

Research on the Development Mechanisms and Implementation Pathways of AI-Empowered Productive Teaching Projects

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Abstract: Against the backdrop of deepening industry-education integration in vocational education and AI-driven digital transformation, productive teaching projects face not only the perennial challenge of transforming authentic production tasks into teachable activities, but also new challenges such as rapid resource obsolescence, heterogeneous learner foundations, and insufficient evidence for process-based assessment. Taking the “Deployment and Maintenance of a Navigation Data Storage Platform” task from the Yangtze River Trunk-Line Ship Water Pollutant Joint Supervision and Service Information System as a case, this study builds on the six-stage process of Select→Deconstruct→Define→Transform→Integrate→Extend and develops a human–AI collaborative mechanism characterized by real projects as the carrier, job competencies as the main line, and AI-supported cognition as the support. To strengthen AI empowerment across project development and implementation, AI is embedded in project selection, work-process deconstruction, competency definition, teaching-task transformation, curriculum integration, and resource expansion, and is integrated with IDEAL project-based learning, multi-stakeholder whole-process assessment, “dual-teacher + AI assistant” collaboration, and a blended virtual–real training environment. This study provides a reference for IT-related programs seeking to build replicable and iteratively improvable AI-empowered productive teaching projects.

Keywords: Artificial intelligence, productive teaching projects, industry-education integration, human–AI collaboration, maritime big data, project-based learning.

1. Introduction

Industry-education integration has evolved from a discrete reform measure in vocational education into an increasingly institutionalized and systematic endeavor. Existing research indicates that industry-education integration involves not only adjustments to school-enterprise cooperation, but also the systematic reconstruction of rules, behavioral norms, and coordination mechanisms among multiple stakeholders [1]. Vocational curriculum reform has increasingly emphasized organizing learning around work processes and authentic tasks, integrating professional knowledge, technical skills, and occupational qualities within complete action contexts [2]. Productive teaching projects therefore serve as an important bridge between enterprise production processes and school curricula. Their key purpose is not simply to “move enterprise cases into the classroom,” but to transform complex, dynamic production tasks with explicit delivery requirements into learning tasks with clear objectives, appropriate progression, guided processes, and assessable outcomes.

The development of artificial intelligence, especially generative AI, has created new technological conditions for this transformation. Zhao et al. note that technical and skilled work in the AI era increasingly involves human–AI collaborative decision-making, and that intelligent technologies in vocational education should move beyond knowledge tutoring toward workflow-oriented learning support [3]. Related studies further suggest that generative AI is driving vocational education from uniform provision toward adaptive learning and from one-way teacher instruction toward human–AI co-teaching, while systematically reshaping knowledge production, resource

generation, learning support, and assessment [4-6]. Accordingly, AI empowerment of productive teaching projects should not remain at the tool level of generating slides, questions, or answers; instead, it should be embedded throughout project development and implementation to support authentic task comprehension, competency mapping, differentiated teaching, process diagnosis, and resource iteration.

For a big data technology program in a maritime institution, sustainable development requires drawing on sector-specific resources, strengthening professional distinctiveness, and pursuing differentiated development. Conventional big data platforms are characterized by rapid technological updates, numerous technical components, and long fault chains, which can easily lead students to acquire fragmented abilities—being able to operate tools without understanding the underlying business. At the same time, traditional teaching often relies on generic static datasets such as e-commerce or student-grade data and provides insufficient immersion in authentic production settings and data-governance processes. Students therefore struggle to understand the industry logic and spatiotemporal constraints behind massive, strongly temporal, and multi-source heterogeneous data. They may conflate large-scale big data processing with conventional small-scale data processing and fail to develop systematic cognition and engineering intuition for complex engineering scenarios.

How to transform authentic production tasks from the maritime industry into teaching projects that are implementable, assessable, and iteratively improvable has thus become a key challenge in program development. To address this issue, the team draws on a foundation of deep

industry-education integration, introduces authentic enterprise projects, real data, and real job standards, and uses AI to empower project selection, work-process deconstruction, competency identification, teaching-task transformation, and resource generation. In this way, complex production tasks are converted into teaching projects aligned with students' cognitive progression, promoting deeper integration between maritime business logic and big data technologies and forming a distinctive maritime-oriented pathway for developing productive teaching projects.

