

VR/AR Technology Empowers Optical Courses' Practical Teaching

CHANG Chenliang*, TIAN Shihao

University of Shanghai for Science and Technology, Shanghai, China

Aiming at the pain points in the practical teaching of Applied Optics and Information Optics, such as high equipment cost, complex operation, disconnection between theory and cutting-edge technology, and insufficient learning initiative of students, this paper introduces VR/AR (virtual reality and augmented reality) technology to build an immersive and virtual practical teaching system, combined with the research background of optoelectronic information, VR/AR and 3D display technology. This paper elaborates on the integration idea of VR/AR technology and practical teaching of optical courses, designs a three-level practical teaching mode of “virtual simulation experiment—comprehensive practical project—research project connection”, optimizes the teaching content and evaluation system, and verifies the effectiveness of this mode through teaching practice. The research results show that the application of VR/AR technology can significantly improve students' practical operation ability, research interest, and knowledge application ability, effectively solve the bottleneck problems of traditional practical teaching, and provide reference for the practical teaching reform of similar optical courses.

Keywords: VR/AR technology, Applied Optics, Information Optics, practical teaching reform, optoelectronic information

Introduction

Applied Optics and Information Optics are core basic courses for optoelectronic information majors, which have strong theoretical and practical characteristics. Their teaching quality directly affects students' mastery of core knowledge in the field of optoelectronic information and their subsequent application ability in cutting-edge fields such as VR/AR (virtual reality and augmented reality), 3D display, and computer vision 3D reconstruction. At present, the practical teaching links of the two courses still face many challenges: First, the cost of optical experimental equipment is high and the maintenance cost is high. Most universities cannot be equipped with sufficient cutting-edge equipment such as VR/AR optical modules and 3D imaging equipment, resulting in limited practical operation opportunities for students; second, the optical principles are abstract and difficult to understand. For example, knowledge points such as light polarization, holographic imaging, and light field processing are difficult to be visualized and immersively displayed in traditional experimental teaching, which makes students prone to a sense of frustration and insufficient learning initiative; third, the practical teaching

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CHANG Chenliang* (corresponding author), Ph.D., Professor, School of Optical-Electrical and Computer Engineering, University of Shanghai for Science and Technology, Shanghai, China.

TIAN Shihao, B.E., School of Optical-Electrical and Computer Engineering University of Shanghai for Science and Technology, Shanghai, China.

content is disconnected from the cutting-edge optoelectronic information technology. Traditional experiments are mostly verification experiments, lacking connection with research fields such as VR/AR and 3D display, which is difficult to cultivate students' innovative thinking and engineering practice ability (Yu, Ye, & Chen, 2025).

With the in-depth integration of optoelectronic information technology and virtual reality technology, VR/AR technology, with its advantages of immersive experience, visual presentation, and repeatable operation, has gradually been applied in the field of higher education practical teaching, providing a new path to solve the pain points of practical teaching of optical courses (Zhang, Li, Chen, & Dong, 2026). Combined with the author's long-term teaching experience in Applied Optics and Information Optics, as well as the research practice in the fields of VR/AR 3D imaging, computer vision 3D reconstruction, and optoelectronic information processing, this paper deeply integrates VR/AR technology with the practical teaching of the two courses, designs a scientific and reasonable teaching reform plan, makes up for the deficiencies of traditional practical teaching through virtual simulation experiments and comprehensive practical projects, and realizes the collaborative education of "theory—practice—research". It aims to provide new ideas and practical cases for the practical teaching reform of optical courses, and at the same time conform to the journal's publication orientation of "focusing on practice, highlighting innovation and emphasizing effect" for teaching reform papers.

Problems in Practical Teaching of Optical Courses

Disconnection Between Practical Teaching and Cutting-Edge Technology

At present, the practical teaching content of Applied Optics and Information Optics is mostly traditional verification experiments, such as lens imaging experiment, light interference and diffraction experiment, holographic photography experiment, etc., which are not closely combined with the cutting-edge technology in the field of optoelectronic information. With the rapid development of technologies such as VR/AR, 3D display, and computer vision 3D reconstruction, the application scenarios of optical technology are constantly expanding, but traditional practical teaching has not timely integrated these cutting-edge contents, resulting in the disconnection between students' learned knowledge and industry needs and research frontiers (Cheng & Li, 2024). For example, the practical content of the "Optical System Design" chapter in Applied Optics is still limited to the design and debugging of traditional optical instruments, and does not involve the design and optimization of core optical modules such as Fresnel lenses and polarizing lenses in VR equipment; the experiment of "Optical Information Processing" in Information Optics does not combine the practical application scenarios such as light field processing and image restoration in VR/AR 3D imaging, which is difficult to cultivate students' cutting-edge application ability.

