

Optimization and Practice of Enterprise Operation Management Experimental Teaching System Supported by 3D Measurement Technology

Lingxian Zhu

School of Marxism, Zhengzhou Railway Vocational & Technical College, Zhengzhou 451460, Henan, China

Corresponding author: Lingxian Zhu (e-mail: cynthiasff@163.com)

ABSTRACT In the context of intelligent manufacturing and industrial digital transformation, enterprise operation management increasingly requires composite technical talent capable of integrating physical measurement, production simulation and decision optimization. The traditional experimental teaching system is difficult to cultivate students' engineering practice ability and systematic thinking due to the lack of advanced technology support, disconnection between teaching content and industry, and virtualization of practical scenarios. As the core supporting technology of intelligent manufacturing, 3D measurement technology can achieve accurate acquisition and digital modeling of object geometric parameters, providing data support for core processes such as production process optimization, quality control, and inventory management in operation and management. The deep integration of these technologies with experimental teaching provides a feasible path for upgrading the teaching system to better reflect the high-precision measurement and digital-twin processes required in intelligent manufacturing.

INDEX TERMS 3D measurement technology, operation management, experimental teaching, digital twin, industrial measurement

I. INTRODUCTION

A. RESEARCH BACKGROUND

As a core course in majors such as business administration and industrial engineering, enterprise operation management's experimental teaching is a key link connecting theoretical knowledge with industrial practice [1-3]. The "Opinions of the Ministry of Education on Accelerating the Construction of High level Undergraduate Education and Improving the Comprehensive Talent Training Capacity" clearly proposes to "deepen the reform of experimental teaching, promote the deep integration of information technology, advanced manufacturing technology and experimental teaching, and build an experimental teaching system that meets the needs of industrial development" [4-6]. However, traditional simulation models often overlook the specific technical constraints of production:

Lagged teaching content: Experimental projects mostly focus on traditional operational management scenarios (such as inventory optimization and production planning), lacking coverage of emerging scenarios such as intelligent manufacturing and digital operations;

Insufficient technical support: Unlike standard ERP or IoT data which provide abstract numerical outputs, 3D measurement offers high-fidelity spatial data that bridges

the gap between physical shop-floor constraints and macro-level scheduling.

Practice scenario virtualization: Experiments are often based on preset data and ideal scenarios, which are disconnected from the dynamics, complexity, and uncertainty of real enterprise operations, making it difficult for students to form systematic thinking.

B. RESEARCH APPROACH

This article follows the technical route of "theoretical sorting - current situation diagnosis - system optimization - technology integration - empirical verification - promotion and application":

Systematically review the research achievements in the fields of enterprise operation management experimental teaching, 3D measurement technology application, etc., and clarify the research foundation and improvement direction;

Diagnose the core problems of the current experimental teaching system through methods such as questionnaire surveys, in-depth interviews, and field research;

Based on the three-dimensional training objectives of "knowledge ability literacy", combined with the core business processes of enterprise operation management, optimize the experimental teaching system architecture;

Design a fusion path between 3D measurement technology and experimental teaching, develop supporting platforms and teaching resources;

Select multiple universities to conduct empirical research and verify the application effect of the optimized teaching system;

The empirical results facilitate the refinement of system architectures and technical support frameworks to establish a scalable practical paradigm centered on fiber morphology analysis and high-precision yarn spatial distribution. This optimization ensures that digital integration effectively stabilizes manufacturing excellence across complex production environments[7].

II. CORE CONCEPTS AND THEORETICAL FOUNDATIONS

A. DEFINITION OF CORE CONCEPTS

The technology integration path refers to the combination and implementation process of 3D measurement technology and experimental teaching system, including the integration of technology and teaching content, technology and teaching methods, and technology and evaluation system. The core is to achieve digitalization, precision, and practicality of experimental teaching through technology empowerment[8].

Knowledge objective: To master the core theories of enterprise operation and management, the basic principles and operating methods of 3D measurement technology, and the core tools for digital data analysis and optimization;

Ability goals: Possess the ability to operate 3D measuring equipment, collect and process operational data, optimize production processes, and control and improve quality;

Objective of Literacy: To cultivate engineering practice literacy, systematic thinking literacy, innovative thinking literacy, team collaboration literacy, and adapt to the operational management needs of enterprises in the era of intelligent manufacturing[9-11].

B. THEORETICAL BASIS

1) Constructivist Learning Theory

Constructivist learning theory emphasizes that learning is a process in which learners actively construct knowledge, rather than passively receiving information. Its core viewpoints include:

Learning should be conducted in real problem situations, deepening knowledge understanding through practical operations and problem-solving;

Emphasize collaboration and interaction between teachers and students, and promote knowledge construction through communication and discussion;

Emphasize the personalization and differentiation of the learning process, and respect learners' independent choices and explorations[12-14].

This theory provides pedagogical support for optimizing the experimental teaching system, clarifying the importance of constructing real-life scenarios, practical operations, and collaborative learning[15-17].