2. Theoretical Logic of AI-Empowered Productive Teaching Projects

2.1. From “Digital-Tool Assistance” to “Human–AI Collaborative Workflow Learning”

The learning object of a productive teaching project is not an isolated knowledge point, but a complete and authentic work process. Research on Engineering Practice Innovation Projects emphasizes embedding engineering, practice, innovation, and project-based elements throughout the teaching process [7-8]. When AI is introduced into practical teaching, its role should not remain at the level of “digital-tool assistance” or simple “answer generation.” Instead, it should function as a cognitive scaffold and collaborative tool oriented toward the work process, supporting students in problem identification, standards retrieval, solution comparison, error diagnosis, and reflective review.

2.2. From Static Course Resources to Dynamic Provision through “Knowledge Base + Generative Resources”

Authentic production projects are characterized by rapid technological updates, diverse document types, and highly specialized enterprise terminology, making it difficult for traditional textbooks and fixed cases to remain synchronized with industrial change. Generative AI can support the creation of multimodal resources such as text, code, diagrams, and scenario scripts; however, direct generation by open models may introduce factual errors and hallucinations. Therefore, this study bases AI resource generation on a course-specific knowledge base. De-identified enterprise technical documents, curriculum standards, job specifications, component manuals, typical fault cases, and exemplary task outcomes are used as trusted sources, and retrieval-

augmented generation (RAG) provides students with explanations and prompts that are source-grounded and traceable. Research on generative AI in vocational education worldwide likewise shows that AI has been widely applied to text processing, programming learning, feedback, and data-driven decision-making, while reliability and governance must be addressed in parallel [9-10].

2.3. From One-Off Project Development to Continuous Iteration Driven by a Data Loop

For productive teaching projects to operate sustainably, they must evolve with changes in job competencies, industrial technologies, and students' learning conditions. AI can aggregate versions of enterprise technical documents, recurring student errors, task-completion time, and assessment data to help identify “obsolete points,” “difficulty points,” and “breakpoints” in course content, thereby informing the next round of task adjustment. Research on AI-enabled digital transformation in vocational education emphasizes that pedagogy in the intelligent era should coordinate learning objectives, learning activities, technological environments, and data feedback [11]. Thus, the core of AI empowerment is not to add an independent technical module, but to establish a sustainable data loop across “project development–teaching implementation–learning assessment–resource updating.”

3. An AI-Empowered Select–Deconstruct–Define–Transform–Integrate–Extend Development Mechanism

As shown in Fig. 1, this study considers the complexity of enterprise production tasks, the cognitive characteristics of vocational students, and the capability boundaries of generative AI, and adds the dual mechanisms of “AI scaffolding” and “human verification” to the six-stage process of Select → Deconstruct → Define → Transform → Integrate → Extend. Authentic enterprise projects, job standards, and curriculum objectives remain the basis for development. AI primarily performs information aggregation, semantic matching, structured extraction, differentiated generation, and data analysis, while teachers and enterprise experts are responsible for verifying professional authenticity, pedagogical appropriateness, and safety.

