World Journal of Educational Studies
Print ISSN: 2959-9989
Online ISSN: 2959-9997
DOI: https://doi.org/10.61784/wjes3181

TEACHING REFORM EXPLORATION FOR THE "LITHIUM-ION BATTERY MATERIALS TECHNOLOGY" COURSE UNDER THE BACKGROUND OF AI-EMPOWERED NEW ENGINEERING

Jun Yang[1], BinBin Xin[1], Lei Wang[1*], Chen Pan[2*]
[1]School of Chemical Engineering, Guangdong University of Petrochemical Technology, Maoming 525000, Guangdong, China.
[2]Architecture and Civil Engineering Institute, Guangdong University of Petrochemical Technology, Maoming 525000, Guangdong, China.
[*]These authors contributed equally to this work.
[*]Corresponding Author: Chen Pan, Lei Wang

Abstract: With the rapid development of the new energy industry and the in-depth advancement of new engineering discipline construction, the talent cultivation model of the new energy materials and devices major in colleges and universities is facing new opportunities and challenges. As a core course of the New Energy Materials and Devices major, "Lithium-ion Battery Materials Technology" shoulders the important task of cultivating students' material design ability, engineering practice ability and innovation ability. However, the traditional teaching mode has problems such as the disconnection between knowledge imparting and engineering application, insufficient students' autonomous learning ability, and weak innovative practical training, which are difficult to meet the demands of engineering talent cultivation in the new era. This project is guided by the OBE educational concept, deeply integrating artificial intelligence technology with micro-project-based teaching, and constructing a three-in-one teaching model of "AI+ micro-projects + engineering cases". Relying on intelligent tools such as ChatGPT, DeepSeek, Rain Classroom AI Workbench, Materials Project database and COMSOL Multiphysics simulation platform, typical micro-projects such as cathode material optimization, anode material modification, electrolyte development and solid-state battery material design are designed. Form a complete teaching chain of "knowledge acquisition - material design - performance prediction - engineering verification - outcome evaluation". Teaching practice shows that this model has significantly enhanced students' achievement of course objectives, engineering practice ability and innovative design ability, achieving a transformation from knowledge imparting to ability cultivation, and providing new ideas for the reform of new energy materials-related courses.
Keywords: Artificial intelligence; New Engineering; OBE concept; Micro-project-based teaching; Lithium-ion battery material technology

1 INTRODUCTION

1.1 Research Background

Against the backdrop of the "dual carbon" strategy and the rapid development of the new energy industry, lithium-ion batteries, with their high energy density, long cycle life and good environmental adaptability, have been widely applied in new energy vehicles, energy storage systems and consumer electronics, among other fields, and have become one of the key technologies driving energy transformation and green development [1-3]. With the continuous expansion of the scale of the new energy industry, the demand for high-quality engineering and technical talents in the field of new energy materials in the industry is constantly increasing, which puts forward higher requirements for the quality of talent cultivation in colleges and universities [4].
The construction of new engineering disciplines emphasizes the cultivation of high-quality talents with engineering practice ability, innovation ability and the ability to solve complex engineering problems in line with the major strategic demands of the country and the development direction of industries [5-6]. "Lithium-ion Battery Materials Technology" is an important core course for the major of New Energy Materials and devices, covering cathode materials, anode materials, electrolytes, separators and advanced energy storage materials, etc. It is an important course for cultivating students' material design and application abilities. However, the knowledge system of this course is complex and highly interdisciplinary. The traditional teaching mode mainly focuses on theoretical instruction, which leads to problems such as insufficient students' learning initiative, weak engineering practice training, and inadequate cultivation of innovation ability [7-8]. In recent years, generative artificial intelligence technologies represented by ChatGPT and DeepSeek have developed rapidly, providing new technical support for the reform of higher education teaching [9-10]. Artificial intelligence can achieve intelligent integration of knowledge resources, personalized learning guidance, and auxiliary analysis of engineering problems, demonstrating broad application prospects in fields such as material design, performance prediction, and experimental optimization [11-12]. Meanwhile, Project-Based Learning (PBL) drives

