Education Reform and Development, 2026, Volume 8, Issue 10
https://bbwpublisher.com/journal/erd
Online ISSN: 2652-5372
Print ISSN: 2652-5364

Teaching Reform for Industry-Education Collaboration in Database Courses through Virtual-Real Integration: A Case Study of the University-Enterprise Co-developed Course Database Technology and Applications

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Abstract: To address persistent problems in database education, including the delayed incorporation of enterprise technologies into the classroom, the difficulty of converting authentic engineering tasks into teachable activities, the disconnect between virtual practice and industrial contexts, and course assessment that inadequately reflects job-relevant competencies, this study uses Database Technology and Applications as the course vehicle and integrates Huawei GaussDB, the State Grid Common Information Model (CIM), and regional agricultural data scenarios. We develop a university-enterprise co-development model comprising standards translation, case reconstruction, virtual-real training, dual-mentor collaboration, multi-source assessment, and continuous iteration. Enterprise technical standards are first decomposed into learnable, trainable, and assessable tasks. Cloud-based sandbox environments and augmented reality (AR) are then used to create complementary virtual and real practice settings, while university instructors and enterprise engineers jointly participate in task design, process guidance, and outcome assessment. To address three key problems—the mismatch between enterprise technology systems and students' learning progression, inefficient integration of university-enterprise resources, and insufficient objective evidence for validating teaching outcomes—the model establishes an evidence-based assessment mechanism supported by platform logs, project work orders, student artifacts, and process portfolios. The model emphasizes the pedagogical translation of enterprise knowledge before it enters the curriculum, with the aim of strengthening the engineering orientation, regional relevance, and capacity for continuous updating of database courses under resource constraints. It provides a practical reference for deepening industry-education integration in computing programs at regional universities.

Keywords: Database Technology and Applications; Industry-education integration; University-enterprise co-

development; Virtual-real integration; GaussDB; Course assessment

Online publication: November 25, 2026

1. Introduction

Database courses are an important foundation of computing programs and a key bridge between data management theory and the digital transformation of industry. With the rapid development of cloud databases, distributed architectures, and industry-specific data governance, enterprise expectations for graduates have expanded from basic database creation and SQL programming to system deployment, performance optimization, fault diagnosis, and business adaptation. However, university curricula often evolve more slowly than industrial technologies, and classroom experiments still rely largely on standalone environments and standardized datasets. As a result, students may be able to complete prescribed procedures without being able to solve engineering problems under authentic constraints.

Industry-education integration is not equivalent to moving enterprise projects directly into the classroom. Prior research indicates that its sustainability depends on stable mechanisms that align learning objectives, the depth of collaboration, and quality assurance [1]. New Engineering Education emphasizes solving authentic engineering problems in applied contexts and requires the boundaries between university-based knowledge production and industrial practice to be crossed [2]. The cultivation of outstanding engineers likewise depends on sustained university-enterprise collaboration through knowledge interaction, knowledge integration, and competency development [3]. From a systems perspective, the long-term effectiveness of industry-education integration also requires coordinated governance among multiple stakeholders [4]. In database education, reforms under the "101 Plan," teaching with domestically developed database systems, and digital course transformation have increasingly focused on restructuring knowledge systems, building experimental platforms, and strengthening process-oriented assessment [7-10]. For regional universities, however, it remains difficult to convert enterprise resources into undergraduate-level learning tasks, connect virtual environments with authentic industrial contexts, and transform learning processes into traceable evidence.

Against this background, this study draws on the university-enterprise co-development project for Database Technology and Applications. Using Huawei GaussDB, the State Grid CIM spatial data model, and regional agricultural data scenarios as the principal carriers, we explore a lightweight pathway for industry-education collaboration built around three linked processes: introducing enterprise standards into the curriculum, using virtual-real environments to support training, and using multi-source data feedback to improve teaching.