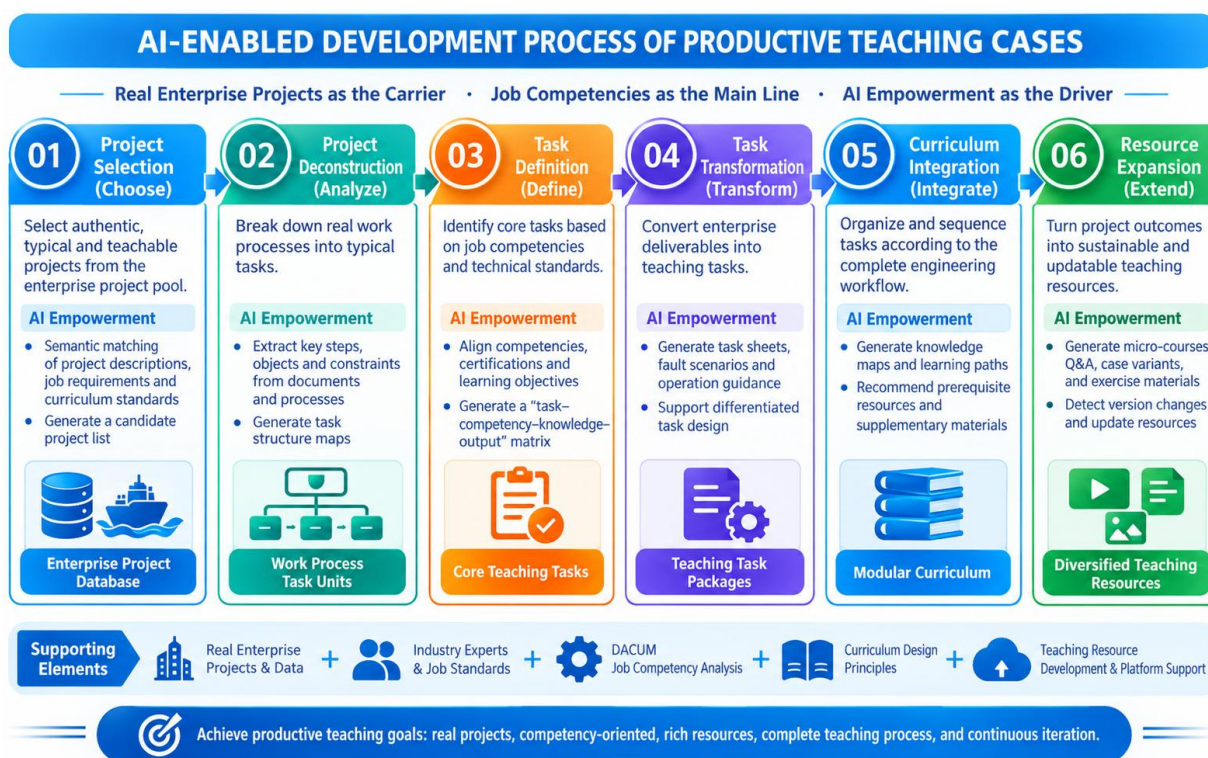


Figure 1. AI-Empowered Functional Mapping of the Six-Stage Development Process

3.1. “Select”: AI-Assisted Semantic Matching to Improve the Efficiency of Authentic Project Selection

The project originates from the Yangtze River Trunk-Line Ship Water Pollutant Joint Supervision and Service Information System, which was developed with the participation of a partner enterprise. Through teachers’ enterprise practice and job-shadowing investigations, the team reviewed production tasks involving massive navigation-data acquisition, trajectory reliability verification, multi-source heterogeneous data storage, and high-concurrency platform operation and maintenance. On the basis of conventional expert selection, AI is used to semantically match enterprise task descriptions, curriculum standards, and job-competency terms, rapidly identify candidate tasks highly relevant to the course Big Data Platform Deployment and Operations, and provide auxiliary analysis across dimensions such as authenticity, typicality, competency coverage, data availability, and teaching risk.

3.2. “Deconstruct”: AI-Assisted Process Extraction to Make Tacit Work Knowledge Explicit

Project deconstruction does not follow textbook chapters; instead, it identifies typical work tasks along the enterprise engineering process. Across the lifecycle from navigation data entering the platform to stable system operation, the task is decomposed into requirements analysis, technical architecture selection, runtime-environment deployment, storage-component setup, data processing and storage, and platform debugging and maintenance. At this stage, AI is used to process de-identified requirements documents, technical specifications, operation-and-maintenance records, and workflow texts; automatically extract business objects, inputs and outputs, technical constraints, upstream and downstream dependencies, and exception scenarios; and generate process

sketches and task lists. Teachers and enterprise engineers then verify the outputs, focusing on tacit experience, risk boundaries, and enterprise-specific rules that AI may overlook, thereby combining machine extraction efficiency with expert contextual knowledge.

3.3. “Define”: AI-Assisted Competency Mapping to Build a “Task–Competency–Standard” Matrix

After task deconstruction, course competencies are refocused according to the job requirements of big data engineering technicians. For the storage requirements of spatiotemporal navigation trajectories and structured business data, the course emphasizes deployment and configuration, data-model design, data reading and writing, query optimization, and operation and maintenance for components such as HBase, Hive, and ClickHouse. HBase focuses on high-concurrency reads and writes for trajectory data and RowKey design; Hive focuses on layered modeling and querying of business data such as shore-power records; and ClickHouse focuses on efficient retrieval of analytical data such as vessel information. AI can semantically align job standards, curriculum objectives, skill-certificate requirements, and task stages, generate a draft competency matrix, and identify gaps such as “tasks without objectives” or “objectives without evidence.” Teachers determine competency levels, assessment thresholds, and teaching boundaries to prevent mechanical matching based merely on textual similarity.

