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Exploration of Remote Sensing Course Teaching Supported by Virtual Simulation

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Abstract: Remote sensing is a modern technology for collecting surface spatial information and detecting its dynamic changes. With the rapid development of China's social economy, there is an urgent need to cultivate a large number of talents who can use remote sensing information resources and promote the widespread application of remote sensing technology in various fields of the national economy. "Principles and Applications of Remote Sensing" is a very practical and comprehensive course. Teaching software and hardware facilities are the prerequisites for teaching and directly determine the effectiveness of teaching. Through virtual simulation technology, abstract remote sensing theories and models are presented in the classroom, making teachers' classroom teaching more vivid and deepening students' understanding of relevant knowledge points. It also helps to cultivate students' moral education goals of observation, thinking, and summarization, and achieve the core literacy goal of establishing a spirit of scientific exploration.
Keywords: Remote sensing; Higher education; Course teaching; Virtual simulation

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1. Introduction

Remote sensing is a modern technology for collecting surface spatial information and detecting its dynamic changes. Since the 21st century, remote sensing technology and remote sensing data analysis methods have made great progress, and the application of remote sensing has become increasingly broad [1,2]. In particular, the successful acquisition of high-resolution remote sensing data below the meter level has further expanded the field of remote sensing data applications. Remote sensing technology provides humans with all-round earth observation data every day. It has become a trend to use remote sensing data to solve practical problems in many areas of the national economy. The development of remote sensing technology applications has shifted from the research stage to the practical stage [3,4].

How to quickly extract and mine the information provided by remote sensing data is the key to the current massive remote sensing data playing a greater role in the construction of the national economy.

2. Necessity of curriculum construction

With the rapid development of China's social economy, there is an urgent need to cultivate a large number of talents who can use remote sensing information resources and promote the wide application of remote sensing technology in various fields of the national economy. Undergraduate and graduate majors in geography, geographic information systems, remote sensing, surveying and mapping, environment, ecology, urban planning, land resources, etc., in many universities have opened various types of remote sensing courses from different perspectives [5,6].

Our school's Human Geography and Urban and Rural Planning majors recruit both arts and science students during the college entrance examination, and arts students account for about half of the class. The course "Principles and Applications of Remote Sensing" is highly theoretical and abstract, involving a lot of physical foundations, radiation models, aerospace platforms, image processing algorithms, etc. During the course, it seems that these contents are difficult for most students, causing some students to feel afraid of difficulties.

"Principles and Applications of Remote Sensing" is a very practical and comprehensive course. Teaching hardware and software facilities are the prerequisites for teaching and directly determine the effectiveness of teaching [7,8]. For example, when talking about the spectral characteristics of typical objects, due to the lack of object spectrometers, it is impossible to carry out in-class experiments on the collection of object spectral data and the drawing of spectral curves, which increases the difficulty for students to learn about object spectra; when talking about aerospace remote sensing platforms, since these devices are far away in the air, they cannot be directly displayed to students, which is a great challenge for understanding the imaging working principle of sensors; in addition, high-resolution hyperspectral remote sensing data is expensive [9]. At present, the data used in the classroom is mainly based on the data provided by the software and satellite images downloaded from the Internet, which makes it difficult for students to understand the processing of related data.

3. Main content and forms of curriculum construction

3.1. Main contents and innovations of curriculum construction

Remote sensing is one of the core technologies of modern spatial informatics and an emerging discipline developed in the mid-to-late 20th century. It, together with geographic information systems and global positioning systems, constitutes the 3S technology, which has been widely used in various fields such as land, urban planning, environment, agriculture, and forestry, and plays an increasingly important role in the national economy [7]. With the rapid development of modern remote sensing technology, high-resolution remote sensing satellite images and drone aerial remote sensing images are used to obtain urban spatial information, provide auxiliary decision-making for urban master

planning and regional detailed planning, and provide scientific support for land and resources monitoring. The role of remote sensing technology in human geography and urban and rural planning is becoming increasingly significant.

In order to meet society's growing demand for remote sensing talents, more than 170 universities in China have included remote sensing courses in their teaching plans [10,11]. In these universities, most remote sensing courses adopt offline theoretical explanations or a combination of online and offline teaching methods [12,13], and there are almost no teaching methods that present theories through virtual simulation technology. In view of this, through this exploration, it is hoped that abstract theoretical models and unattainable satellite sensors can be presented in the classroom through virtual simulation technology, which not only solves the problem that students find it difficult to understand remote sensing models, but also alleviates the embarrassment of teachers when they have no physical objects to explain in class.

