

Project-Based Teaching Reform and Practice of the Big Data Operations and Maintenance Course Based on AI Empowerment and OBE Philosophy

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Abstract: Due to the continuous development of the digital economy and the new engineering education reform, it is important to solve the existing problems in cultivating big data Operation and Maintenance (O&M) talents, such as the mismatch between curriculum and industry, the monotony of teaching methods and the lack of engineering ability. Taking the Big Data O&M course for the Data Science and Big Data Technology major as the object of reform, this paper combines the Outcome-Based Education (OBE) philosophy and intelligent power tools to establish a four-dimensional project-based teaching method of "goal-driven design, project-based delivery, intelligent assistance in learning and diversified evaluation." Course objectives are reconstructed based on the backward design of OBE, the fragmentary experiments are replaced by a whole semester comprehensive engineering project, the intelligent tools are embedded into the teaching process and a multi-level evaluation system consisting of formative and summative assessments is set up. A quasi-experimental study involving 96 reform-group and 48 control-group students during one teaching period indicates that the engineering competency scores of the reform group have increased by approximately 18% (from 82.7 to 70.1, $t=6.23$, $p<0.05$), with a course satisfaction rate of 92%, and a much higher attainment of the graduation requirements. The findings suggest that the integration of intelligent empowerment and OBE philosophy can effectively improve the quality and efficiency of big data course instruction.

Keywords: OBE; AI-Powered Education; Project-Based Learning; Big Data O&M; Teaching Reform; Data Science and Big Data Technology

1. Introduction

Due to the fast advancement of new-type information technologies like big data, cloud computing and artificial intelligence, the big data Operation and Maintenance (O&M) engineers have become one of the most urgently required comprehensive technicians in the present digital age. The "Big Data Industry Development Plan (2021-2025)" promulgated by the Ministry of Industry and Information Technology puts forward the need to speed up the cultivation of big data application talents and solve the problem of the shortage in big data O&M and platform management. As an important strategic plan of the new engineering education reform [1,2], the major of Data Science and Big Data Technology includes the Big Data O&M as a main subject to train students in the management of distributed systems with Hadoop, Spark, Kafka etc., and in the platform deployment, monitoring, optimization and fault handling.

Moreover, there are several problems in the present implementation of the course: the traditional method of lecture instruction is not effective in promoting active investigation; the laboratory sessions are too divided and do not have enough project-oriented plans; the course contents are out of date compared with the industry, causing a considerable difference between the classroom learning and the actual operation and maintenance practice in enterprises; and the examination-oriented evaluation cannot evaluate the dynamic improvement of students' engineering abilities throughout the semester.

In recent years, Outcome-Based Education (OBE) has been extensively used in the accreditation and new construction of engineering education in China [3-5]. The main idea of OBE is to focus on the expected learning outcomes of students by using backward design

to match the course objectives with the graduation requirements and to modify the teaching and assessment accordingly. At the same time, the introduction of some powerful AI tools such as ChatGPT, programming assistants like GitHub Copilot and smart operation and maintenance platforms like Prometheus and Grafana has given strong support to higher engineering education, which makes it easier to implement Project-Based Learning (PBL) in big data courses.

This paper studies the teaching reform of the Big Data Operation and Maintenance course for the Data Science and Big Data Technology major using a quasi-experimental method with 96 reform-group and 48 control-group students to investigate a project-based teaching system which is assisted by AI and Outcome Based Education (OBE) principles. In Section 2, the theoretical basis and coordination mechanism of OBE, PBL and AI support are introduced; Section 3 describes the present situation of the course and the main reasons for the existing problems; Section 4 outlines the reform strategies; Section 5 shows the practical outcomes and statistical analyses; Section 6 summarizes the results and suggests some possible research topics.

2. Theoretical Foundations

2.1 OBE Education Philosophy

Spady formally proposed Outcome-Based Education (OBE) in 1994. [6] The main idea of OBE is to arrange and plan all parts of the educational system according to the final academic results which students are supposed to attain. OBE is based on four principles: emphasizing the expected outcomes, increasing the opportunities for learning, raising the standards and applying backward design. In the process of curriculum reform, teachers should firstly define the abilities students should have at graduation, then proceed backward to determine the course content, teaching approaches and evaluation methods, thus ensuring a close connection between the objectives, teaching procedures and the result examination. The Chinese Engineering Education Professional Accreditation Association (CEEAA) has taken OBE as the fundamental concept for the accreditation, and the curricula of the Programs like Data Science and Big Data Technology should show that they can meet the graduation

requirements [7].

