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2026 Volume 4, Issue 3
Contemporary Education Frontiers
ISSN:3029-1879 (Online)
ISSN: 3029-1860 (Print)

Innovation and Practice of the VPC Teaching Paradigm for the "Database Principles" Course in the Context of Emerging Engineering Education

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Abstract: Addressing the pain points in the teaching of the "Database Principles" course, such as the disconnection between theory and practice, lack of engineering thinking cultivation, rigid integration of ideological and political education, mismatch between teaching supply and personalized needs, and the one-dimensional nature of learning assessment, this study, guided by the construction of "Emerging Engineering Education" and fulfilling the fundamental task of "Fostering Virtue through Education", constructs a new VPC teaching paradigm with "Value guidance as the soul, Problem orientation as the bone, and Case teaching as the flesh". Through the implementation of "dual-chain driven" curriculum content restructuring, innovation in teaching methods via "university-enterprise collaboration + digital empowerment", "three-levels and three-integrations" ideological and political education design, a "five-stage three-closed-loop" teaching organization process, and diversified evaluation reform, a shift from knowledge impartation to the integrated cultivation of values, abilities, and literacy has been achieved. Teaching practice shows that this model effectively enhances students' ability to solve complex engineering problems. Related achievements have been awarded national-level recognitions such as the National First-Class Offline Undergraduate Course, providing a replicable and scalable reference paradigm for teaching reform in specialized courses under the context of Emerging Engineering Education.

Keywords: Database principles; VPC teaching paradigm; Five-stage three-closed-loop; Curriculum ideology and politics; Emerging engineering education; Teaching innovation

Online publication: March 26, 2026

1. Introduction

Against the backdrop of the rapid development of the digital economy, database technology, as the core support of information technology, has been widely applied in various industries. There is an increasingly urgent social demand for application-oriented talents in databases. The "Database Principles" course, a core fundamental course for computer-related majors, undertakes the important mission of cultivating students' abilities in data modeling, system design, and engineering applications. Its teaching quality directly affects the overall level of talent cultivation in Emerging Engineering Education.

Currently, the teaching of the "Database Principles" course in China generally faces challenges in adapting traditional models to the talent cultivation requirements of the new era. The traditional "theory first, experiment later" teaching model has structural contradictions. The parsing of syntax in theoretical classes and the lagging experimental sessions create a temporal disconnect and spatial separation, leading students to form a gap between theory and practice, making it difficult to construct a complete knowledge chain and resulting in the cognitive dilemma of "understanding in class but being unable to apply in practice" [1–5]. Furthermore, there is a prominent contradiction between standardized teaching and students' personalized needs. The alienation of abstract theoretical knowledge from concrete engineering practice leads to attenuated learning motivation, insufficient classroom participation, and difficulty in stimulating enthusiasm for active exploration [6]. In terms of aligning with industrial demands, teaching content is disconnected from industry practices, lacking training in real projects and integration of domestic database technology, making it difficult for students' engineering thinking and practical abilities to meet enterprise recruitment standards, resulting in a long adaptation period for graduates [7]. Additionally, curriculum ideology and politics are often mechanically implanted, with shallow integration between value guidance and professional teaching, failing to effectively stimulate students' endogenous motivation for serving the country through technology, which shows a gap with the fundamental requirement of "Fostering Virtue through Education" in Emerging Engineering Education [8–10].

To address these challenges, the "Database Principles" course team at Lingnan Normal University has focused on curriculum construction, successively obtaining approvals for the Guangdong Provincial Offline First-Class Undergraduate Course (2020), the University-Level Ideological and Political Demonstration Course (2023), and the National Offline First-Class Undergraduate Course (2025). Gradually, a teaching innovation system with the VPC teaching paradigm as the core has been formed. This paper systematically elaborates on the teaching reform path and results of this course from the aspects of pain point analysis, innovative ideas and measures, practical effectiveness, and promotion value, providing a reference for teaching reform in similar courses.