3.2. Course teaching method

Specific practices in classroom teaching include [14]: keeping up with the development of remote sensing technology to broaden students' horizons; guiding students to learn independently and cultivate their learning ability; strengthening experimental teaching links to improve students' practical ability; the teaching model mainly uses "theoretical teaching," "case teaching," "inspirational teaching," "interactive teaching," "scenario teaching," etc. Under the guidance of the basic principles of remote sensing theory, combined with relevant case practice analysis, gradually deepen the study of professional theories, so that students can better master the relevant knowledge of remote sensing applications and cultivate students' analytical ability [15].

Students are divided into several study groups to cultivate their sense of cooperation and make them participate in learning consciously and automatically. A reward and punishment system is implemented, giving extra points to groups with outstanding performance and effectively mobilizing students' enthusiasm. We focus on the cultivation of students' remote sensing image information, so that students can adapt to the needs of social and economic development.

3.3. Main course resources

At present, the Surveying and Mapping (City) Geographic Information Virtual Simulation Experiment Teaching Project has been deployed on the teaching management platform of the Basic Virtual Simulation Experiment Teaching Center of our school, and is maintained by dedicated teachers. The project can be used by students from different colleges and classes, and there is no limit on the number of people who can conduct experiments online at the same time; the platform has data backup and system monitoring functions to ensure the security of the experimental project system and students' personal information.

After completion, the relevant teaching projects will be deployed on the teaching management platform of the school's basic virtual simulation experimental teaching center. Through virtual simulation technology, abstract remote sensing theories and models will be presented in the classroom, making teachers' classroom teaching more vivid and

deepening students' understanding of relevant knowledge points.

4. Course construction objectives

4.1. Teaching team formation

The course director and the main lecturer have a doctoral degree, good teacher ethics, and strong teaching ability. 60% of the teaching team have senior titles, all teachers have joined the company in 2018 or later, and the proportion of teachers teaching in the past three years is 100%. The knowledge background of the teachers in the teaching team includes geology and geomorphology, physical geography, remote sensing and geographic information systems, and the age structure of middle-aged and young people is reasonable. The teachers in the teaching team have a strong sense of responsibility, a good spirit of unity and cooperation, and a clear division of labor. In the past five years, the research projects presided over include one National Natural Science Youth Fund, three projects of Sichuan Provincial Department of Science and Technology, five projects of Sichuan Tourism Development Research Center, and one project of Sichuan World Heritage Popularization Base. In the past three years, more than 10 scientific research academic papers have been published. The proportion of teachers in the teaching team who have received off-campus professional learning and training is 100%. They have participated in academic exchanges such as the 2020–2023 Sichuan Geography Annual Conference, the 2020 World Study and Tourism Conference, the 2021 Spring Annual Meeting of the Chinese Geographical Society and the China Geography Editing and Publishing Annual Conference, the 2021 Yellow River Basin Ecological Protection and High-quality Development High-level Forum, and the 2023 Cartography and Geographic Information Systems Academic Conference.

4.2. Teaching resource construction

4.2.1. Textbooks and auxiliary materials

The textbook selected for the course is "Introduction to Modern Remote Sensing" published by Science Press. This textbook is a national planning textbook for general higher education. It mainly introduces the concept, characteristics, and basic principles of remote sensing, as well as the characteristics of remote sensing data and the principles and methods of analysis and interpretation. The supporting experimental textbook is "Remote Sensing Digital Image Processing—Practice and Operation" published by Higher Education Press. The content is organized according to the remote sensing digital processing process, and remote sensing digital image processing is comprehensively explained.

At the same time, effective reference materials are also designated for students, including extracurricular textbooks such as "Introduction to Remote Sensing," "General Theory of Remote Sensing," "Remote Sensing Digital Image Processing—Principles and Methods," "Remote Sensing Principles and Applications," as well as relevant website resources such as China Remote Sensing Data Network, Institute of Space Information Science and Technology of the Chinese Academy of Sciences, Institute of Remote Sensing and Digital Earth of the Chinese Academy of Sciences, and National Excellent Course Resource Network.

4.2.2. Teaching conditions

The on-campus experimental bases for this course include the Geographic Information Laboratory of the School of Tourism and Geographical Sciences and the "Southwest Sichuan Space Effect Detection and Application Laboratory," a key laboratory of Sichuan universities. Among them, the Geographic Information Laboratory of the School of Tourism and Geographical Sciences is equipped with more than 50 graphic workstations and remote sensing image processing software. The equipment is in good condition and has a high utilization rate. The image data and multimedia facilities required for the course are complete, and the basic experiment opening rate reaches 100% of the syllabus requirements. The daily operation and maintenance of laboratory equipment is personally responsible for the laboratory section chief, and the management is standardized, which can meet the corresponding experimental practice teaching requirements.