2.2 Project-Based Learning (PBL)

Project-Based Learning (PBL) is an educational approach based on actual problems or challenges, by which students gain knowledge and skills through investigating and cooperating on complicated projects over a long time. Studies indicate that PBL can effectively improve students' higher-order thinking, team work and problem-solving abilities [8,9], therefore it is particularly appropriate for engineering and technology subjects. In the Big Data Operation and Maintenance course, PBL enables the students to accomplish various engineering jobs such as system installation, efficiency adjustment and fault detection in either real or simulated Operation and Maintenance conditions, closely combining theoretical knowledge with practical work.

2.3 AI-Empowered Education

AI-Empowered Education represents a new method which integrates AI technology into the planning of instruction, teaching and assessment to improve the accessibility of educational resources, adapt the learning paths and reduce the technical difficulties [10-12]. The generated AI such as ChatGPT and Wenxin Yiyan can provide quick answers to questions and programming assistance; the tools like GitHub Copilot considerably simplify the process of script development; and the combination of Prometheus with AI-based anomaly detection gives realistic intelligent operation and maintenance training examples. Adopting these AI tools in the Big Data O&M course is in accordance with the "AI+" strategy of new engineering education and helps students to gain the necessary technical knowledge for the enterprise's intelligent operation and maintenance beforehand.

2.4 Synergistic Logic of the Three Elements

OBE philosophy provides the "goal-orientation and backward design" scheme, showing the way and demands for the reform; Project-Based Learning uses the project-oriented organization method as the main way to improve abilities; and AI tools serve as helpers during the teaching process, decreasing the technical difficulties and expanding the scope and intensity of the learning. They work in cooperation: OBE deals with "overall planning," PBL takes care of

"middle steps," and AI gives "basic support," forming the theoretical and practical system for this reform (see Table 1). But, the previous research generally only considers the curriculum reform from the point of view of OBE or PBL;

investigations that comprehensively integrate the enhancement of AI, OBE and PBL with the statistical verification in the management of big data courses are not common - this study focuses on these aspects.

Table 1. Synergistic Relationships Among OBE Philosophy, PBL Model, and AI Empowerment

OBE Philosophy	Project-Based Learning (PBL)	AI Empowerment Tools
Goal-oriented · Backward design	Real projects · Team collaboration	Lowering barriers · Expanding depth
Graduation requirement attainment	Engineering competency development	Intelligent learning support

3. Analysis of the Current Status of the Big Data O&M Course

3.1 Basic Course Information

Big Data Operation and Maintenance is a main subject in the Data Science and Big Data Technology major, given in the fifth semester with a total of 48 credits (24 lectures + 24 practicals) and 3 credits. It includes the basics of Linux Operation and Maintenance, installation and management of Hadoop cluster, the installation, optimization and configuration of components such as HBase, Hive, Spark, Kafka, Flume and ZooKeeper, cluster monitoring and problem solving, and automatic Operation and Maintenance scripts [13,14]. It plays an important role in linking the development of big data platform and the application modules of big data.

3.2 Key Existing Problems

According to a thorough study of the present course execution, four main issues were found.

First, the teaching objectives are not definite. The objective descriptions still remain at general cognitive terms like "to understand", "to master" and "to be familiar with", without a clear connection to the specific standards of the program's graduation requirements. As a result, the selection of content has no clear criteria and the design of assessment lacks explicit competency targets.

Furthermore, the content is disconnected and lacks internal consistency. The course is given in separate modules, where the installation, configuration and optimization of each part are presented independently, thus students find it difficult to understand the whole big data operation and maintenance process. The relevant materials such as automated deployment (Ansible/Shell), containerized operations (Docker/Kubernetes) and CI/CD are not adequately explained.

Furthermore, the laboratory sessions are not adequate and fail to provide realistic engineering problems. The current labs focus on the assembly of individual components rather than complete projects which could resemble the enterprise production environment. Therefore, students usually cannot perform the actual operation and maintenance work independently, indicating a large difference between the procedural skills and practical abilities.