students' independent exploration and teamwork through real engineering problems, which can effectively promote the deep integration of knowledge learning and engineering practice [13-14]. Therefore, integrating artificial intelligence technology with micro-project-based teaching, introducing typical cases from the research and development and industrial application of lithium-ion battery materials, and constructing an "AI+ micro-project teaching" model are of great significance for enhancing students' autonomous learning ability, engineering practice ability and innovative design ability.Based on this, this project takes the "Lithium-ion Battery Materials Technology" course as the research object, combines the construction of new engineering disciplines and the OBE education concept, and explores the path of micro-project-based teaching reform empowered by artificial intelligence, with the aim of providing references for the teaching reform of new energy materials courses and the cultivation of innovative talents.

1.2 Problems Existing in Traditional Teaching

The course "Lithium-ion Battery Materials Technology" is an important core course for the major of New Energy Materials and Devices. It is characterized by a complex knowledge system, strong interdisciplinary nature, and prominent engineering application. However, under the traditional teaching mode, there are still several problems in course teaching. The course content involves abstract knowledge such as material structure, electrochemical reaction mechanisms, and interface regulation. Students find it difficult to establish an intuitive understanding through simple classroom lectures, and their comprehension of the relationship between material structure and performance is not deep enough. Secondly, the teaching process mainly relies on the teacher's lecturing. Students are in a passive state of accepting knowledge, lacking opportunities for independent exploration and active learning. Their learning enthusiasm and participation need to be improved. Most of the course cases are derived from textbooks and classic literature, but they are not closely integrated with the actual demands of the lithium-ion battery industry. As a result, students find it difficult to apply the knowledge they have learned to solve practical engineering problems, and their engineering practice abilities are not well cultivated. Meanwhile, traditional course assessment mainly relies on final exams, which place more emphasis on the mastery of knowledge. The evaluation of innovative design ability, teamwork ability, and the ability to solve complex engineering problems is not comprehensive enough.Therefore, in the face of the demand for cultivating innovative engineering talents under the background of new engineering disciplines, it is urgent to introduce artificial intelligence technology and micro-project-based teaching methods, and build a new teaching model centered on students and oriented towards engineering problems, to achieve the organic integration of knowledge learning, engineering practice and the cultivation of innovation ability.

2 DESIGN OF AI-ENABLED MICRO-PROJECT-BASED TEACHING SYSTEM

In view of the problems existing in the "Lithium-ion Battery Materials Technology" course, such as abstract teaching content, insufficient students' learning initiative, and weak cultivation of engineering practice ability, in combination with the requirements of new engineering construction and the OBE (Outcome-Based Education) educational concept, with the cultivation of students' ability as the core and solving practical engineering problems as the orientation, Introduce artificial intelligence technology and micro-project-based teaching methods to build a teaching system that integrates "AI empowerment + micro-project-driven + engineering practice integration". By reconstructing the teaching objectives of the course, designing typical micro-project tasks, and building a full-process AI-assisted teaching framework, the organic unity of knowledge imparting, ability cultivation, and value shaping is achieved..

2.1 Reconstruction of Teaching Objectives

Under the background of the new engineering discipline, the teaching objectives of courses should shift from the traditional knowledge imparting orientation to the ability cultivation orientation. In light of the development demands of the new energy industry and the professional talent cultivation goals, the teaching objectives of the "Lithium-ion Battery Materials Technology" course have been restructured to form a three-dimensional cultivation system of "knowledge goals - ability goals - quality goals".

In terms of knowledge objectives, students are required to systematically master the composition, structural features and performance regulation mechanisms of lithium-ion battery cathode materials, anode materials, electrolytes, separators and new energy storage materials, understand the relationship between material structure and battery performance, and master the basic theories of lithium-ion battery material design and application.