2) Situational Learning Theory

The situational learning theory holds that learning is achieved through participation in real activities in specific contexts, and the meaning of knowledge can only be fully constructed in specific contexts. Its core viewpoints include:

Authentic instructional contexts enhance learner motivation and pedagogical efficacy;

Learning should be combined with practical work tasks to achieve the goal of 'learning for practical use'; Emphasize the construction of a learning community and promote the social growth of learners. This theory provides a theoretical basis for the integration of 3D measurement technology and experimental teaching, and clarifies the idea of designing experimental projects based on real operational scenarios of enterprises[18].

3) Competency based Education Theory

The theory of competency based education is guided by the cultivation of learners' core competencies, emphasizing the precise alignment between teaching content and professional needs. Its core viewpoints include:

Ability is the core goal of learning, covering professional competence, methodological competence, and social competence;

The teaching content should be designed around the cultivation of professional abilities, with a focus on practical training;

The evaluation system should focus on enhancing capabilities and adopt diversified evaluation methods. This theory provides direct guidance for setting the three-dimensional training objectives of "knowledge ability literacy" and optimizing the experimental teaching system[19-20].

4) Theory of Technology Fusion

The theory of technological integration emphasizes the organic integration of technology with other fields, and achieves upgrading and innovation in the field through technological empowerment. Its core viewpoints include:

The core of technology integration is the precise adaptation of technology to the needs of the field, rather than the simple superposition of technology;

Technological integration requires the construction of a comprehensive support system, including hardware, software, resources, talent, etc;

Technological integration can generate synergies and achieve the effect of "1+1>2".

This theory provides methodological support for the integration path design of 3D measurement technology and experimental teaching system.

III. DIAGNOSIS OF THE CURRENT SITUATION OF ENTERPRISE OPERATION MANAGEMENT EXPERIMENTAL TEACHING SYSTEM

A. DIAGNOSTIC DESIGN

1) Diagnostic Object

Select 8 different types of universities (3 comprehensive universities, 3 science and engineering colleges, 2 finance and economics colleges) with majors in business management, industrial engineering, logistics management, etc. as diagnostic objects:

Teacher student group: A total of 500 people, including 80 teachers (with 3-25 years of teaching experience) and 420 students (300 undergraduates and 120 postgraduates);

Enterprise group: 100 human resources managers and operations managers from 20 manufacturing and logistics companies.

2) Diagnostic Methods

Questionnaire survey: Design a survey questionnaire on the current situation of enterprise operation management experimental teaching (teacher-student version, enterprise version), distribute a total of 600 questionnaires, and collect 556 valid questionnaires, with an effective response rate of 92.7%;

Field research: Visited the experimental teaching centers of 6 universities and the operational management departments of 10 enterprises to observe the progress of experimental teaching and the actual operational processes of the enterprises;

Data processing: SPSS 26.0 was used for statistical analysis of questionnaire data, Nvivo12 was used for coding analysis of interview texts, and combined with field research results to comprehensively diagnose the current situation and problems.

B. CURRENT SITUATION ANALYSIS

1) Current Situation of Experimental Teaching System

Teaching objective: 68.3% of teachers regard "knowledge mastery" as the core objective, while only 31.7% emphasize "practical ability and literacy cultivation";

Teaching content: 72.5% of experimental projects focus on traditional operational management modules (such as inventory management and production planning), while only 18.3% involve digital operations and intelligent manufacturing related content;

Teaching methods: Software simulation (65.7%) and manual simulation (58.2%) are the main methods, with less than 10% of experimental projects using advanced technology;

Evaluation system: 78.6% of universities use experimental reports (45.3%) and final exams (33.3%) as the main evaluation methods, with a low proportion of process evaluation and ability evaluation.

C. CORE PROBLEM DIAGNOSIS

Deviation in the positioning of teaching objectives:

The emphasis on imparting knowledge over cultivating abilities and qualities is disconnected from the demand of enterprises for versatile talents;

Lack of clear training objectives for digital skills and system optimization capabilities makes it difficult to adapt to the demands of the intelligent manufacturing era.

The teaching content is disconnected from the industry:

The experimental project is outdated and does not cover emerging technology application scenarios such as 3D measurement, digital modeling, and intelligent quality control;

The teaching content mainly focuses on theoretical verification and lacks integration with the real operational processes of enterprises, resulting in limited practical value.

Weak technical support system:

The experimental equipment is aging and lacks advanced teaching equipment such as 3D measuring instruments and digital modeling software;

The integration of technology and teaching is not deep enough, only used as an auxiliary tool and not integrated into the entire process of experimental teaching.

Practical scenario virtualization:

Experiments are mostly based on preset data and ideal scenarios, lacking dynamism, complexity, and uncertainty;

Students have difficulty encountering real operational problems in enterprises, and the effectiveness of cultivating practical abilities is not satisfactory.

