of social livelihood needs, such as the production of special education map puzzle teaching AIDS, and also strengthen the professional thinking. Since the initial opening of the course in 2020, the lab has led students to publish papers, a number of patents, and various

competition awards at all levels. Because of these achievements, some students won the qualification of postgraduate protection and went to their favorite schools for further study. Some went to foreign universities for further study; Some students get satisfactory jobs.

5. Conclusion

The design and implementation of the open course of Geoscience 3D printing laboratory bridged the gap between the basic course and the current frontier information technology as early as possible. From scratch, the Chinese-blind bilingual tactile map puzzle teaching AIDS for special education have been made, and various ways and methods of snap modeling have been summarized. These projects are closely related to the real needs of social people's livelihood. Through course learning, students have not only improved their learning initiative, strengthened their professional confidence, improved their social responsibility and innovative practice ability. And more actively participate in the entrepreneurship and innovation projects and all kinds of competitions at all levels, and constantly achieve a variety of exciting results. On the other hand, these projects and competitions broaden the idea and topic selection of laboratory open courses, forming a virtuous cycle of "teaching and learning are mutually beneficial", which provides an effective way for cultivating composite talents with innovative thinking, innovative ability, multi-perspective, digital knowledge structure and practical ability. It provides an important knowledge energy and talent reserve for the construction of Digital China and Digital Earth.

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