3.4. “Transform”: AI-Assisted Differentiated Generation for the Pedagogical Transformation of Enterprise Tasks

Enterprise projects aim at stable system operation and business delivery, whereas teaching projects must also accommodate cognitive progression and competency formation. The workflows, technical standards, and

deliverable requirements of enterprise tasks therefore need to be transformed into learning outcomes that are learnable, teachable, and assessable. For example, “building navigation-data storage capability” is transformed into “deploy an AIS trajectory database and explain the rationale for the RowKey design,” while “supporting shore-power business analysis” is transformed into “complete layered modeling of a vessel shore-power data warehouse, conduct SQL queries, and verify the results.” Within objectives, difficulty levels, and knowledge boundaries set by teachers, AI can generate basic, advanced, and innovative task variants as well as typical errors, fault scripts, and prompts. Students thus face tasks of different complexity under the same authentic work logic rather than receiving standard answers directly from AI.

3.5. “Integrate”: AI-Assisted Knowledge Association to Form a Work-Process-Driven Learning Path

Curriculum integration continues to follow the engineering sequence of “requirements analysis–architecture design–component deployment–data storage–data querying–debugging and maintenance,” so that the sequence of knowledge learning remains aligned with actual enterprise workflows. On this basis, knowledge graphs or semantic association can link knowledge points from Linux, the Hadoop ecosystem, databases, and data warehouses to specific work tasks, while students’ pre-assessment and process performance can be used to recommend compensatory resources. AI is responsible only for “identifying associations and making recommendations”; teachers retain control of the curricular main line and key nodes, preventing personalized recommendation from devolving into fragmented learning.

3.6. “Extend”: AI-Assisted Resource Generation and Version Monitoring to Support Continuous Course Updating

Authentic projects are time-sensitive and organizationally dependent. Without systematic resource accumulation, they can easily become short-term activities that end when the project is completed. The team can build a course-specific knowledge base from enterprise technical materials, operating procedures, de-identified data, typical faults, and task outcomes. On the premise of source traceability, generative AI can then assist in producing micro-course scripts, task guides, FAQs, case variants, and review materials, while also flagging version changes in component documentation.

4. Implementation Pathways for AI-Empowered Productive Teaching Projects

4.1. Building a Task Environment of “Authentic Business Scenarios + AI Scenario Assistant”

The course continues to center on de-identified authentic maritime data, highlighting the high-frequency, strongly temporal, and multi-source heterogeneous characteristics of vessel navigation data, and forms a progressive structure of “design introduction–deployment and operations–application monitoring.” Within this structure, the “Deployment and Maintenance of a Navigation Data Storage Platform” task

builds a technical chain of “technology selection–database construction–querying–operations” through tasks such as storage-solution selection, an HBase trajectory database, a Hive vessel shore-power data warehouse, and a ClickHouse vessel information database. On this basis, the AI scenario assistant does not provide direct operational answers; instead, it plays the role of a “business stakeholder,” “operations colleague,” or “technical documentation assistant,” providing contextual information about throughput, latency, data structures, reliability, and resource constraints so that students must gradually clarify requirements through questioning, retrieval, and verification.

4.2. Forming a Human–AI Collaborative Learning Process through “IDEAL + AI-Assisted Learning”

Teaching organization follows the five-step IDEAL mechanism—Identify the problem, Define the problem, Explore solutions, Act on the solution, and Look back and reflect—while explicitly defining the boundaries of AI intervention. AI provides support in problem analysis, solution comparison, and process feedback, whereas key decisions, hands-on operations, and outcome evaluation remain the responsibility of students under teacher guidance.

4.3. Establishing an Assessment Mechanism of “Multiple Stakeholders + Whole Process + AI Evidence Chain”

The original project allocated 70% of assessment to process performance and 30% to summative outcomes, with teachers, students, and enterprise engineers jointly participating. With AI empowerment, the assessment focus shifts further from “whether the final platform runs” to “whether sufficient evidence demonstrates competency formation.” The system can automatically collect data such as task-submission times, configuration-file versions, command and error logs, SQL scripts, query results, performance tests, revision traces, and reflection reports. AI structures these records, identifies recurring errors, abnormal copying, and competency gaps, and generates stage-based diagnostic reports and developmental profiles.