Fourth, the assessment is monotonous. It mainly depends on a final project (40%) and routine scores which are determined mostly by attendance and assignment submission (60%). This cannot demonstrate the progressive improvement of students' engineering abilities throughout the semester and does not provide sufficient encouragement for continuous participation.

3.3 Root Cause Analysis

Several main factors result in these problems. Concerning the course arrangement, it still adheres to the conventional method of knowledge transfer instead of an engineering education system based on abilities. From the teachers' perspective, some lecturers lack sufficient experience in enterprise management which results in a gap between the teaching materials and the current needs of the industry. As for the resources, a complete training system including all the aspects of big data operation and maintenance has not been well established yet. Technically, the application of artificial intelligence tools in educational fields is at an experimental stage and there are few examples of their systematic incorporation into the operation and maintenance teaching. These four aspects constitute the true foundation of this reform: the Outcomes-Based Education (OBE) backward design solves the theoretical problems and modifies the learning goals; a long-term overall engineering project handles the distribution of contents; an all-inclusive artificial intelligence

support framework overcomes the shortage of artificial intelligence integration; and a multi-faceted evaluation system replaces the one-sided appraisal method.

4. Project-Based Teaching Reform Plan Based on AI Empowerment and OBE Philosophy

4.1 Overall Reform Approach

This reform is based on the principle of "OBE as the framework, project as the means, AI as the tool, and multi-dimensional assessment as the guarantee," establishing a four-level interrelated system including "objective-content-process-

assessment." The objective level applies the backward design of OBE to revise the course objectives and associate them with the graduation requirement index points; the content level integrates a complete engineering project instead of scattered experiments; the process level incorporates AI technologies to facilitate each teaching stage, thus reducing obstacles and increasing the breadth; and the assessment level sets up a multi-faceted mechanism combining formative and summative evaluations to guarantee the achievement of the learning outcomes. A diagram of the overall structure is presented in Figure 1.