In terms of ability goals, the focus is on cultivating students' ability to analyze and solve complex engineering problems by applying professional knowledge. Students can utilize artificial intelligence tools to conduct literature retrieval, material screening, performance prediction and scheme optimization. Be capable of conducting material design and performance analysis in combination with engineering requirements; Be capable of conducting performance simulation and verification of battery materials using simulation software, and develop engineering thinking and innovative design capabilities.

In terms of quality goals, it is necessary to cultivate students' awareness of autonomous learning, teamwork spirit and innovation and entrepreneurship. Through project collaboration and task-driven approaches, students are guided to pay attention to the cutting-edge development trends of the new energy industry, enhance their professional identity and sense of social responsibility, and improve their lifelong learning ability.

Based on the above goals, course teaching has shifted from "teachers imparting knowledge" to "students solving problems", and from "single knowledge assessment" to "comprehensive ability evaluation", achieving an effective connection between course teaching and the requirements for cultivating new engineering talents.

2.2 Design Ideas for Micro-Projects

Project-based learning emphasizes being problem-oriented and promoting knowledge construction and ability improvement through project implementation. Considering the limited class hours of undergraduate courses and the significant differences in students' knowledge bases, this course adopts a "micro-project-based teaching" model. It takes typical problems in the research and development and industrial application of lithium-ion battery materials as the carrier, breaks down complex engineering problems into multiple implementable small projects, and achieves a deep integration of knowledge learning and engineering practice. Each micro-project is carried out around four links: "raising questions - analyzing problems - solving problems - evaluation and feedback", guiding students to actively learn relevant theoretical knowledge during the project implementation process and apply the knowledge to the analysis and solution of engineering problems.

2.3 Construction of AI-Enabled Teaching Framework

To enhance the implementation effect of micro-projects, the course introduces artificial intelligence and digital tools such as ChatGPT, DeepSeek, Rain Classroom AI Workbench, Materials Project database, and COMSOL Multiphysics, to construct an AI-enabled teaching framework covering the entire process before, during, and after class. As shown in Figure 1.

In the pre-class stage, AI mainly undertakes the function of knowledge assistance learning. Teachers use artificial intelligence platforms to build course knowledge bases and case libraries, and release learning tasks. Students conduct autonomous learning through generative artificial intelligence tools, completing tasks such as concept understanding, literature retrieval, and problem analysis. The system automatically generates learning profiles based on students' learning behaviors, helping teachers understand students' learning situations and optimize teaching designs.

During the in-class stage, AI mainly undertakes project support and collaborative learning functions. Teachers organize classroom teaching around micro-project tasks and guide students to use AI tools to carry out plan design, data analysis and material screening. Through the three-party interactive model of "student - AI - teacher", knowledge sharing and collaborative exploration are achieved. At the same time, artificial intelligence is utilized to assist in classroom discussions and immediate feedback, enhancing students' classroom participation and learning enthusiasm.

During the after-school stage, AI mainly undertakes the functions of outcome evaluation and continuous improvement. Students use artificial intelligence tools to complete project report writing, simulation result analysis and achievement presentation. Teachers, in combination with the AI analysis platform, evaluate students' learning process, project contribution, and ability achievement, forming a full-process evaluation system. Continuously optimize project design and teaching content through data feedback to achieve continuous improvement.