2. Diagnosis of problems in the course reform

2.1. A translation gap between enterprise technologies and course knowledge

Traditional database courses are commonly organized around the internal logic of data models, SQL, database design, transactions, and recovery, whereas enterprise work is typically organized around deployment, operations, performance optimization, and business delivery. Content such as GaussDB cluster deployment, load balancing, failover, and CIM-based spatial data modeling cannot be mapped mechanically onto textbook chapters. If enterprise technical documents are used directly, students may learn to follow procedures without

understanding the underlying principles. If instruction remains confined to textbook examples, however, students struggle to develop an authentic engineering perspective. Enterprise technologies therefore need to be decomposed, selected, and reorganized before entering the course so that technical standards can be aligned with knowledge points, competency objectives, and experimental tasks.

2.2. A context gap between virtual practice and authentic engineering

Authentic industrial systems are often constrained by data confidentiality, equipment costs, and operational safety, making it impractical for undergraduates to enter production environments repeatedly for trial and error. Yet experiments conducted entirely on virtual platforms can become overly idealized. Research on virtual simulation has shown that virtual resources are most effective when they are systematically connected with professional course objectives, offline practice, and authentic problems [5-6]. Accordingly, this course does not treat the virtual environment as a substitute for reality. High-risk, difficult-to-reproduce, and costly operations are practiced in cloud and AR environments, whereas data interpretation, solution design, technical documentation, and deliverable review are conducted, as far as possible, according to real industry standards.

2.3. An evidence gap between course assessment and job-relevant competencies

Traditional assessment relies mainly on laboratory reports, assignments, and final examinations. These measures can indicate whether students understand concepts, but they offer limited evidence of whether students can deploy systems, locate faults, optimize queries, and deliver work in accordance with engineering standards. Recent digital reforms in database education have begun to recognize the value of process data for teaching improvement [9]. In a university-enterprise co-developed course, platform operation logs, project work orders, code and model artifacts, and defense records should therefore be transformed into competency evidence so that assessment moves from outcome-only scoring to process-oriented diagnosis.

3. Reform objectives, technical roadmap, and key problems

3.1. Reform objectives

The overall objective is to cultivate application-oriented graduates who can use database principles to solve authentic industry problems. The reform does not simply add more enterprise technologies to the syllabus; rather, it establishes a mechanism through which evolving enterprise technologies can continuously enter the curriculum and be pedagogically absorbed. The course objectives are organized at three levels. At the cognitive level, students are expected to understand database principles and the boundaries of their application to different industry data contexts. At the skills level, students should be able to perform data modeling, query optimization, system deployment, and fault diagnosis. At the professional level, students should develop awareness of engineering standards, collaboration, and data ethics.

3.2. Technical roadmap

The reform proceeds through the following sequence: problem diagnosis, standards translation, case reconstruction, virtual-real training, collaborative guidance, multi-source assessment, feedback-driven iteration, and dissemination.