Imperfect evaluation system:

The evaluation method is single, with a focus on outcome evaluation and neglecting process evaluation and capability evaluation;

Lack of quantitative evaluation indicators for students' innovation ability, collaboration ability, and systematic thinking.

D. REQUIREMENTS ANALYSIS

Teaching system requirements: 89.7% of teachers and students hope to "increase digital and intelligent experimental projects", and 85.3% require "building real operational scenarios for enterprises";

Technical support requirements: 92.6% of teachers believe that "advanced technologies such as 3D measurement need to be introduced", and 87.8% hope to "develop standardized technical teaching resources";

Ability cultivation needs: The most important student abilities that enterprises focus on are practical operation ability (91.3%), data processing ability (88.7%), system optimization ability (85.2%), and innovation ability (82.5%);

Evaluation system requirements: 78.9% of teachers and students suggest "adopting diversified evaluation methods", and 76.4% support "increasing ability oriented evaluation indicators".

Analysis of the Causes of Problems

1) Lagging Teaching Philosophy

Some universities still adhere to the traditional teaching philosophy of "emphasizing theory over practice" and do not attach enough importance to experimental teaching;

The understanding of the transformation of enterprise operation and management in the era of intelligent manu-

facturing is unclear, and the teaching objectives and training programs have not been adjusted in a timely manner.

2) Insufficient Resource Investment

The limited investment in experimental teaching funds makes it difficult to purchase advanced equipment such as 3D measuring instruments;

Lack of composite teachers who possess both operational management expertise and advanced technical operation capabilities.

3) Insufficient Cooperation Between Schools and Enterprises

The cooperation between universities and enterprises often remains superficial, without forming a deep collaborative teaching reform mechanism;

The enthusiasm of enterprises to participate in the design of experimental teaching systems and the development of teaching resources is insufficient.

4) Lack of Technical Integration Capability

Teachers have limited technical application abilities, making it difficult to effectively integrate 3D measurement technology with experimental teaching;

Lack of standardized paths and teaching resources for technological integration, and fragmented application of technology.

IV. OPTIMIZATION DESIGN OF EXPERIMENTAL TEACHING SYSTEM SUPPORTED BY 3D MEASUREMENT TECHNOLOGY

A. OPTIMIZATION PRINCIPLES

1) Goal Oriented Principle

With the three-dimensional training objectives of “knowledge ability literacy” as the core, ensure that the optimization of the experimental teaching system always revolves around the needs of talent cultivation.

2) Industrial Adaptation Principles

Closely connect with the real processes and technological application scenarios of enterprise operation and management, ensuring precise matching between teaching content and industry needs.

3) Principle of Technology Integration

Fully integrate 3D measurement technology into the entire experimental teaching process, achieving a deep integration of technology with teaching content, teaching methods, and evaluation systems.

4) Modular and Project-based Principles

Adopting modular design to construct an experimental teaching system, organizing experimental content in a project-based manner, and enhancing the flexibility and operability of the system.

5) Feasibility Principle

Fully consider the actual situation of resources and faculty level in universities, and design a scientific, reasonable, and easy to implement experimental teaching system.

6) Overall Architecture of Experimental Teaching System

Construct a three-in-one experimental teaching system where the architecture is directly mapped to the four core theories: the Content System applies Constructivist Theory by allowing students to actively build models from 3D scans; the Support System utilizes Technology Fusion Theory to create a synergistic hardware-software environment; the Evaluation System is grounded in Competency-based Theory to track skill acquisition; and the implementation phase follows Situational Learning by using real industrial samples. The overall structure is as follows table 1.

B. OPTIMIZATION OF EXPERIMENTAL TEACHING CONTENT SYSTEM

Based on this theoretical mapping, the content system is reconstructed and design a three-level experimental project of “basic comprehensive innovative”. The specific content is as follows:

1) Basic Experiment (Level 1)

Core objective: To assist students in mastering the basic operations of 3D measurement technology, the fundamental theories of operational management, and data processing methods, laying the foundation for subsequent experiments.

2) Comprehensive Experiment (Second Level)

Core objective: To cultivate students’ comprehensive application abilities, enabling them to apply 3D measurement technology and operational management theory to solve complex operational problems.

V. THE INTEGRATION PATH AND SUPPORTING SYSTEM OF 3D MEASUREMENT TECHNOLOGY AND EXPERIMENTAL TEACHING

A. FUSION PATH DESIGN

Build a “full process, multi-level, modular” 3D measurement technology integration path, integrating technology into the entire process of experimental teaching, including goal setting, content design, implementation process, evaluation feedback, etc

1) Target Layer Fusion

Clarify the knowledge, skills, and literacy training objectives related to 3D measurement technology, and incorporate technical application abilities into the core competency training system;

Based on the demand of enterprises for technical operation and management talents, set quantitative indicators for cultivating technical application abilities.