4.4. Building Collaborative Support through “Dual Teachers + AI Assistant + Three-Authenticities Training”

Productive projects place high demands on teachers’ engineering experience, enterprise standards, and training conditions. The team continues to strengthen teachers’ enterprise practice, bring enterprise engineers into the classroom, and implement dual-mentor collaboration, with enterprise personnel participating in solution review, operations troubleshooting, and final acceptance. Meanwhile, the maritime big data engineering research platform, server clusters, and a digital-twin waterway simulation system support a training environment oriented toward “authentic projects, authentic data, and authentic job roles.” As a third type of support role, the AI assistant mainly undertakes knowledge retrieval, learning diagnosis, process recording, and resource recommendation; it does not replace teachers’ educational responsibilities or enterprise experts’ engineering judgment.

5. Risk Boundaries and Continuous Improvement of AI Empowerment

5.1. Controlling Model Hallucinations through a “Dedicated Knowledge Base + Human Review”

Maritime big data platforms involve specific technology versions and engineering constraints, and general-purpose large language models may produce commands, parameters, or architecture recommendations that appear plausible but are inapplicable. A dedicated knowledge base should therefore be built primarily from de-identified enterprise materials, official technical documentation, and course resources, with AI outputs accompanied by source citations and version information. Critical configurations, architecture solutions, and assessment conclusions must be reviewed by teachers or enterprise experts. Research on generative-AI empowerment in vocational education generally emphasizes that expanding the scope of application must be accompanied by clear norms, governance mechanisms, and accountability boundaries.

5.2. Ensuring Production-Data Security through “Minimum Necessary Data + Full Traceability”

Authentic production data constitute a core advantage of productive teaching projects, but they are also a major source of risk in AI applications. When enterprise operations, vessel trajectories, or system operation-and-maintenance information are involved, de-identification, tiered authorization, and the minimum-necessary principle should be followed. Models and knowledge bases deployed locally or in controlled environments should be preferred, and unauthorized raw data must not be submitted directly to public models. Model calls, prompts, outputs, data sources, and revision records should be logged to meet traceability and auditability requirements.

5.3. Preventing Student AI Dependence through “Task Constraints + Competency Verification”

If students can directly use AI to complete scripts, configurations, or reports, a productive project may degenerate from “authentic practice” into “text generation.” AI access should therefore be authorized in stages: at the foundational stage, concept explanation and information retrieval may be permitted; at the advanced stage, solution comparison and fault prompts may be allowed; and critical operations, performance verification, and final defense must be completed independently without AI. Assessment should also include oral explanation, on-site operations, and random fault handling to verify whether students have genuinely mastered the required competencies.

6. Conclusion

The key to AI-empowered productive teaching projects is not simply to add generative tools to existing projects, but to redesign project development, learning support, assessment feedback, and resource updating around authentic work processes. Taking the “Deployment and Maintenance of a Navigation Data Storage Platform” task as an example, this study builds an AI-empowerment layer onto the six stages of Select–Deconstruct–Define–Transform–Integrate–Extend:

semantic matching assists selection, process extraction supports deconstruction, competency alignment strengthens definition, differentiated generation optimizes transformation, knowledge association supports integration, and the knowledge base and generative resources advance extension. Together, these elements form a closed loop of “authentic projects–job competencies–AI scaffolding–human verification–data feedback.”

The appropriate role of AI in productive teaching projects is “augmentation” rather than “replacement.” It augments teachers’ ability to process complex information and provide targeted guidance, students’ ability to understand, compare, diagnose, and reflect, and enterprises’ ability to continuously transform technical resources into curricular assets. However, authentic production tasks, critical engineering operations, professional judgment, and educational responsibility must remain human-led. Future research can conduct longitudinal tracking and quasi-experimental studies using indicators such as project-development time, resource-update efficiency, student AI dependence, fault-diagnosis ability, learning gains, and enterprise evaluation to further verify the practical effects and applicable boundaries of the AI-empowerment mechanism.

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