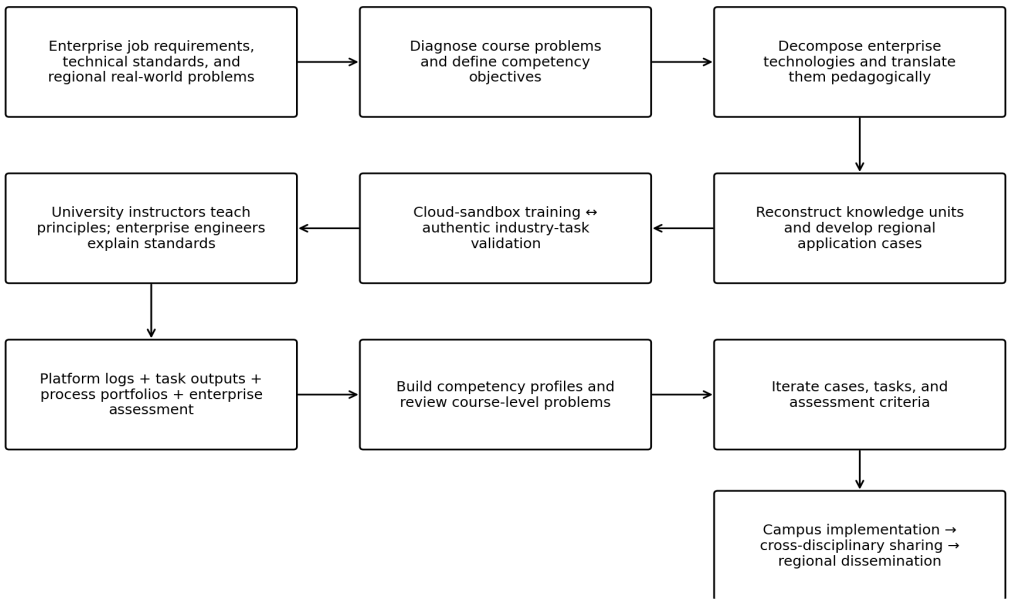

Figure 1. Technical roadmap for the course reform.

The core of this roadmap is pedagogical translation. Enterprise production knowledge is not naturally equivalent to course knowledge. It must be redesigned according to students' learning progression, prerequisite knowledge, and available class hours before deciding which elements are suitable for principle-based instruction, which for virtual training, and which for validation through authentic tasks. This process helps balance industrial authenticity with pedagogical appropriateness.

3.3. Key problems to be addressed

First, the reform addresses the structural mismatch between enterprise technology systems and the progression of student learning. Because topics such as GaussDB high-availability architecture and CIM-based spatial relationship computation are difficult to introduce directly into undergraduate teaching, the course adopts a three-step strategy of decomposing complex technologies, mapping key concepts, and designing graded tasks. Enterprise workflows are translated into progressive tasks covering basic configuration, performance tuning, and fault diagnosis, while visualization and AR are used to reduce cognitive load at the introductory stage.

Second, the reform addresses the efficiency of resource integration in university-enterprise collaboration. Enterprise production cycles do not always align with academic schedules, and tensions may also arise between the openness required for teaching and the protection of intellectual property. The course therefore processes enterprise resources through modular encapsulation, pedagogical case reconstruction, and tiered sharing. Problem contexts, data structures, and engineering standards are retained, while production details that are unsuitable for disclosure are abstracted or removed. This allows authentic cases to support learning without crossing enterprise data or technology boundaries.

Third, the reform addresses the rigor and objectivity of validating teaching outcomes. Reform outcomes are not judged solely by examination scores. Instead, cloud-platform operation logs, project-task completion, student artifacts, and enterprise assessment are collected to establish an evidence chain spanning micro-level operations, meso-level tasks, and integrated competencies. This provides traceable evidence for data modeling, SQL optimization, system operations, and industry-specific adaptation. The three problems correspond

respectively to course content, collaboration mechanisms, and assessment systems, and thus define the three main directions for subsequent course iteration.

Table 1. Mapping of course modules to industry-education tasks

Course module	Primary objective	Industry task carrier	Virtual-real integration	Assessment evidence
Database modeling	Master relational models and schema design	Cotton-field and fruit-production business data	Virtual design + authentic field constraints	ER model, schema description, revision records
SQL and query optimization	Understand indexes and execution plans	Agricultural time-series data queries	Cloud stress testing + performance comparison	Execution plans, response time, optimization report
Distributed databases	Understand clustering and fault recovery	GaussDB deployment and failover	Cloud-sandbox trial-and-error + process review	Deployment logs, fault localization, operating standards
Spatial data management	Understand spatial relationships and consistency	Substation CIM modeling	AR training + industry-model validation	Topology accuracy, completeness, defense records
Integrated project	Develop cross-context problem-solving ability	Power-industry or smart-agriculture mini-project	Student development + enterprise review	Project artifacts, technical documentation, enterprise assessment

4. Course reconstruction and implementation pathways

4.1. Reconstructing teaching content with reference to enterprise standards

The course adopts a three-stage structure of theoretical foundations, case-driven application, and project validation. The foundation stage continues to emphasize core principles such as relational models, SQL, indexing, and transactions, so that the pursuit of emerging technologies does not weaken disciplinary fundamentals. At the application stage, GaussDB development standards, the CIM data model, and regional agricultural data-processing requirements are embedded in teaching. At the integration stage, knowledge transfer is achieved through projects such as spatial modeling of power equipment, time-series analysis of cotton-field environmental data, and database design for fruit production.