2. Analysis of teaching pain points in the course

Through multi-dimensional learning analysis, including Questionnaire Star surveys, Learning Superstar data tracking, experimental process observation, and student interviews, five core teaching pain points were identified, as shown in **Table 1**.

Table 1. Five core teaching pain points and their manifestations

Pain Point Type	Core Manifestations
"Chasm Effect" between Theory and Practice	Abstract theories are difficult to concretize, knowledge points are fragmented, and students "understand the lecture but cannot apply it"
"Blind Spot" in Cultivating Engineering Thinking	Weak system design ability, insufficient optimization skills, lack of practical experience in solving complex engineering problems
"Two Skins" Phenomenon in Curriculum Ideology and Politics	The Perfunctory Integration of Ideological and Political Elements, Low Relevance to Professional Knowledge, Insufficient Student Identification, and Inadequate Cultivation of National Sentiment
"Mismatch Contradiction" in Teaching Supply	Single teaching method, lack of interactivity, lack of real case studies in teaching resources, difficulty in meeting personalized learning needs
Limitations of "One-Dimensional" Evaluation System	Emphasis on results over process, knowledge over ability, rigid assessment methods, and inability to fully reflect students' comprehensive literacy

2.1. Knowledge level: The "Chasm Effect" between theory and practice

Core content, such as relational algebra and normalization theory, is abstract and difficult to understand. Students struggle to establish the connection between theory and actual database design. Knowledge points from various chapters are relatively isolated. Students cannot connect content like SQL programming, transaction management, and database design into a complete knowledge system, resulting in a fragmented learning state and leading to “understanding the lecture but being unable to apply it.”

2.2. Ability level: The “Blind Spot” in engineering thinking and innovative ability

Course teaching emphasizes theoretical instruction and lacks comprehensive, industry-level project training. Students’ system design abilities are weak, making it difficult for them to independently complete the entire process from requirements analysis and conceptual structure design to physical implementation. When facing practical problems like concurrency conflicts and query optimization, they lack effective solutions. There is a significant gap between their practical abilities and industry needs.

2.3. Literacy level: The “Two Skins” phenomenon in value guidance and curriculum ideology and politics

Ideological and political education often manifests as “hard grafting”, mechanically inserting concepts such as the “craftsman spirit” and “patriotic sentiment” into courseware with low relevance to professional knowledge, resulting in limited student identification. Students possess minimal understanding of the international landscape within the database field and the developmental achievements of domestic databases, leading to an ineffective stimulation of their intrinsic motivation for serving the nation through technological advancement. Furthermore, the cultivation of information ethics and professional morality is insufficient.

2.4. Teaching methods and resources: The “Mismatch Contradiction” between teaching supply and personalized needs

The teaching model is primarily based on “teacher lectures, students listen, “ lacking interactive teaching methods like case-based and seminar-style learning, resulting in insufficient student initiative and classroom participation. Teaching resources mostly consist of textbook examples and simple experiments, lacking support from real industry cases, making it difficult to meet the personalized growth needs of students with different foundations.

2.5. Assessment and evaluation: The “One-Dimensional” limitation in learning outcome evaluation

The assessment method relies too heavily on final exams, emphasizing results over process and knowledge over ability, failing to comprehensively reflect students’ practical abilities, innovative thinking, and value literacy. There is a lack of effective means to assess core abilities such as database design, optimization, and teamwork. Evaluation results struggle to reflect students’ genuine growth.

3. Construction and implementation of the VPC teaching paradigm

Addressing the above pain points and guided by the requirements of “Emerging Engineering Education” construction, the course team built a new VPC teaching paradigm: “Value guidance + Problem orientation + Case teaching.” The framework of the VPC teaching paradigm is shown in **Figure 1**. Through five major measures, “content restructuring, method innovation, organization optimization, ideological and political integration, and evaluation reform”, innovation across the entire teaching process is achieved.