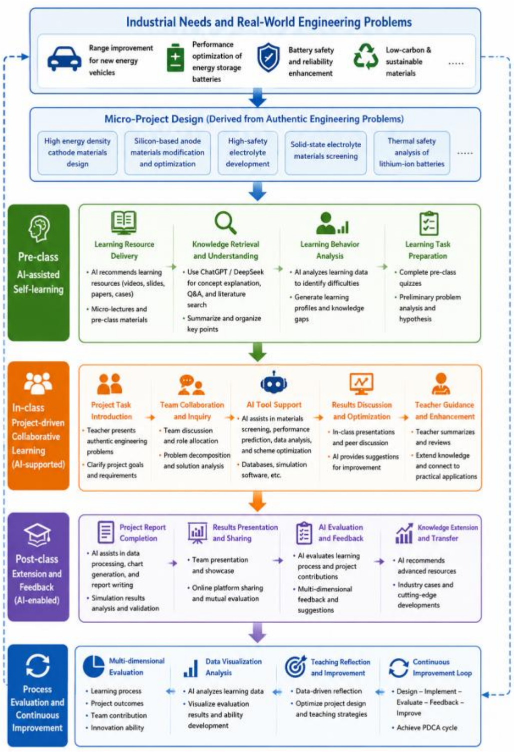

Figure 1 AI-Enabled Micro-Project-Based Teaching Framework

3 THE IMPLEMENTATION PROCESS OF MICRO-PROJECT-BASED TEACHING EMPOWERED BY AI

Based on the teaching concept of "AI empowerment + micro-project-driven", this course constructs a teaching model of "pre-class autonomous learning - in-class collaborative exploration - post-class extended feedback", integrating artificial intelligence technology throughout the teaching process to promote students' knowledge acquisition and engineering practice ability cultivation, as shown in Figure 2.

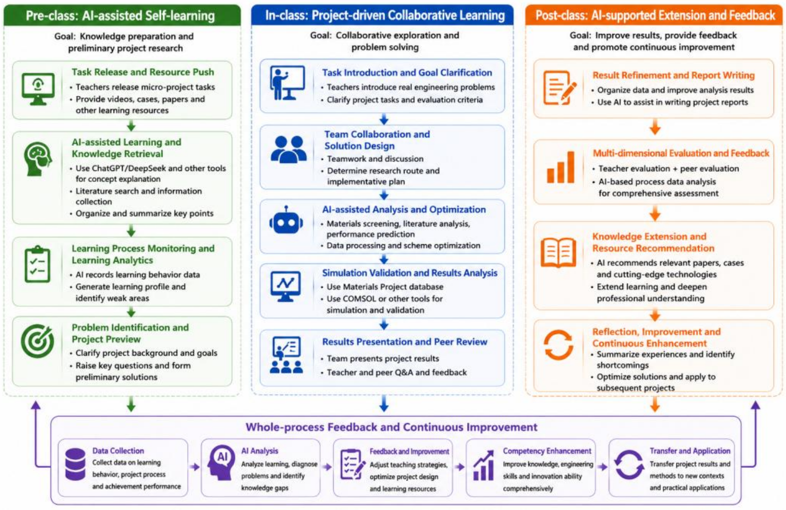

Figure 2 The Implementation Process of AI Empowering Micro-Project-Based Teaching

3.1 Before Class: AI-assisted Autonomous Learning

Before class, teachers rely on platforms such as Rain Classroom to release micro-videos, case materials and learning tasks, guiding students to carry out autonomous learning around the project theme. Students use generative artificial intelligence tools such as ChatGPT and DeepSeek to conduct knowledge retrieval, literature review and concept understanding, and master the basic principles and research status of lithium-ion battery materials. The AI platform can record students' learning behavior data, analyze their mastery of knowledge and learning difficulties, help teachers understand students' learning situations in a timely manner and optimize classroom teaching content, and achieve precise teaching.

3.2 Project-Driven Collaborative Learning

Classroom teaching is carried out with micro-projects as the carrier, focusing on typical projects such as the design of high-energy-density cathode materials, the optimization of silicon-based anode materials, and the development of high-safety electrolytes. Teachers propose project tasks based on engineering cases and guide students to conduct discussions and design plans in groups. During the Project implementation process, students utilized AI tools for material screening, literature analysis and performance prediction, and carried out scheme verification in combination with the Materials Project database and COMSOL simulation software. Teachers help students continuously optimize their design plans through process guidance and classroom discussions, achieving an organic integration of knowledge learning and engineering practice. After the project was completed, each group presented and reported their achievements. Through interaction between teachers and students as well as communication among groups, the ability to analyze and solve problems was further enhanced..