As the largest space environment observation base in the southwest region, the Southwest Sichuan Space Effect Detection and Application Laboratory has a wealth of observation equipment, which can monitor the evolution of rainstorms, lightning, and earthquake disasters in all directions, and serve the early warning and forecast of disaster weather at all levels. After years of construction, the laboratory has established close cooperative relations with the University of Adelaide, Australia, National Central University, Taiwan, Wuhan University, China University of Geosciences, the State Seismological Bureau and its subordinate research units, the Chinese Academy of Sciences, the Leshan Meteorological Bureau and the Leshan Simulation Disaster Reduction Center, and other institutions, and has jointly built a comprehensive chain network for space environment monitoring in the southwest region. The laboratory has a resident team of more than 10 doctoral professors, of whom two have been approved as outstanding high-level talents in Leshan City, and four have been approved as academic and technical backbones of the school.

4.3. Teaching reform and research

4.3.1. Teaching and research activities

The teaching and research activities of this course are carried out in accordance with the principle of college coordination and flexible and independent arrangement of the teaching and research office. They are reported by the teaching and research office and coordinated by the leaders in charge of the college. It can ensure that at least five teaching and research activities with various forms and contents are carried out every year, such as the resource exploration and civil engineering department (resource and soil department) of the School of Engineering and Technology of Chengdu University of Technology, the visit and study of the China Nuclear Fusion Museum, the young teachers' teaching competition, the human geography and urban and rural planning professional competition, and the project cooperation and exchange with relevant units. Each teaching and research activity has corresponding records and is reported on the news website of the School of Tourism and Geographical Sciences. In the activities, classroom teaching experience can be shared to broaden the horizons of teachers, deficiencies in teaching can be found, and countermeasures to further improve teaching quality can be discussed.

4.3.2. Teaching reform and achievements

In the past five years, there have been three provincial teaching and research reform projects and two school-level teaching reform projects related to this course. Among them, “Research on the Inclusive Sharing of Ideological and Political Practice Teaching in Human Geography and Urban and Rural Planning Courses in the New Era” was successfully approved as a Sichuan Provincial Higher Education Talent Cultivation Quality and Teaching Reform Project from 2021 to 2023, and “Surveying and Mapping (Urban) Geographic Information Virtual Simulation Experiment” was approved as a Sichuan Provincial First-Class Undergraduate Course in 2022; “Physical Geography” was recommended to apply for the third batch of provincial course ideological and political demonstration projects, and “Practical Exploration of Physical Geography Applied Talent Cultivation” was successfully approved as a school-level first-class undergraduate course construction and research special scientific research project; “Exploration of the Application of Information Technology in Land Management Practical Teaching” became a school-level higher education teaching reform project. Through a comprehensive review of the teaching content and knowledge points of the textbooks, and the collection of relevant technical information and problems, a preliminary virtual teaching project was formed (**Table 1**).

Table 1. Remote sensing virtual teaching project list

Serial number	Project name	Main content
1	Remote Sensing Technology System	Remote sensing platform, sensors, reception, and processing of remote sensing information
2	Fundamentals of Remote Sensing Electromagnetic Radiation	Electromagnetic waves, electromagnetic spectrum, basic laws of radiation, solar radiation
3	Sensor	Composition and classification of sensors
4	Aerial Remote Sensing Data	Aerial photographs, reflective properties of ground objects, geometric properties of aerial photographs, visual interpretation of aerial photographs
5	Landsat Data	Landsat satellite orbit characteristics, operating systems, data characteristics, and visual interpretation of common landforms
6	Microwave Remote Sensing Data	Radar image penetration, polarization, geometry, radiation characteristics, lidar
7	Thermal Infrared Remote Sensing Data	Thermal characteristics of ground objects, imaging time of thermal infrared images, interpretation of thermal infrared images
8	Hyperspectral Remote Sensing Data	Image-spectrum integration, working principle of imaging spectrometer, image cube, hybrid spectral decomposition technology, application of hyperspectral remote sensing in vegetation survey
9	Fundamentals of Remote Sensing Digital Image Processing	Remote sensing digital data storage format, statistical characteristics of digital images

5. Conclusion

Remote sensing is a comprehensive earth observation technology that plays an increasingly important role in the national economy and social development, and is increasingly valued by people. Various universities have opened remote sensing technology courses to meet society's growing demand for remote sensing. Remote sensing has become a compulsory and core course in the fields of earth science, resource and environmental science, and ecology. It is the unshirkable responsibility and obligation of remote sensing science teachers to update and improve the teaching content in remote sensing teaching. It is important to pay attention to the development and frontiers of remote sensing technology, strengthen computer processing of remote sensing data and its information analysis methods, and emphasize the information concept of remote sensing data to meet teaching needs and lay a solid foundation for students to further study and work in the future.

Disclosure statement

The authors declare no conflict of interest.

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