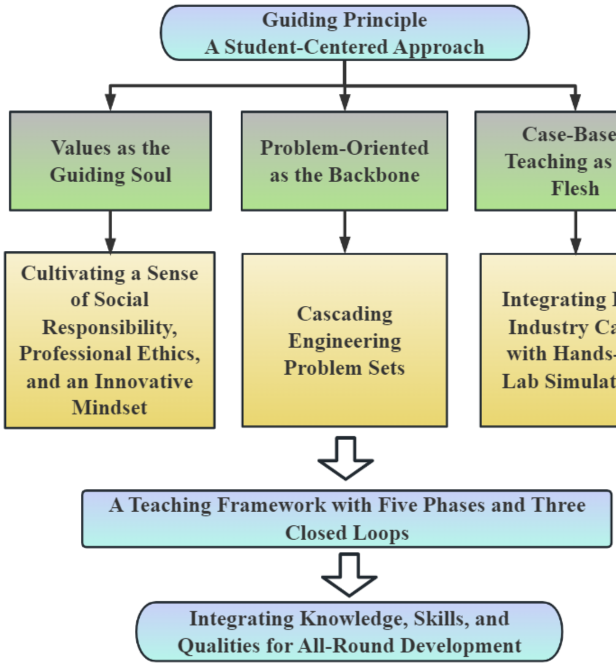

Figure 1. Framework of the VPC teaching paradigm.

3.1. Dual-chain drive: Restructuring of course content

Using a "problem chain" to guide knowledge construction, progressive engineering problems, such as "Breakthrough in Domestic Database Technology" and "E-commerce System Database Optimization", were designed to organically connect core knowledge points like SQL optimization, transaction processing, and data security, forming a complete knowledge system. Infusing educational elements through a "value chain, " cases of domestic databases like OpenGauss and Renmin Jincang were introduced. National security awareness was integrated into the database security module, the craftsman spirit of excellence was cultivated in the query optimization session, and information ethics and professional morality education were strengthened in project practice.

The course content covers core modules, such as data models, SQL language, database programming, normalization theory, database security, transaction processing, and database design. Thirty experimental teaching cases and ten industry-level cases were developed, as shown in **Table 2**, achieving deep integration of theoretical knowledge and industrial practice.

Table 2. Core course case resource library

Case Type	Case Name	Corresponding Knowledge Points	Ideological and Political Integration Points
Industry-level Case	E-commerce System Database Design and Optimization	Data modeling, query optimization, transaction processing	Craftsman spirit, user-first concept
Industry-level Case	COVID-19 Normalized Management System	Data query, statistical analysis, security control	Patriotic Sentiment, social responsibility
Experimental Case	Online Shopping Cart Management System	SQL programming, data manipulation	Information ethics, privacy protection
Experimental Case	Database for Red Tourism VR System	Data storage, multi-dimensional query	Patriotic Sentiment, cultural inheritance
Ideological Case	Technological Breakthrough of OpenGauss Database	Database principles, optimization technology	echnological confidence, innovative spirit

3.2. University-enterprise collaboration + digital empowerment: Innovation in teaching methods

In collaboration with enterprises like Hunian Zhiqing Technology, practical teaching resources were co-developed. Project-based learning through the "Learning by Doing" platform was utilized, where students enhance their system design and optimization abilities by completing real projects such as online malls, hotel room management systems, and bank credit ledger management systems. A three-dimensional hybrid teaching model integrating "MOOCs + classroom seminars + platform simulation" was constructed, as shown in **Figure 2**, organically combining pre-class preview, in-class interaction, and post-class expansion to meet students' self-directed learning and personalized development needs.