Research on domestic database education indicates that combining fundamental database theory, SQL testing, and application development helps shift course objectives from simple knowledge acquisition toward competency outcomes [8]. Accordingly, this reform does not create a separate “enterprise course.” Instead, authentic data objects are used to reorganize existing knowledge so that the same database principles are repeatedly applied in agricultural, power, and other contexts.

4.2. Building a practice chain of virtual training and authentic validation

Students first use a cloud-based sandbox to practice environment deployment, parameter configuration, fault injection, and recovery, thereby gaining low-cost opportunities for repeated trial and error. Enterprise rules and industry data are then introduced to validate their solutions. In a substation spatial-database task, for example, students can use virtual or AR environments to practice equipment coordinates, topological relationships, and data mapping, and then check data integrity and relationship correctness against CIM rules. Agricultural data cases can similarly focus on time-series data cleaning, index design, and query performance. In this way, the virtual environment functions as a training ground for engineering competence, whereas authentic standards provide the criteria for judging the quality of that training.

4.3. Establishing a dual-mentor + task-sheet collaboration mechanism

University instructors and enterprise engineers are not separated mechanically into "theory" and "practice" roles. Instead, they jointly design learning tasks. University instructors are responsible for knowledge connections, explanations of principles, and learning pace, whereas enterprise engineers focus on engineering constraints, technical standards, and deliverable review. Each task sheet contains at least five elements: problem context, prerequisite knowledge, operational boundaries, deliverables, and assessment criteria. The classroom presents not only correct solutions but also requires students to explain failed attempts, design trade-offs, and revision processes. In this way, enterprise expertise shifts from simply supplying answers to explaining the reasoning behind engineering decisions.

4.4. Establishing a multi-source, data-driven assessment mechanism

Assessment comprises knowledge mastery, the practice process, and integrated projects. Knowledge assessment focuses on core concepts and principles. Process assessment uses cloud-platform logs, laboratory records, and staged tasks to evaluate operational compliance, problem localization, and optimization processes. Integrated projects are evaluated jointly by university instructors and enterprise engineers using models, code, technical documentation, and project defenses. Performance across tasks is aggregated into student competency profiles, making it possible to distinguish specific patterns such as "can write SQL but cannot optimize it" or "can operate the platform but has weak modeling skills." These profiles then inform adjustments to case difficulty and instructional emphasis in the next iteration.

5. Value of the reform and boundaries of implementation

The first value of the model lies in improving the sustainability of course updating. When new enterprise technologies enter the curriculum, it is unnecessary to replace an entire textbook or course structure. Instead, local cases and training units can be updated through a mapping of technical standards, competency objectives, and teaching tasks, thereby reducing the cost of curricular iteration. Second, cloud-based virtual training can mitigate constraints faced by regional universities in equipment, space, and geographic access to enterprises, while authentic industry standards help prevent virtual experiments from becoming disconnected from production practice. Third, the inclusion of regional agricultural and power-industry cases links database teaching with the university's disciplinary strengths and local industries, creating a concrete carrier for interdisciplinary learning in "database + industry" contexts.

Course resources should also be developed according to a minimum reusable-unit principle. Cases should not be tied too closely to a particular platform version. Transferable database principles, engineering judgments, and assessment criteria should remain stable, while specific commands and interface operations should be treated as replaceable layers. This approach makes it easier to respond to product updates, prevents the entire resource system from becoming obsolete when a partner or platform changes, and increases the feasibility of sharing reform outcomes across disciplines and institutions.