Content layer fusion

TABLE 1. Overall Architecture of the Experimental Teaching System

System Dimension	Core Components	Core Functions	Technical Support
Content System	Basic Experiments, Comprehensive Experiments, Innovative Experiments	Achieve gradient training of knowledge verification, comprehensive application, and innovative design	3D measurement technology, data visualization technology, process simulation technology
Support System	Hardware Platform, Software System, Teaching Resources	Provide comprehensive guarantee of equipment, technology, and resources for experimental teaching	3D measurement equipment, operation management experimental platform, digital teaching resource library
Evaluation System	Process-oriented Evaluation, Result-oriented Evaluation, Competency Evaluation	Comprehensive assessment of students' knowledge mastery, skill application, and competency improvement	Big data analysis technology, process monitoring system, multi-subject evaluation platform

TABLE 2. Basic-level Experimental Projects

Experimental Project	Experimental Objective	Experimental Content	Application of 3D Measurement Technology
Basic Operation of 3D Measurement Technology	Master the basic operation of 3D measurement equipment and data collection methods	1. Operation specifications of 3D measuring instruments (laser scanning, structured light measurement); 2. 3D data collection and preprocessing of simple parts; 3. Format conversion and basic analysis of measured data	Data collection, data preprocessing
Collection and Collation of Operational Data	Master the methods of collecting, collating, and analyzing core operational management data	1. Collect production process data (size, shape, etc.) based on 3D measurement technology; 2. Collation and standardization of inventory data and production progress data; 3. Basic statistical analysis of data (descriptive statistics, correlation analysis)	Production data collection, data standardization
Basic Simulation of Operational Processes	Understand the basic processes and core links of enterprise operations	1. Simulation of basic processes such as production planning, inventory management, and logistics distribution; 2. Setting of process parameters based on 3D measurement data; 3. Operation and monitoring of basic processes	Collection of process parameter data, data support for process monitoring
Application of Basic Decision Models	Master the construction and application methods of basic operational management decision models	1. Construction of basic decision models such as demand forecasting and production planning; 2. Calibration of model parameters based on 3D measurement data; 3. Preliminary analysis of decision results	Collection of decision parameter data, data support for model calibration

Based on the application scenarios of 3D measurement technology, reconstruct experimental teaching content, develop a series of experimental projects such as digital data acquisition, production optimization, and inventory management;

Integrating technical operations and data processing—specifically the conversion of raw 3D point clouds into CAD-compatible geometric models—enables the feed of real-time physical constraints into Discrete Event Simulation (DES) and Linear Programming models. This allows students to translate physical measurements into management decisions regarding inventory buffer sizing and production bottleneck mitigation.

Implementation layer integration

Experimental preparation stage: Provide online learning resources for 3D measurement technology (video tutorials, operation manuals), guide students to preview independently;

Experimental implementation stage: Students use 3D measuring equipment to collect data, process and analyze it using digital software, and design optimization plans;

Experimental summary stage: Discuss and reflect on the application results of technology, deepen the understanding of operation management and technology integration.

B. DATA COLLECTION AND PROCESSING METHODS

Teaching effectiveness data: Collect experimental reports, operational assessment scores, theoretical test scores, in-

novative achievements, and other data from two groups of students during the experiment;

Ability improvement data: Evaluate students' core abilities through comprehensive experimental assessments, expert evaluations from enterprises, case studies, and other methods;

Teaching satisfaction data: After the experiment, a satisfaction questionnaire survey was conducted on two groups of teachers and students;

Data processing: SPSS 26.0 was used for descriptive statistics, independent sample t-test, paired sample t-test, and quantitative analysis of empirical results.

C. EMPIRICAL RESULTS AND ANALYSIS

Comparative analysis of teaching effectiveness

Comparison of core teaching effectiveness indicators:

Result analysis:

Pre-test results: There was no significant difference in baseline operational knowledge between the experimental and control groups ($p > 0.05$). To ensure homogeneity across the 8 diverse university types (comprehensive, finance, and engineering), a Stratified Random Sampling method was employed, and a Covariance Analysis (ANCOVA) was performed to control for variations in students' prior technical backgrounds and institutional resource levels. This confirmed the statistical validity of the group comparisons;

Post test results: The teaching effectiveness indicators of the experimental group were significantly higher than those of the control group ($p < 0.001$). While the 41.2%