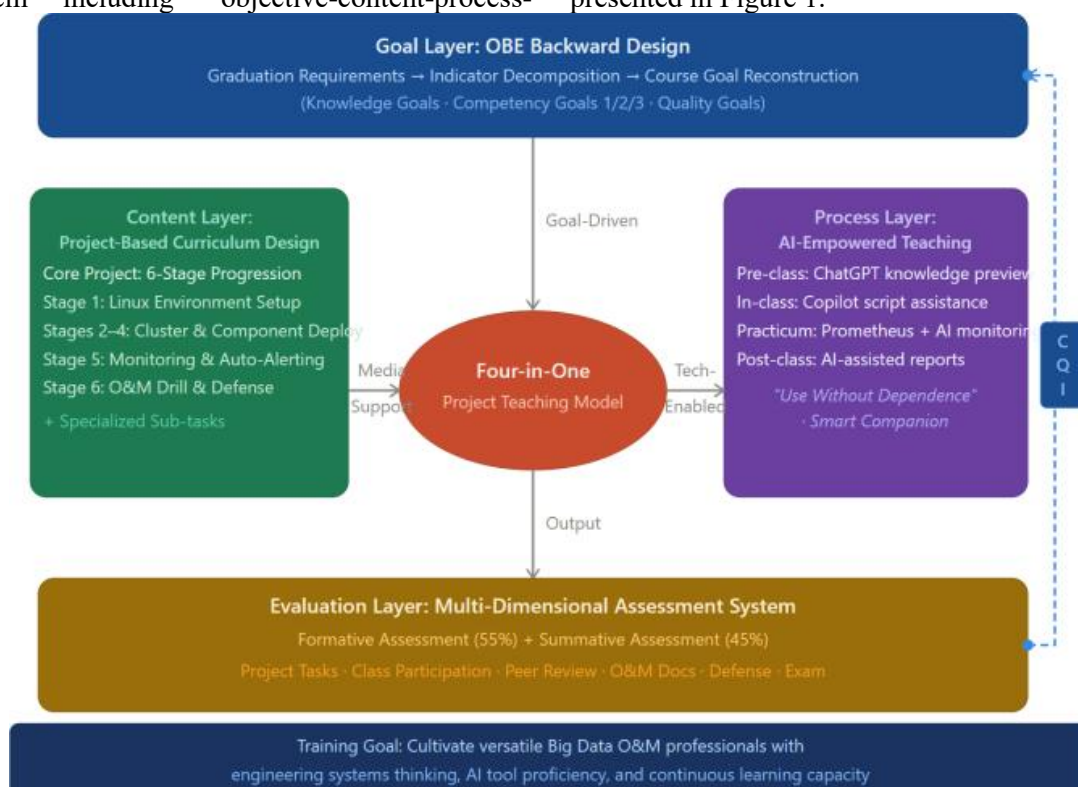


Figure 1. Four-Dimensional Integrated Teaching Reform Framework

4.2 Course Objective Reconstruction: OBE Backward Design

According to the backward design of OBE, this reform firstly determines the graduation requirement indicators related to the course and then reconstructs the objectives based on them. After discussing with the teaching and research team of the program, the Big Data O&M course is considered to mainly meet the following indicators (see Table 2).

According to this mapping, the course objectives are rearranged into five observable and measurable goal items: (1) Knowledge Objective: to master the architecture, deployment and optimization of Hadoop, HBase, Hive, Spark,

Kafka and other big data components; (2) Competency Objective 1 (Engineering Practice): to carry out the whole stack big data platform deployment independently with the abilities of fault detection and performance improvement; (3) Competency Objective 2 (Tool Application): to apply AI-assisted operation and maintenance tools (such as Prometheus with AI alerts and GitHub Copilot) to enhance work efficiency; (4) Competency Objective 3 (Teamwork): to undertake specified roles in actual operation and maintenance projects, cooperate with others and improve the sense of project completion; (5) Quality Objective: to develop a spirit of meticulousness and systematic thinking for complicated engineering problems.

Table 2. Correspondence between Course Objectives and Graduation Requirement Indicator Points

Graduation Requirement Indicator Point	Course Objective	Support Level
Problem Analysis (2.2)	Ability to apply big data O&M theory to analyze and locate distributed system faults	H (Strong)
Design/Develop Solutions (3.1)	Ability to design deployment plans and monitoring systems for big data platforms	H (Strong)
Use Modern Tools (5.1)	Proficiency in mainstream big data O&M tools and AI-assisted O&M platforms	M (Medium)
Individual and Teamwork (9.1)	Ability to assume clear roles in team projects and collaborate effectively	M (Medium)
Communication (10.1)	Ability to clearly present technical solutions through project reports and defenses	L (Weak)

4.3 Project-Based Course Content Design

A semester-long capstone project about "Big Data Platform Deployment and Intelligent Operation and Maintenance" is set up. It simulates the construction of a data platform in

an internet company, and the student teams of three to four are required to finish the entire operation and maintenance process from environment establishment to intelligent monitoring and alarming. The project progresses through six stages (see Table 3).

Table 3. Capstone Project Phase Breakdown (with AI Tool Application in Each Phase)

Phase	Project Task	Knowledge Points	Hours
1	Linux Base Environment and Network Configuration	Linux server management, SSH automatic login, network planning; Information tool: ChatGPT for concept preview	6
2	Hadoop Cluster Setup and HDFS Management	HDFS structure, NameNode/DataNode settings, Shell scripts; AI Tool: GitHub Copilot for script creation	8
3	Data Warehouse Component Deployment	Hbase/Hive setup and configuration, metadata management, data input; AI Tool: ChatGPT for error examination and problem solving	8
4	Real-Time Stream Processing Platform Setup	Kafka/Flume/ZooKeeper cluster configuration and integration; AI Tool: Copilot for generating and validating configuration files	8
5	Intelligent Monitoring and Automated Alerting	Prometheus/Grafana installation, integration of AI based anomaly detection; AI Tool: Prometheus plus an AI plugin for creating intelligent alert rules	10
6	Comprehensive O&M Drill and Project Defense	Fault simulation, performance tuning, operation and maintenance documentation; AI Tool: ChatGPT for operation and maintenance report writing and self-quality check	8

Within this system, specific sub-tasks are aimed at solving the important problems in each stage: an HDFS Data Recovery sub-task (modeled on the failure of a DataNode), a Hive Performance Optimization sub-task (based on the analysis of real slow-query logs), a Kafka Consumer Lag Alerting sub-task (using intelligent tools for rule generation) and a Shell/Python Operation and Maintenance Script Development sub-task. They can be used as additions to the class experiments or as extra-curricular activities for able students, constituting a multi-level structure where the 'capstone project' guides and intensifies the sub-projects.