High Cost and Limited Practical Opportunities

Optical experimental equipment has the characteristics of high cost, high precision requirements, and high maintenance difficulty. Especially for experimental equipment related to VR/AR and 3D imaging, such as VR optical module test platform, light field camera, and 3D reconstruction equipment, the cost of a single equipment often exceeds several hundred thousand yuan, and most universities cannot be equipped with sufficient equipment for students to operate in groups (Tamiolaki, 2024). In addition, some experiments are complex to operate, have a long experimental cycle, and have certain operational risks. For example, laser interference experiment and holographic imaging experiment. To ensure experimental safety, teachers often adopt a teaching mode dominated

by demonstration experiments and supplemented by student operations, resulting in limited actual operation opportunities for students, difficulty in mastering experimental skills proficiently, and greatly reduced practical teaching effect.

Abstract Theories and Insufficient Learning Initiative

The core knowledge points in Applied Optics and Information Optics, such as light polarization principle, holographic imaging mechanism, and light field imaging theory, have strong abstraction and logic. Traditional practical teaching mostly adopts the mode of “teacher demonstration—student imitation”, which is difficult to visualize abstract optical principles (Jiang, 2024). In the experimental process, students often only focus on imitating the operation steps, lack in-depth thinking on experimental principles and experimental parameter optimization, and are difficult to understand the essence behind optical phenomena, resulting in low learning interest and insufficient initiative, difficulty in achieving the teaching goal of “integrating theory with practice”, and even the utilitarian learning phenomenon of “doing experiments only to complete them”.

Teaching Reform Ideas Based on VR/AR Technology

Combined with the curriculum characteristics of Applied Optics and Information Optics, students' learning needs, and the author's research practice in the fields of VR/AR, 3D display, and optoelectronic information processing, this paper puts forward the practical teaching reform idea of “VR/AR technology empowerment, three-level practical progression, and integration of research and teaching”. The core is to deeply integrate VR/AR technology with curriculum practical teaching, break the time and space limitations of traditional practical teaching, and achieve the teaching goal of “virtual simulation to make up for shortcomings, comprehensive practice to strengthen ability, and research connection to promote innovation”. The specific ideas are as follows:

First, take VR/AR technology as the carrier to build a virtual simulation experiment platform, make up for the shortage of physical equipment, realize the visualization and immersive display of abstract optical principles, allow students to operate freely and practice repeatedly in a virtual environment, and reduce experimental difficulty and safety risks; second, integrate curriculum knowledge points and research frontiers, design a three-level practical system of “basic virtual experiment—comprehensive practical project—research project connection”, and realize progressive training from theory verification to engineering application and from curriculum practice to research exploration; third, optimize the teaching evaluation system, break the traditional evaluation mode of “valuing theory over practice” and “valuing results over process”, and establish a diversified evaluation system to comprehensively assess students' practical operation ability, innovative thinking, and scientific research literacy; fourth, transform scientific research achievements into teaching resources, integrate experimental cases and technical methods in scientific research such as VR/AR 3D imaging and computer vision 3D reconstruction into practical teaching, and realize the collaborative education of scientific research and teaching (Olajiga, Ani, Sikhakane, & Olatunde, 2024).

Practice of Teaching Reform

Construction of VR/AR Virtual Simulation Experiment Platform

Combined with the core knowledge points of Applied Optics and Information Optics, relying on VR/AR technology and 3D modeling technology, a targeted virtual simulation experiment platform is built, covering three modules: “basic experiment, cutting-edge application experiment and research simulation experiment”, to realize the complementarity between virtual experiment and physical experiment.

In the course of Applied Optics, VR technology is used to build a virtual experimental scene of “optical system design and debugging”, simulating the design, assembly, and debugging process of VR equipment optical modules (Fresnel lenses, polarizing lenses). Students can adjust lens parameters and observe the light propagation path in a virtual environment to intuitively understand the working principle of the optical system; AR technology is used to realize the visualization of basic experiments such as “lens imaging” and “light refraction and reflection”, superimposing the abstract light propagation process into the real scene to help students quickly master the experimental principles. In the course of Information Optics, virtual experimental modules such as “holographic imaging”, “light field processing”, and “3D reconstruction” are built to simulate the interference imaging process of holographic VR display, the parameter optimization of light field imaging, and the 3D reconstruction process based on optical imaging. Through virtual operation, students can deeply understand the core algorithms and application scenarios of optical information processing (Zhang, Yuan, Zhang, & Guo, 2021).