3.3 After-Class: AI support Expansion and Feedback

After class, students use AI tools to complete project report writing, data analysis and result organization. The course adopts a combined approach of "teacher evaluation + student peer evaluation +AI evaluation" to conduct a comprehensive assessment of students' learning process, project achievements and team contributions. In addition, the AI platform recommends relevant literature, industry cases and cutting-edge technology materials based on students' learning progress, guiding them to continuously pay attention to the development trends in the field of new energy materials, and achieving knowledge expansion and ability improvement. Through the closed-loop mechanism of "learning - practice - evaluation - improvement", the quality of course teaching and the effect of talent cultivation are continuously enhanced.

4 EVALUATION AND ANALYSIS OF TEACHING EFFECTIVENESS

To comprehensively evaluate the effectiveness of AI-enabled micro-project-based teaching reform, this course has established a multi-dimensional evaluation system based on the concept of Outcome Orientation (OBE), which assesses students' learning outcomes from multiple dimensions such as knowledge acquisition, engineering practice, innovation ability, and teamwork. The teaching reform effect is verified through methods such as course achievement analysis, questionnaire surveys, and student achievement presentations.

4.1 Reform of the Course Assessment System

The traditional course assessment mainly focuses on the final exam, emphasizing the mastery of theoretical knowledge, and is difficult to comprehensively reflect the development level of students' engineering practice ability and innovation ability. To this end, this course adopts a combined assessment method of process evaluation and summative evaluation to establish a multi-dimensional course evaluation system. Process evaluation mainly examines students' autonomous learning ability, project participation and teamwork ability. Summative evaluation mainly examines the quality of project outcomes and comprehensive application capabilities. The specific evaluation indicators and their weights are shown in Table 1.

Table 1 Composition of the Course Assessment System

Evaluation content	Evaluation index	Proportion%
Self-study before class	AI learning records, task completion status	15
Participation in classroom projects	Classroom discussion, project participation	20
Project implementation process	Classroom discussion, project participation	15
Team collaboration performance	Scheme design, process record	10
Project Outcome Report	Division of labor and cooperation, communication and exchang	20
Project Research Report	Exhibition of Achievements	20

4.2 Teaching Effectiveness

Through the practice of the teaching cycle, the curriculum reform has achieved good teaching results. Compared with the traditional teaching mode, students' classroom participation and learning enthusiasm have significantly improved. Most students can proactively utilize AI tools to conduct data retrieval, literature reading and project design, thus developing the habit of autonomous learning.

The statistical results of the achievement rate of course objectives show that the overall achievement rate of the courses has increased from 78.4% before the reform to 91.2% after the reform. The improvement in engineering practice ability and innovative design ability is most obvious. Students can carry out material screening, performance analysis and scheme optimization in combination with project tasks, and complete design verification by using simulation tools. Their ability to comprehensively apply knowledge has been significantly enhanced.

In addition, during the project implementation process, students complete project tasks through teamwork, enhancing their communication and problem-solving skills, and gradually developing an engineering mindset and innovative consciousness.

4.3 Student Feedback and Achievement Presentation

To understand students' recognition of the teaching reform, a questionnaire survey was conducted after the course ended. The results show that over 92% of the students believe that AI tools can enhance learning efficiency, over 90% think that micro-project-based teaching helps them understand course knowledge, and over 94% believe that project practice has improved their ability to analyze and solve engineering problems.

In terms of the presentation of achievements, students completed a series of project results around themes such as the design of high energy density cathode materials, optimization of silicon-based anodes, modification of electrolytes, and screening of solid-state battery materials. Some outstanding projects have been further transformed into college students' innovation and entrepreneurship training program projects, subject competition works and scientific research practice topics.

Overall, the AI-enabled micro-project-based teaching model has effectively stimulated students' interest in learning, improved the quality of course teaching, and achieved an organic unity of knowledge acquisition, engineering practice and innovation ability cultivation, providing a useful reference for the teaching reform of new energy materials-related courses.