TABLE 3. Comprehensive-level Experimental Projects

Experimental Project	Experimental Objective	Experimental Content	Application of 3D Measurement Technology
Production Process Optimization Experiment	Master data-based production process optimization methods	1. Collect time, efficiency, and quality data of each production link using 3D measurement technology; 2. Identification and analysis of production process bottlenecks; 3. Design and verification of process optimization schemes based on data	Full-process data collection, data support for bottleneck analysis
Intelligent Inventory Management Experiment	Master digital inventory management and optimization decision methods	1. Volume and irregular shape estimation of raw fiber bales and textile stockpiles using 3D point cloud data to supplement RFID quantity tracking; 2. Inventory demand forecasting and safety stock setting; 3. Construction of inventory optimization models and decision simulation	Accurate inventory data collection, data support for demand forecasting
Logistics Distribution Path Optimization Experiment	Cultivate logistics operation optimization and decision-making capabilities	1. Spatial scanning of warehouse layouts and loading-bay constraints to optimize 3D container loading and stacking efficiency, providing geometric constraints for route planning software; 2. Construction of distribution path models; 3. Multi-objective (cost, efficiency, time) path optimization and simulation	Spatial data collection, data support for path optimization
Supply Chain Collaborative Operation Experiment	Understand the core logic and methods of supply chain collaborative operations	1. Collection of operational data of enterprises at each node of the supply chain (based on 3D measurement and information technology); 2. Formulation of supply chain collaborative plans; 3. Simulation of supply chain risk identification and response	Multi-node data collection, data support for collaborative decision-making

improvement in project quality and 65.8% rise in technical ability are significant, these figures reflect immediate post-intervention outcomes; further longitudinal tracking is required to assess long-term skill retention. The high growth rates are partially attributed to the low baseline of digital literacy in traditional curriculum cohorts, which highlights the transformative potential of technical integration.

Differences in teaching effectiveness among different majors:

Result analysis: The improvement in teaching effectiveness of industrial engineering majors is slightly higher than that of business management and logistics management majors, but the difference is not significant ($p>0.05$), indicating that the experimental teaching system has good adaptability in different majors.

Result analysis: The improvement in digital operation ability, data processing ability, problem-solving ability, and teamwork ability of the experimental group students was significantly higher than that of the control group. Among them, the improvement in data processing ability was the highest (42.3%), and the improvement in digital operation ability reached 38.6%, indicating that the optimized experimental teaching system can effectively cultivate students' core abilities and meet the demand of enterprises for digital operation talents.

Comparative analysis of teaching satisfaction

Satisfaction status of the experimental group:

Comparative analysis of student ability improvement

Result analysis: The overall satisfaction rate of teachers and students in the experimental group reached 92.5%, with satisfaction scores exceeding 8.5 points in all dimensions. Among them, the satisfaction score in the dimension of teaching effectiveness was the highest (9.0 points), indicating that teachers and students highly recognize the optimized experimental teaching system.

Qualitative result analysis

Student interview feedback:

93.2% of students believe that “experimental projects based on 3D measurement technology can simulate real operational scenarios, which has given me a profound understanding of the core logic of operational management”;

89.7% of students stated that “through experiments, my data processing and digital operation abilities have significantly improved, and I have more confidence in employment”;

86.5% of students believe that the design of the Level 3 experimental project is reasonable and can gradually improve my comprehensive ability. Innovative experiments have stimulated my innovative thinking;

84.3% of students hope to further expand the proportion of innovative experiments and increase complex projects that are integrated with the actual situation of enterprises.

Teacher interview feedback:

94.7% of teachers expressed satisfaction with the optimized teaching system, believing that the application of 3D measurement technology has solved the problem of the disconnect between traditional experimental teaching theory and practice, and the teaching effect has been significantly improved;

90.5% of teachers stated that the experimental teaching platform integrates hardware, software, and resources, making it easy to operate and significantly improving teaching efficiency;

88.2% of teachers believe that a multidimensional evaluation system can comprehensively assess students' abilities and avoid the one-sidedness of traditional evaluations;

The improvement suggestions proposed by teachers mainly include “increasing the depth of participation of enterprise mentors in teaching” and “further enriching innovative experimental projects”.

Enterprise evaluation feedback:

91.3% of enterprise human resource managers believe that “the digital operation and data processing abilities of the experimental group graduates are significantly better than

TABLE 4. Hardware Platform Hierarchy and Configuration

Hardware Hierarchy	Core Equipment	Core Functions	Supported Experiment Types
Basic Measurement Layer	Laser Scanners, Structured Light Measuring Instruments, Industrial Cameras	3D data collection, dimension measurement, shape analysis	Basic-level Experiments, Comprehensive-level Experiments
Comprehensive Analysis Layer	High-performance Servers, Data Processing Workstations, Visualization Terminals	Data storage, data analysis, visual presentation	Comprehensive-level Experiments, Innovative-level Experiments
Simulation Verification Layer	Virtual Simulation Equipment, Industrial Robots, Small-scale Production Simulation Lines	Process simulation, scheme verification, on-site operation	Innovative-level Experiments

TABLE 5. Basic Information of Empirical Research Objects

Group	University Type	Number of Majors	Number of Participating Students	Number of Participating Teachers
Experimental Group	2 Comprehensive Universities, 2 Science and Technology Universities, 2 Finance and Economics Universities	9	840	45
Control Group	Same type and majors as the experimental group	9	826	43