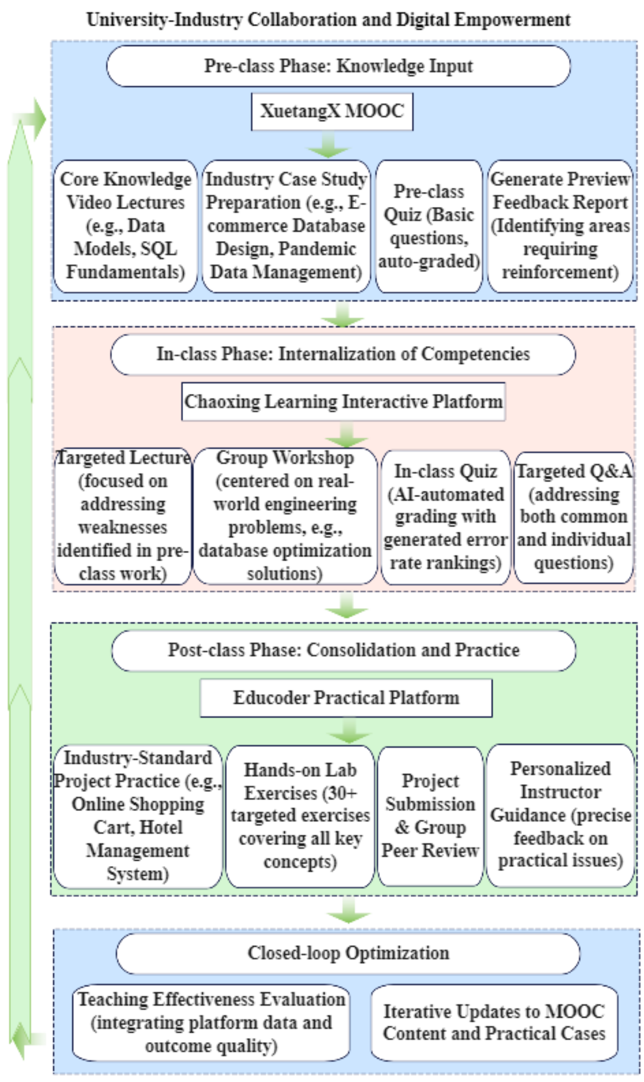

Figure 2. Three-dimensional hybrid teaching model.

Knowledge graph technology was used to outline the core knowledge points and key/difficult test points of the course, forming a visual knowledge network to help students build a systematic knowledge structure. Using AI-powered automatic grading for in-class quizzes on the Learning Superstar platform, error rate rankings were generated automatically, allowing teachers to provide targeted explanations for concentrated issues, achieving precise teaching.

3.3. Five-stage three-closed-loop: Optimization of teaching organization process

A five-stage teaching process of "Guidance - Instruction - Review - Evaluation - Sharing" was constructed, forming three closed loops that drive the spiral rise of teaching quality, as shown in **Figure 3**.

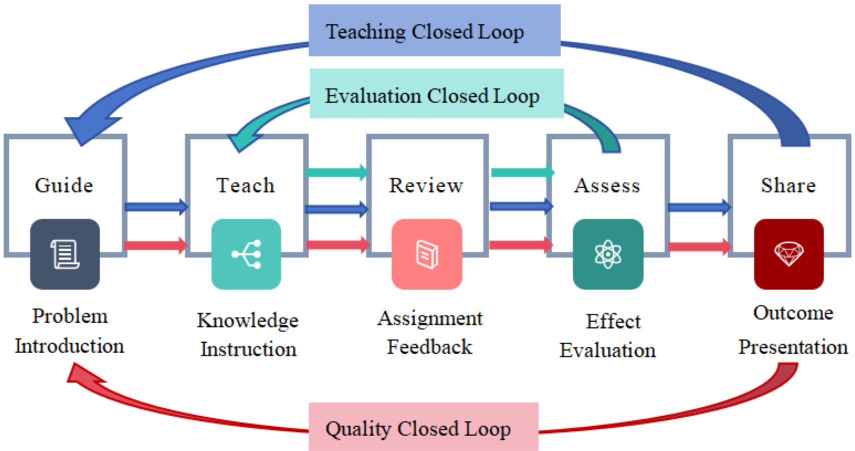

Figure 3. Five-stage three-cycle teaching process.