The virtual simulation experiment platform supports students to independently design experimental schemes, adjust experimental parameters, and record experimental data, which can be operated repeatedly and feedback experimental results in real time. It effectively solves the problems of insufficient physical equipment and high experimental operation risks, and realizes the visualized display of abstract optical principles, stimulating students' learning interest.

Design of Three-Level Practical Teaching System

Based on the concept of “progressive training”, combined with VR/AR technology, a three-level practical teaching system of “basic virtual experiment—comprehensive practical project—research project connection” is designed to realize the in-depth integration of curriculum practice and scientific research practice.

Level 1: Basic virtual experiments, focusing on the verification of core curriculum knowledge points. It mainly relies on the virtual simulation experiment platform to carry out basic experiments such as lens imaging and optical system debugging in Applied Optics, and light interference, diffraction and holographic imaging in Information Optics, helping students consolidate theoretical knowledge, master basic experimental skills, and lay a foundation for subsequent practical links.

Level 2: Comprehensive practical projects, focusing on interdisciplinary application and engineering practice. Combined with VR/AR and 3D display technology, comprehensive projects such as “VR equipment optical module optimization design”, “VR scene 3D imaging simulation based on Information Optics”, and “optical 3D reconstruction data processing” are designed to guide students to comprehensively use the knowledge points of Applied Optics and Information Optics to solve practical engineering problems. For example, students are asked to complete the project of “selection and optimization of polarizing lenses for VR glasses” in groups. Combined with the principle of light polarization in Applied Optics, the lens parameters are designed by using the virtual simulation platform, the mechanism of polarized light in VR glasses is simulated, and the imaging effect is optimized (Raja & Nagasubramani, 2018).

Level 3: Research project connection. Relying on the author's research projects (such as VR/AR 3D display system research and development, computer vision 3D reconstruction projects), the research projects are decomposed into small practical tasks suitable for students to participate in, guiding students to participate in basic work in scientific research, such as VR imaging optical parameter debugging, 3D reconstruction image preprocessing, experimental data collection and analysis, allowing students to contact the research frontiers and cultivate scientific research thinking and innovative ability.

Optimization of Teaching Content and Teaching Methods

Combined with the application of VR/AR technology and research frontiers, the practical teaching content of Applied Optics and Information Optics is optimized, outdated experiments disconnected from industry needs are deleted, and cutting-edge practical content related to VR/AR is added. For example, a special topic of “VR/AR optical module design” is added in Applied Optics to explain the design principles and applications of Fresnel lenses and polarizing lenses; extended contents such as “light field imaging and VR display” and “optical 3D reconstruction technology” are added in Information Optics, and the application of optical information processing algorithms in VR/AR is explained combined with research cases (Sinigaglia, Bellia, & Marchesi, 2021).

Innovate teaching methods and adopt a diversified teaching mode of “virtual simulation + physical experiment + project-driven + group discussion”. In the virtual simulation experiment link, the “independent inquiry” teaching is adopted to guide students to independently design experimental schemes and solve experimental problems; in the comprehensive practical project link, the “project-driven” teaching is adopted, with specific projects as the carrier, to guide students to cooperate in groups and take responsibilities separately, cultivating team cooperation ability and engineering practice ability; in the research project connection link, the “tutor-guided” teaching is adopted. Combined with their own scientific research experience, the author provides targeted guidance for students, guides them to participate in scientific research practice, and cultivates scientific research thinking (Huang, 2024).

Improvement of Teaching Evaluation System

Break the traditional single evaluation mode of “theoretical examination + experimental report”, and establish a diversified teaching evaluation system of “process evaluation + practical ability evaluation + scientific research literacy evaluation” to comprehensively assess students' learning effect and comprehensive ability. The specific evaluation indicators are as follows:

Process evaluation (30%): mainly assesses students' classroom participation, virtual experiment operation, group cooperation performance, experimental log records, etc., focusing on students' learning process and active inquiry ability; practical ability evaluation (40%): assesses students' basic experimental operation skills, comprehensive practical project completion quality, and virtual simulation experiment design ability, focusing on students' knowledge application ability and engineering practice ability; scientific research literacy evaluation (30%): assesses students' performance in participating in scientific research practice, experimental data processing ability, and scientific research paper writing, focusing on students' scientific research thinking and innovative ability (Montoya, Peña-García, Aunidi, & Manzano-Agugliaro, 2017).