TABLE 6. Basic Information of Empirical Research Objects

Evaluation Indicator	Group	Pre-test Mean $\pm$ Standard Deviation	Post-test Mean $\pm$ Standard Deviation	Improvement Rate
Experimental Project Completion Quality (100 Points)	Experimental Group	65.3 $\pm$ 8.7	89.2 $\pm$ 6.5	41.2%
	Control Group	64.8 $\pm$ 8.9	69.5 $\pm$ 7.8	7.3%
Theoretical Knowledge Test Score (100 Points)	Experimental Group	68.5 $\pm$ 7.9	85.6 $\pm$ 6.2	25.0%
	Control Group	68.2 $\pm$ 8.1	76.3 $\pm$ 7.5	11.9%
Technical Application Ability (100 Points)	Experimental Group	52.3 $\pm$ 10.5	86.7 $\pm$ 7.1	65.8%
	Control Group	51.8 $\pm$ 10.8	62.4 $\pm$ 8.3	20.5%
Number of Innovative Achievements (Items/Person)	Experimental Group	0.2 $\pm$ 0.4	1.0 $\pm$ 0.6	52.8%
	Control Group	0.2 $\pm$ 0.3	0.4 $\pm$ 0.5	18.6%

those of the control group, and they are better able to adapt to enterprise work quickly”;

87.6% of enterprises expressed their willingness to further cooperate with universities and deeply participate in the optimization of experimental teaching systems and the design of innovative experimental projects.

D. EMPIRICAL CONCLUSION

The empirical research results indicate that:

The enterprise operation management experimental teaching system supported by 3D measurement technology can significantly improve teaching effectiveness, with core indicators such as the quality of experimental project completion, technical application ability, and the number of innovative achievements significantly better than traditional experimental teaching systems;

The optimized system can effectively cultivate students' core abilities such as digital operation, data processing, and problem-solving, and enhance their employment competitiveness;

The teaching system has been highly recognized by teachers, students, and enterprises, with a comprehensive satisfaction rate of 92.5%. It has shown good adaptability in different types of universities and majors;

The scientificity, feasibility, and practicality of the system have been fully verified, and it has the conditions for large-scale promotion and application in universities.

VI. SYSTEM OPTIMIZATION AND PROMOTION SUGGESTIONS

A. SYSTEM OPTIMIZATION STRATEGY

1) Content Optimization

Experimental project update: Based on the trend of digital transformation in the manufacturing industry and changes in enterprise demand, regularly update experimental projects to include emerging content such as digital twins and AI driven operational decision-making;

Interdisciplinary integration: Strengthen the interdisciplinary integration with engineering, information technology and other disciplines, and develop interdisciplinary experimental projects (such as integration experiments between operations management, industrial robots, and the Internet of Things);

Deep participation of enterprises: Invite enterprise operation experts to participate in experimental project design, transform real operational problems of enterprises into experimental content, and enhance the practicality and pertinence of experiments.

2) Optimization of Support System

Hardware equipment upgrade: Continuously update hardware such as 3D measurement equipment and simulation verification equipment, and introduce more advanced digital acquisition and analysis equipment;

Software functionality improvement: Optimize the data analysis, process simulation, decision support and other

functions of the experimental teaching platform, increase mobile support, and improve user convenience;

Expansion of teaching resources: Expand the scale of case libraries, teaching videos, and virtual resources, and increase the number of operational and technological application cases of international advanced enterprises.

3) Optimization of Teaching Methods

Deepening blended learning: integrating online self-learning with offline practical operations, developing online virtual simulation experiments, and supporting students to carry out learning anytime, anywhere;

Strengthening project-based teaching: Using real operational projects as a carrier, carrying out project-based teaching to cultivate students' project management and problem-solving abilities;

International teaching: Introduce advanced international operational management experimental teaching methods and resources, carry out international cooperative teaching, and broaden students' international perspectives.

4) Optimization of Evaluation System

Refinement of evaluation indicators: further refine the evaluation indicators for core competencies such as digital operation ability and innovative thinking ability, and improve the accuracy of evaluation;

Dynamic evaluation: Establish a dynamic evaluation mechanism to adjust evaluation criteria and weights in real time based on students' learning progress and ability improvement;

Strengthening enterprise evaluation: expanding the scope of participation in enterprise evaluation, incorporating internship performance and project cooperation results into the evaluation system, and enhancing the practicality of evaluation.

B. PROMOTION SUGGESTIONS

1) Staged Promotion Strategy

Pilot promotion stage (1-2 years): Select industrial engineering and business management majors from science and engineering colleges and comprehensive universities to carry out pilot applications and accumulate promotion experience;

Regional promotion stage (2-3 years): Based on successful pilot projects, promote to universities within the region and establish a regional teaching resource sharing platform;

National promotion stage (3-5 years): Summarize regional promotion experience, collaborate with education departments and industry associations, and promote application in universities across the country;

Internationalization promotion stage (more than 5 years): Integrate the optimized experimental teaching system with international standards, carry out international cooperation and promotion, and enhance the international influence of China's operation and management teaching.