Cycle through "Problem Introduction → Hybrid Teaching → Precise Feedback → Multi-faceted Evaluation → Achievement Showcase → New Problem Introduction" to achieve continuous iteration of teaching content.

Form a loop of "Evaluation Results → Teaching Adjustment → Precise Guidance → Effect Verification → Evaluation Optimization, " dynamically adjusting teaching strategies based on evaluation data.

Drive continuous teaching quality improvement through the loop of "Achievement Showcase → Experience Sharing → Problem Reflection → Teaching Improvement → Quality Enhancement → New Achievement Showcase."

Twenty-eight instructional videos were released on the XuetangX MOOC platform, with cumulative course enrollment reaching 3058 students. The Learning Superstar platform facilitated functions like class management, assignment distribution, and discussion interaction, covering majors such as Computer Science and Technology, Software Engineering, and Artificial Intelligence, effectively supporting the implementation of online and offline blended teaching.

3.4. Three-levels three-integrations: Systematic design of curriculum ideology and politics

The three-level ideological and political education goals of "Patriotic Sentiment - Professional Ethics - Innovative Spirit" were constructed. Through the three-integration path of "Technology History + Industry Cases + Teacher's Deeds, " the organic integration of ideological/political education and professional teaching was achieved, as shown in **Figure 4**.

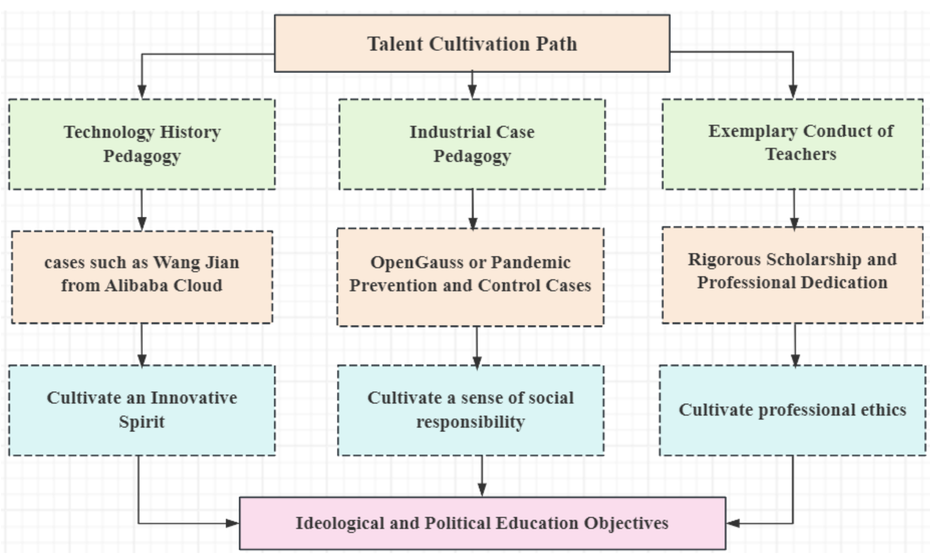

Figure 4. The three-level, three-integration path for ideological and political education.

In teaching technology history, the entrepreneurial journeys of figures like Wang Jian (Father of Alibaba Cloud) and Su Meng (Leader in Big Data Industry) were presented to inherit the craftsman spirit. In industry cases, examples like the technological breakthrough of OpenGauss and the development of COVID-19 prevention and control systems were used to stimulate students' Patriotic Sentiment for serving the country through technology. Throughout the teaching process, teachers influenced students with rigorous scholarly attitudes and professional dedication, strengthening the cultivation of professional ethics. Course websites featured sections for ideological/political cases, including themes like patriotism, craftsman spirit, and national security awareness. Cases integrating ideological/political elements, such as those based on COVID-19 normalized management and red tourism VR systems, were developed, achieving pervasive value guidance throughout the course.