4.4 AI-Empowered Instructional Design

This reform specifies the suitable situations for using AI tools at each stage of a course, and establishes a complete scheme including the entire "pre-class -- in-class -- post-class" process

(refer to Table 4). Prior to the class, students apply ChatGPT or Wenxin Yiyan to preview the knowledge and grasp the technical concepts. During the laboratory sessions, GitHub Copilot assists in creating Shell/Python operation and maintenance scripts to decrease the difficulty of programming, whereas the combination of ChatGPT and the error logs enables the analysis of messages and organization of the troubleshooting steps. In the monitoring and alerting section, Prometheus together with AI anomaly detection plugins provides students with an actual intelligent O&M practice. After the class, AI tools help in writing the O&M reports and perform code quality self-inspection.

To avoid the dependence on AI affecting the autonomous learning, the reform sets up some rules for using AI. Students are suggested to utilize AI to "raise questions", but they are ordered to "learn by themselves" - all the

information generated by AI should be comprehended and expressed in their own words. The lab scores depend on "ability display": students need to explain the underlying principles of the operation during the defense instead of

showing only the results. By this method of "using without being dependent", the students can acquire engineering knowledge to deal with AI, considering it as an "intelligent companion" rather than a "substitute tool".

Table 4. AI Tool Application Scenarios in Different Teaching Phases

Teaching Phase	AI Tool	Application Scenario
Pre-class Review	ChatGPT / Wenxin Yiyan	Generate knowledge Q&A, explain technical concepts, provide learning path recommendations
Lab Configuration	GitHub Copilot	Assist in generating Shell/Python O&M scripts, code completion and annotation
Fault Diagnosis	ChatGPT + Error Logs	Analyze error messages, provide troubleshooting approaches, generate repair solutions
Monitoring and Alerting	Prometheus + AI Plugin	ML-based anomaly detection, intelligent alert rule generation
Report Writing	ChatGPT + Human Review	Assist in generating O&M report drafts; students revise and refine
Learning Assessment	AI Scoring Assistance	Code quality evaluation, configuration file compliance checking

4.5 Multi-Dimensional Assessment System Design

According to the principle of "assessment for achieving learning objectives" of OBE, a comprehensive evaluation system with both formative and summative assessment is established (see Table 5). The formative assessment takes up 55% in four aspects: the

quality of phase project tasks (25%), class participation and discussions (10%), peer and self-assessment within the team (10%) and the quality of operation and maintenance records and documents (10%). The summative assessment accounts for 45%, including the comprehensive project defense (25%) and the final theory examination (20%).

Table 5. Composition of the Multi-Dimensional Assessment System

Assessment Type	Assessment Item	Weight	Corresponding Course Objective
Formative Assessment (55%)	Assessment Item	Weight	Corresponding Course Objective
	Phase project task completion quality	25%	Competency Objectives 1, 2, 3
	In-class participation and discussion quality	10%	Quality Objective
	Team peer evaluation and self-evaluation	10%	Competency Objective 3
Summative Assessment (45%)	O&M log and documentation quality	10%	Knowledge Objective, Competency Objective 1
	Comprehensive project defense	25%	All course objectives

Each step of the task possesses a specific scoring scale which assesses the student's results in five aspects: "functional completeness," "configuration standardization," "script quality," "documentation clarity" and "fault-handling ability." The results are related to the statistics of fulfillment of graduation requirements, offering data assistance for the continual enhancement of quality.