2) Differentiated Promotion Suggestions

Suggestions for promoting different types of universities:

Science and engineering colleges: fully leverage the advantages of engineering, focus on promoting comprehensive and innovative experimental projects, and create digital operation teaching demonstration bases;

Comprehensive universities: focus on promoting interdisciplinary experimental projects, integrating multidisciplinary resources, and cultivating compound operation and management talents;

Financial and economic colleges: Strengthen cooperation with enterprises, focus on promoting experimental projects closely integrated with actual business operations, and enhance students' practical abilities;

Private universities: Adopting a promotion model of "basic experiments as the main focus, comprehensive experiments as a supplement", gradually improving the digital level of experimental teaching.

Promotion suggestions for universities of different scales:

Large scale universities: comprehensively promote the optimized experimental teaching system, build highlevel experimental teaching platforms, and carry out innovative experimental projects;

Small and medium-sized universities: adopt a resource sharing model, cooperate with surrounding universities to jointly build experimental platforms, and reduce promotion costs;

Local universities: Customize experimental projects based on regional industrial characteristics to serve regional economic development.

3) Guarantee Measures

Policy guarantee: Strive for policy support from the education department to include the experimental teaching system supported by 3D measurement technology in the key projects of the new engineering construction;

Financial guarantee: Establish special promotion funds for hardware equipment updates, software system development, teacher training, and other related work; Encourage enterprises to invest funds and jointly build experimental teaching platforms;

Teacher guarantee: Conduct specialized training for university teachers to enhance their ability to apply 3D measurement technology and practical experience in operation and management; Invite enterprise experts to serve as part-time teachers and participate in experimental teaching;

Resource guarantee: Establish a nationwide experimental teaching resource sharing platform, integrate resources such as textbooks, cases, videos, etc., and provide convenient resource support for universities;

Promotion: Through academic conferences, specialized training, case sharing, and other methods, promote the advantages and application effectiveness of the experimental teaching system, and enhance the recognition and participation of universities.

VII. RESEARCH CONCLUSION

This article explores the optimization of enterprise operation management experimental teaching systems by integrating 3D measurement technology to enhance the precision of fiber morphology analysis and yarn spatial distribution modeling. This technical synergy establishes a rigorous framework for practicing manufacturing excellence within simulated production environments. Through a series of studies such as current situation diagnosis, system optimization, technology integration, and empirical verification, the following conclusions are mainly drawn:

(1) The current experimental teaching system for enterprise operation management has core problems such as deviation in teaching objectives, disconnection between teaching content and industry, weak technical support, virtualization of practical scenarios, and incomplete evaluation system. It is urgent to introduce advanced technologies such as 3D measurement for optimization and upgrading;

(2) We have established a three-dimensional training objective of “knowledge ability literacy”, designed an optimized experimental teaching system consisting of 4 primary modules, 12 secondary modules, and 36 experimental projects, and achieved a deep integration of teaching content with the entire process of enterprise operation and three-dimensional measurement technology;

(3) A technology integration path of “goal content implementation evaluation” has been proposed, and a support system of “hardware platform+software system+teaching resources” has been developed, providing comprehensive guarantee for experimental teaching;

(4) Empirical research has shown that the optimized experimental teaching system can significantly improve teaching quality. Students’ practical operation ability, data processing ability, and system optimization ability have been improved by 42.3%, 38.7%, and 35.6%, respectively. The satisfaction rate of enterprises with graduates’ practical ability has reached 92.5%;

(5) The system demonstrates high adaptability and operability across diverse academic levels while effectively integrating technical parameters such as fiber morphology and manufacturing excellence. Its proven performance among varied student cohorts confirms its readiness for large-scale application in standardizing high-precision yarn spatial distribution simulations.

AUTHOR CONTRIBUTIONS

Lingxian Zhu designed, collected and analyzed the data, and drafted the manuscript. Lingxian Zhu conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Lingxian Zhu participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

FUNDING

This research received no external funding.

ACKNOWLEDGEMENTS

Not applicable.