3.5. Diversified assessment: Reform of the evaluation system

A diversified assessment mechanism combining "Formative Assessment (50%) + Summative Assessment (50%)" was implemented to comprehensively evaluate students' knowledge acquisition, ability enhancement, and value development. Formative Assessment rely on data from platforms such as XuetangX, Learning Superstar (Chaoxing), and EduCoder, it covers chapter preview (15%), in-class quizzes (10%), classroom interaction (5%), experimental practice (40%), discussion participation (10%), check-in status (5%), self-assessment (5%), and course achievement evaluation (10%). Summative Assessment adopts a closed-book examination format, which focuses on assessing students' ability to solve complex engineering problems. Process Assessment for Database Principles Course shows as **Table 3**.

Table 3. Process assessment for database principles course

Assessment Content	Assessment Dimension	Data Source	Weight
Assessment of Knowledge Objectives	(1) Preview of chapter knowledge points	XuetangX statistics	15%
	(2) In-class quizzes	Learning Superstar statistics	10%
Assessment of Ability Objectives	(1) Selected Q&A participation	Learning Superstar statistics	5%
	(2) Experiments	Educoder platform statistics	40%
Assessment of Value Objectives	(1) Discussion participation	Learning Superstar statistics	10%
	(2) Check-in status	Learning Superstar statistics	10%
	(3) Self-assessment	Questionnaire statistics	5%
	(4) Course achievement evaluation	Competitions, works, awards	5%

The diversified assessment system effectively reversed the traditional evaluation orientation of "emphasizing knowledge over ability, results over process, " comprehensively reflecting students' actual learning outcomes.

4. Effectiveness of teaching innovation practice

4.1. Significant improvement in students' comprehensive abilities

Over the past three years, leveraging the course knowledge, students have participated in competitions such as the National College Student Computer Design Competition, the "Challenge Cup, " and the "Internet +" Innovation and Entrepreneurship Competition. They have won 15 awards at the provincial level or above, including 5 national awards. Students have also secured 8 computer software copyrights and developed multiple practical application projects, such as an Agricultural Products Self-operated Sales Platform, a Rural Epidemic Normalized Prevention and Control Platform, and the Zhanjiang Red Tourism VR System. Furthermore, students have published research papers in journals like *Wireless Internet Technology*, demonstrating a significant enhancement in their ability to solve complex engineering problems.

4.2. High student satisfaction and course objective attainment

Questionnaire results (valid responses: 52) show that 55.77% of students **strongly agree** that they have mastered knowledge and skills related to database design.53.85% **strongly agree** that they possess the ability to analyze practical problems. 51.92% **strongly agree** that they can design complex relational databases. Satisfaction with teachers' teaching methods and attitudes reached 92.31%, and satisfaction with their own knowledge and skill mastery reached 80.77%. Both course objective attainment and teaching satisfaction are at a high level, as shown in **Table 4**.

Table 4. Student course attainment and satisfaction survey results (n = 52)

Survey Dimension	Strongly Agree / Very Satisfied (%)	Agree / Satisfied (%)	Neutral / Generally Agree (%)	Disagree / Dissatisfied (%)
Mastery of Database Design Knowledge & Skills	55.77	28.85	15.38	0
Practical Problem Analysis Ability	53.85	23.08	23.08	0
Complex Relational Database Design Ability	51.92	23.08	25.00	0
Self-directed & Lifelong Learning Ability	50.00	32.69	17.31	0
Teacher's Teaching Methods & Attitude	69.23	23.08	7.69	0
Own Knowledge & Skill Mastery	50.00	30.77	19.23	0

4.3. Abundant achievements in course construction and teaching research

The course has been successively recognized as Provincial-level Quality Course (2017), Guangdong Province Offline First-class Undergraduate Course (2020), University-level Ideological and Political Demonstration Course (2023), and National Offline First-class Undergraduate Course (2025). The teaching team has led 5 teaching reform projects at the provincial level or above and 3 at the university level. They have published 7 teaching research papers and authored the textbook "Database Principles and Practice (MySQL Edition)." The team has received two Second Prizes for Outstanding Teaching Achievements from Lingnan Normal University, one Teaching Achievement Award from the Guangdong Educational Evaluation Association, and one First Prize and one Second Prize in teaching innovation competitions.