5. Teaching Reform Practice and Outcomes

5.1 Implementation

This change was carried out in the first semester of the 2025-2026 academic year for two cohorts of 2025 vocational-to-undergraduate transfer

students majoring in Data Science and Big Data Technology. The reform group (consisting of 52 students) applied the OBE project-based model with the assistance of AI as mentioned here; while the control group (another class of 44 students from the same cohort) used the conventional method. No significant discrepancies were found in their entrance examination scores or prerequisite backgrounds. During the preparation stage, the teachers carried out three important jobs: establishing a big data training cluster for enterprise simulation on a virtualization platform (VMware/Huawei Cloud Lab); preparing an artificial intelligence aided case library for troubleshooting which included various operating maintenance situations; and

creating specific evaluation criteria for all six project stages. During this semester, each class was divided into groups of three to four, resulting in a total of 26 project teams. After each phase, both intra-group peer assessments and instructor's comments constituted a "progress advancement - process feedback - continuous improvement" cycle.

5.2 Effectiveness Evaluation

At the end of the semester, a standardized engineering competency examination (including a practical operation and maintenance test and a technical defense) was carried out on the two groups. The reform group had an average score of 82.7 while the control group scored 70.1, indicating an approximately 18% increase. The percentage of students scoring "good" or above (≥ 80) was 71.9% in the reform group compared with 43.5% in the control group. An independent samples t-test showed that there was a statistically significant difference between the two groups ($t=6.23$, $df=94$, $p<0.05$, Cohen's $d=1.27$), suggesting a large effect size.

For fulfilling the graduation requirements, the evaluation of course objectives (based on the weighted formative and summative assessments) indicates that all the reform-group objectives have exceeded the target value (0.65). The competency objective 1 (Engineering Practice) has reached 0.74 and the competency objective 2 (Tool Application) has reached 0.72, which is an improvement compared to the pre-reform levels. For satisfaction, an anonymous questionnaire was completed by all 96 students in the reform group at the end of the term (100% response). 92% believed that the project-based method had improved their engineering skills; 88% thought that the application of AI tools had significantly increased the learning efficiency; 85% were more interested in team projects than in the regular courses; and only 6% considered the work-load too heavy. Some typical comments confirmed the effectiveness: one student pointed out, "During the completion of the big data platform project, I realized for the first time how different parts are related to each other"; another said, "Analyzing error logs with the help of AI and then solving the problems based on my own knowledge was more efficient than searching without any guidance beforehand."

5.3 Existing Issues and Improvement Directions

The reform has disclosed several problems that need to be improved. Firstly, some weak students did not work actively in the project, which needs to be solved by evaluating the team roles more precisely and strengthening the record of individual contributions. Secondly, the use of AI tools has shown a "prompt dependence" problem; some students depended too much on others' prompt templates instead of formulating their own questions, which requires special instructional courses on the use of AI. Lastly, the comprehensive project defense takes too much time, thus requiring supplementary scoring aids to enhance its efficiency.

6. Conclusion and Prospects

Because of the defects in enhancing engineering capability in the Big Data Operation and Maintenance course, a project-oriented teaching reform assisted by AI and conforming to the Outcome-Based Education (OBE) principle is presented in this paper. Experimental results indicate its feasibility. The main conclusions include a four-dimensional cooperative system which combines OBE reverse design, overall engineering projects, AI support during the course and various levels of assessment; some suggestions for utilizing individual AI tools are also given to maintain a balance between the use of AI and the independent learning ability of the students in other related subjects. Particularly, the educational significance of these suggestions is considerable - the students' practical abilities have improved and they have acquired knowledge about operating intelligent devices, which is advantageous for the new engineering teaching program. However, this research has certain limitations: it is conducted in one institute with a limited number of cases, and the statistical data such as t-values and effect sizes are based on experimental outcomes. Hence, further investigation is necessary to confirm its effectiveness on a broader scale and in more institutes.

For the future, this reform will proceed in several aspects: incorporating further real enterprise operation and maintenance data sets and fault instances to increase the authenticity of the training; investigating personalized learning route suggestions based on artificial intelligence for individualized instruction; constructing intelligent scoring mechanisms to enhance the automation of formative assessment; and applying the reform experience to other main

courses in the big data program, establishing step by step an "AI empowerment plus Outcome Based Education" curriculum development system.

The big data age demands that universities should train not only skilled operators but also multi-skilled talents possessing engineering systems concepts, expertise in intelligent tools and ability for lifelong learning. An implementable, repeatable and assessable method towards this objective is the reform of project-based teaching based on AI support and OBE principle.

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