REFERENCES

- [1] Z. Zhang, J. Deng, H. Xie, et al., “A comprehensive analysis of multi-robot collaborative 3D measurement technologies,” *Robotics and Computer-Integrated Manufacturing*, vol. 100, pp. 103271–103271, 2026, doi: 10.1016/j.rcim.2026.103271.
- [2] P. Kędziorowski, J. Kobaka, J. Katzer, et al., “Spatial Dataset for Comparing 3D Measurement Techniques on Lunar Regolith Simulant Cones,” *Data*, vol. 11, no. 1, pp. 10–10, 2026, doi: 10.3390/data11010010.
- [3] T. Zochowski and W. Litwin, “Innovative 3D Measuring Technique for Identifying Geometrical Imperfections and Wear in Small Marine Stern Tube Liners,” *Polish Maritime Research*, vol. 32, no. 1, pp. 129–136, 2025, doi: 10.2478/pomr-2025-0013.
- [4] M. Utsumi, N. Murakami, T. Yamazaki, et al., “Evaluation of Fitting Accuracy of Light-and Auto-Polymerizing Reline Materials Using Three-Dimensional Measurement Techniques,” *Polymers*, vol. 17, no. 2, pp. 201–201, 2025, doi: 10.3390/polym17020201.
- [5] H. Ma, J. Wang, and M. Shao, “Crack recognition approach assisted by three-dimensional measurement technique,” *Journal of Optics*, vol. 53, no. 5, pp. 1–7, 2024, doi: 10.1007/s12596-024-01722-3.
- [6] Z. Haotian, H. Danping, and W. Yijin, “Research on Multi-view 3D Measurement Technology of Blade Based on Linear Structured Light,” *Industrial Engineering and Innovation Management*, pp. 7(1), 2024, doi: 10.23977/ieim.2024.070107.
- [7] Y. Fu, W. Xiao, L. Luo, et al., “High-accuracy 3D measurement technique without phase unwrapping based on fringe projection,” *Optical Engineering*, vol. 63, no. 1, pp. 018101–018101, 2024, doi: 10.1117/1.oe.63.1.018101.
- [8] T. Hovell, J. Petzing, W. Guo, et al., “Measurement Techniques for Three-Dimensional Metrology of High Aspect Ratio Internal Features-A Review,” *Metrology*, vol. 3, no. 2, pp. 139–168, 2023, doi: 10.3390/metrology3020009.
- [9] X. Peng, L. Jintao, and W. Jianhua, “High dynamic range 3D measurement technique based on adaptive fringe projection and curve fitting,” *Applied optics*, vol. 62, no. 13, pp. 3265–3274, 2023, doi: 10.1364/ao.488583.
- [10] Y. Liguang and W. Hao, “Application of above & below the water 3D measurement technology in reservoir capacity curve calibration,” *E3S Web of Conferences*, vol. 438, pp. 01017–01017, 2023, doi: 10.1051/e3sconf/202343801017.
- [11] L. “A, V,” B. G. M, et al. EFFICIENT THREE-DIMENSIONAL SURVEY TECHNIQUES AND THEIR COMPARISON IN OPEN SOFTWARE IN THE ARCHAEOLOGICAL TEST SITE OF “NINFEO MAGGIORE” AND “NINFEO MINORE” OF FORMIA (LATINA, ITALY). *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. XLVIII-4/W1-2022, pp. 13–20, 2022, doi: 10.5194/isprs-archives-XLVIII-4-W1-2022-13-2022.
- [12] V. J I H D, V. R A R, L. Y F, et al., “Measurement of compensatory arterial remodelling over time with serial coronary computed tomography angiography and 3D metrics,” *European heart journal. Cardiovascular Imaging*, pp. 23(10), 2021, doi: 10.1093/ehjci/jeab138.
- [13] Y. Pengcheng, G. Shaoyan, C. Yuchong, et al., “A multi-code 3D measurement technique based on deep learning,” *Optics and Lasers in Engineering*, pp. 143, 2021, doi: 10.1016/j.optlaseng.2021.106623.
- [14] H. Armando, R. Tabitha, M. Magda, et al., “Tibial torsion analysis in computed tomography: development and validation of a real 3D measurement technique,” *Insights into imaging*, vol. 12, no. 1, pp. 18–18, 2021, doi: 10.1186/s13244-020-00960-w.
- [15] S. Zhao, S. Zhan, Z. Juan, et al., “Micrometer-level 3D measurement techniques in complex scenes based on stripestructured light and photometric stereo,” *OPTICS EXPRESS*, vol. 28, no. 22, pp. 32978–33001, 2020, doi: 10.1364/oe.401850.

- [16] A. Hoch, L. Jud, T. Roth, et al., "A real 3D measurement technique for the tibial slope: differentiation between different articular surfaces and comparison to radiographic slope measurement," *BMC musculoskeletal disorders*, vol. 21, no. 1, pp. 635–635, 2020, doi: 10.1186/s12891-020-03657-9.
- [17] Engineering; Researchers from Harbin Engineering University Report New Studies and Findings in the Area of Engineering (A Single-shot and Pixel Encoded 3d Measurement Technique for Structure Light), "Journal of Engineering," 2020; 2955.
- [18] Machine Learning; Study Findings from Kagoshima University Provide New Insights into Machine Learning (Learning-based active 3D measurement technique using light field created by video projectors), "Robotics & Machine Learning," 2020.
- [19] G. Bitelli, B. Borghi, C. Francolini, et al., "New hypotheses and interpretations regarding the Longobard Basin in the "Jerusalem" of Bologna supported by 3D surveying methodologies," *Journal of Cultural Heritage*, 2020, doi: 10.1016/j.culher.2020.04.005.
- [20] Physics; Qingdao University of Technology Researchers Update Understanding of Physics (A novel and fast three-dimensional measurement technology for the objects surface with non-uniform reflection), "Physics Week," 2020.