The model also has clear boundaries. Access to an enterprise platform does not in itself constitute meaningful industry-education integration, and technological sophistication cannot substitute for pedagogical appropriateness. Virtual simulation cannot fully reproduce organizational communication, data-quality problems, or responsibility boundaries in authentic engineering. Platform logs record behavior but cannot, on their own, explain the reasoning behind student decisions. Process data should therefore be combined

with instructor observation, project defenses, and enterprise feedback. Because the current project materials primarily describe the design and implementation framework, this paper does not fabricate outcome indicators such as gains in student scores, satisfaction, or certification pass rates. Future work should use longitudinal evidence across multiple semesters—including course-outcome attainment, project quality, platform behavior data, and enterprise assessment—to further evaluate the effectiveness of the reform.

6. Conclusion

The central challenge of industry-education integration in database education is not simply to add enterprise cases but to establish a stable mechanism for translating enterprise knowledge into curriculum. This study addresses three key problems—the mismatch between enterprise technologies and pedagogical progression, inefficient integration of university-enterprise resources, and the lack of objective evidence for teaching outcomes—and proposes a reform pathway comprising standards translation, case reconstruction, virtual-real training, dual-mentor collaboration, multi-source assessment, and continuous iteration. The pathway begins with authentic industry needs, uses pedagogical translation as the connecting mechanism, employs virtual-real practice as the training carrier, and relies on process data and enterprise assessment for feedback. Its purpose is to balance disciplinary foundations, engineering authenticity, and implementation costs. For regional universities, the model offers a lightweight way to strengthen connections between courses and local industries while producing reusable task templates and assessment frameworks for cross-disciplinary sharing and regional dissemination.

Funding

2025 Education and Teaching Reform Research Project of Xinjiang Agricultural University, "University-Enterprise Co-developed Demonstration Course of Database Technology and Applications: Innovative Practice of Industry-Education Collaboration Based on Virtual-Real Integration" (2025XQGJ011); 2025 Undergraduate Education Teaching Research and Reform Project of Universities in the Xinjiang Uygur Autonomous Region, "Construction of a Cross-Domain Collaborative Education System for the Database Applications Smart Course Driven by Dual Engines of AI and Cloud-Native Technologies" (XJGXJGPTB-2025015)

Disclosure statement

The author declares no conflict of interest.

References

[1] Bai Y, Wang H, Wang J, 2022, Current Status, Problems, and Countermeasures of Industry-Education Integration Reform in China: An Analysis Based on 103 Typical Cases. China Higher Education Research, 38(9): 88–94.

[2] Wei C, Fang Y, Heng X, 2022, Exploring the Mechanism of Industry-Education Integration in New Engineering Education from the Perspective of Knowledge Forms. China Higher Education Research, 38(2): 89–94.

[3] Zhang T, Li C, 2023, Relationships and Pathways: The Action Logic of Cultivating Outstanding Engineers Through Industry-Education Integration. China Higher Education Research, 39(5): 48–54.

[4] Zu Q, Xu G, Wei Y, 2023, The “Combination Approach” to Industry-Education Integration from a Higher Education Systems Perspective: Practice and Reflections from Jiangsu. China University Teaching, (4): 61–66.

[5] Xiong H, 2022, Building an Online-Offline Integrated Professional Experimental Teaching System Based on Virtual Simulation. Experimental Technology and Management, 39(3): 5–10 + 25.

[6] Dong G, Zhao G, Wang G, et al., 2022, Analysis and Reflections on Virtual Simulation Experimental Teaching in Higher Engineering Education: A Descriptive Study Based on 278 National Virtual Simulation Experimental Teaching Projects. Experimental Technology and Management, 39(12): 199–204.

[7] Chen H, Lu W, Du X, 2023, Reform Exploration and Practice of Database Courses Under the “101 Plan”. Computer Education, (11): 22–28.

[8] Zhang G, Su Z, 2023, Exploration of Database Course Teaching Oriented to openGauss. Computer Education, (6): 130–135.

[9] Wang Y, Pang J, Zhang H, et al., 2024, Teaching Reform of Database Courses in the Digital Era. Computer Education, (11): 121–125.

[10] Zheng S, Hu M, Luo X, et al., 2026, Exploration and Practice of an Innovative Industry-Education Integrated Teaching Model for Database Systems. Computer Education, (4): 169–173.

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