4.4. Significant demonstration and promotion effects

Online teaching resources have achieved broad influence: the XuetangX MOOC has attracted 3058 cumulative enrollments, and 7407 students have participated in learning on the EduCoder platform. The teaching model has been adapted to multiple courses, including "*Python Programming Language*," forming a replicable teaching paradigm. The published textbook has been adopted by several universities, including Chongqing Institute of Engineering, Jilin University, and Bengbu University, providing valuable reference for teaching reform in similar courses.

5. Promotion value and future outlook

5.1. Promotion value

A replicable teaching paradigm has been formed. The constructed teaching model, "Real Problem-Driven, Dual-Chain Content Restructuring, Five-Stage Closed-Loop Implementation, Multi-dimensional Data Evaluation", is suitable for technical foundation courses in computer-related majors, demonstrating strong universality and operability. An effective path for ideological and political integration is provided. The "Three-Level, Three-Integration, Three-Comprehensive" ideological and political education paradigm addresses the issue of "two separate layers" in ideological education within specialized courses, offering practical reference for ideological construction in professional courses. Blended online and offline teaching resources have been developed. The created MOOCs, experimental cases, and ideological resources can be shared via platforms like XuetangX and EduCoder, extending their reach to more teachers and students in higher education institutions.

5.2. Future outlook

With the continuous innovation of information technology, the course team will further deepen teaching reform. Utilize AI technology to build a learning path recommendation engine, generating personalized exercises and learning plans to meet students' differentiated needs. Deepen collaboration with leading enterprises, integrating the latest trends and technical standards from the "Xinchuang" (Information Technology Application Innovation) industry into teaching content in real-time. Continuously improve the functions of the intelligent teaching platform, strengthening the analysis and application of teaching data to achieve precise teaching decision-making. Expand the promotion scope of teaching achievements, cooperating with more universities to jointly enhance the teaching quality of computer-related courses in the background of Emerging Engineering Education.

Disclosure statement

The authors declare no conflict of interest.

Funding

"Computer Theory Teaching and Research Section" 2025 Guangdong Provincial Undergraduate Teaching Quality and Teaching Reform Engineering Construction Project (Yue Jiao Gao Han [2026] No.4); 2024 Lingnan Normal University Curriculum Ideology and Politics Demonstration Course Project, "Database Principles"; 2023 Lingnan Normal University Education and Teaching Reform Project, "Teaching Research and Reform Practice of the 'Database Principles' Course from the Perspective of Industry-Education Integration and Science-Education Convergence"; 2023 Guangdong Provincial Undergraduate Teaching Quality and Teaching Reform Engineering Construction Project, "Research and Reform Practice on the Teaching Mode of the 'Database Principles' Course from the Perspective of Industry-Education Integration and Science-Education Convergence" (Yue Jiao Gao Han [2024] No.9); Guangdong Provincial Educational Science Planning Project, "Research and Practice on the Intelligent Teaching Mode of the 'Database Principles' Course Driven by 'New Quality Productivity + Digital Transformation'" (Project No.: 2025GXJK0441); Co-construction Project of the Guangdong Provincial Philosophy and Social Sciences Planning (Project No.: GD23XJY71); 2025 Lingnan Normal University Teaching Quality and Teaching Reform Engineering Construction Project (Project No.: ZLGC2532); 2025 Lingnan Normal University Teaching Reform Project, "Research on the Construction and Practice of Personalized Learning Pathways in AI-Empowered Digital Transformation of Vocational Education"; Ministry of Education Humanities and Social Sciences Research Project, "Research on Adolescent Cyberbullying Identification and Attribution in Social Networks" (Project No.: 24YJA860002); Lingnan Normal University University-level Research Project (Project No.: TL2408)

Disclosure statement

The author declares no conflict of interest.

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