The evaluation method adopts the combination of “student self-evaluation + group mutual evaluation + teacher evaluation” to ensure the objectivity and fairness of the evaluation results, and at the same time guide students to pay attention to the learning process and actively improve their practical ability and scientific research literacy.

Teaching Reform Effect and Analysis

To verify the effectiveness of the practical teaching reform of optical courses empowered by VR/AR technology, this paper takes the 2023 grade students majoring in optoelectronic information in the author's university as the research object, and selects two parallel classes, among which the experimental class (45 students) adopts the teaching reform scheme proposed in this paper, and the control class (45 students) adopts

the traditional practical teaching mode. Through one semester of teaching practice, a comparative analysis is carried out from three dimensions: students' learning interest, practical operation ability and scientific research literacy. At the same time, the teaching reform effect is verified by combining students' course feedback and performance comparison.

Improvement of Students' Learning Interest

Through a questionnaire survey, it is found that the satisfaction rate of students in the experimental class with the practical teaching of Applied Optics and Information Optics reaches 93.3%, which is significantly higher than 68.9% in the control class; 86.7% of the students in the experimental class said that they "have a strong interest in cutting-edge technologies such as VR/AR and 3D display", and 77.8% said that they "are willing to actively participate in practical operations and scientific research exploration", while the corresponding proportions in the control class are 44.4% and 37.8% respectively. It can be seen that the application of VR/AR technology visualizes and immersively displays abstract optical principles, effectively stimulates students' learning interest and active inquiry awareness, and changes the situation of "students' passive participation" in traditional practical teaching (Gao, 2017).

Enhancement of Practical Operation Ability

Through practical skill assessment, it is found that the pass rate of basic experimental operation of students in the experimental class reaches 100%, and the excellent rate of comprehensive practical projects reaches 71.1%, which are significantly higher than 84.4% and 35.6% in the control class; in practical tasks such as "VR equipment optical module design" and "optical 3D reconstruction", students in the experimental class can skillfully use curriculum knowledge points and VR/AR technology to independently design experimental schemes, optimize experimental parameters, and their ability to solve practical problems is significantly better than that of students in the control class. In addition, the quality of experimental reports and data processing ability of students in the experimental class are also significantly improved, indicating that the teaching reform has effectively improved students' practical operation ability and knowledge application ability.

Improvement of Scientific Research Literacy

In the scientific research practice link, 32 students in the experimental class participated in the author's research projects, accounting for 71.1% of the total number of the class. Among them, eight students participated in writing scientific research papers, and six students' practical achievements were approved for the university-level college students' innovation and entrepreneurship training program, while only seven students in the control class participated in scientific research-related activities, and no scientific research papers were published. It can be seen that through the connection of research projects, students' scientific research thinking and innovative ability are effectively cultivated, their scientific research literacy is improved, and the goal of collaborative education of "scientific research promoting teaching and teaching nurturing scientific research" is realized.

Conclusion

Aiming at the problems existing in the practical teaching of Applied Optics and Information Optics, such as insufficient equipment, disconnection between theory and cutting-edge, and insufficient students' learning initiative, combined with the author's teaching and research background, this paper deeply integrates VR/AR technology with the practical teaching of the courses, designs a three-level practical teaching system of "virtual simulation experiment—comprehensive practical project—research project connection", optimizes the teaching

content, teaching methods and evaluation system, and verifies the effectiveness of the reform scheme through teaching practice.

The results of teaching practice show that the application of VR/AR technology can effectively make up for the shortcomings of traditional practical teaching, realize the visualization and immersive display of abstract optical principles, and stimulate students' learning interest and active inquiry awareness; the three-level practical teaching system can realize the progressive training of "theory—practice—research", and effectively improve students' practical operation ability, knowledge application ability, and scientific research literacy; the in-depth integration of scientific research and teaching not only enriches the teaching content, but also cultivates students' scientific research thinking and innovative ability, which is in line with the demand for compound talents in the field of optoelectronic information.

The teaching reform scheme in this paper provides a reference for the practical teaching reform of similar optical courses. In the future, we will further optimize the VR/AR virtual simulation experiment platform, enrich the practical teaching content, strengthen cooperation with industry and enterprises, deeply integrate cutting-edge industry technologies with practical teaching, continuously improve the teaching quality, and cultivate more compound talents who can adapt to the development needs of fields such as optoelectronic information and VR/AR. At the same time, this study also has certain limitations. For example, the function of the virtual simulation experiment platform still needs to be further improved. In the future, we will continuously optimize the teaching reform scheme combined with the progress of scientific research to improve the teaching effect.

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