5 CONCLUSIONS AND PROSPECTS

5.1 Effectiveness of Teaching Reform

This project addresses the problems existing in the traditional teaching of the "Lithium-ion Battery Materials Technology" course, such as insufficient learning initiative, weak cultivation of engineering practice ability, and limited improvement of innovation ability. In combination with the requirements of new engineering construction and the OBE education concept, an AI-enabled micro-project-based teaching model has been constructed. By deeply integrating artificial intelligence tools such as ChatGPT and DeepSeek with project-based learning, a full-process teaching system of "pre-class autonomous learning - in-class collaborative exploration - post-class extended feedback" has been formed, achieving an organic unity of knowledge learning, engineering practice and innovation ability cultivation.Teaching practice shows that this teaching mode effectively stimulates students' interest in learning, enhances their classroom participation and autonomous learning ability. Students can utilize artificial intelligence tools to conduct literature retrieval, material screening, performance analysis and scheme optimization, and complete project design and verification in combination with typical engineering cases, thereby enhancing their ability to solve complex engineering problems. Meanwhile, through teamwork and project presentations, students' communication and expression skills, teamwork abilities, and innovative design capabilities have been significantly enhanced. The achievement rate of course objectives and student satisfaction have both significantly improved compared to the traditional teaching mode, demonstrating the positive effects of AI-empowered teaching reform.

5.2 Existing Problems and Improvement Directions

The AI-enabled micro-project-based teaching in this project has achieved good teaching results, but there are still some problems in the implementation process. Firstly, some students are overly dependent on artificial intelligence tools and tend to directly use AI to generate results, lacking the ability to think independently and conduct in-depth analysis. Secondly, the output content of generative artificial intelligence has problems of insufficient information accuracy and professionalism, which requires teachers to screen and guide. In addition, due to the limitations of course hours and teaching resources, the depth of some project contents and practical links still need to be further expanded.The future curriculum reform will be continuously optimized in the following aspects: First, strengthen the education on the use norms of AI tools for students, intensify the cultivation of critical thinking and innovation abilities, and guide students to rationally utilize artificial intelligence to assist in learning; Second, further enrich the enterprise engineering case and project resource library, enhance the authenticity and challenge of the projects, and improve students' engineering practice ability; Third, by integrating digital twin technology, virtual simulation platforms and material databases, a more intelligent and open teaching environment should be constructed. Fourth, improve the multi-dimensional evaluation system, give full play to the advantages of AI in learning analysis and precise evaluation, and achieve continuous improvement in the quality of course teaching.Overall, AI-enabled micro-project-based teaching provides new ideas and practical paths for the teaching reform of new energy material-related courses. In the future, we will further explore the deep integration mechanism of artificial intelligence and professional courses, continuously improve the quality of talent cultivation, and cultivate more high-quality applied talents with innovative spirit and engineering practice ability for the development of the new energy industry.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

FUNDING

Educational and Teaching Reform Project of Guangdong University of Petrochemical Technology (ZLGC202548), The Projects of Talents Recruitment of GDUPT (2023rcyj2006), Science and Technology Project of Maoming (2024011).

REFERENCES

[1] Tarascon JM, Armand M. Issues and challenges facing rechargeable lithium batteries. Nature, 2001, 414(6861): 359-367.
[2] Goodenough JB, Kim Y. Challenges for Rechargeable Li Batteries. Chemistry of Materials, 2010, 22(3): 587-603.
[3] Nitta N, Wu F, Lee JT, et al. Li-ion battery materials: present and future. Materials Today, 2015, 18(5): 252-264.
[4] Xu B, Qian D, Wang Z, et al. Recent progress in cathode materials research for advanced lithium ion batteries. Materials Science and Engineering: R: Reports, 2012, 73(5): 51-65.
[5] Zhong Denghua. The Connotation and Actions of New Engineering Discipline Construction. Research in Higher Education of Engineering, 2017(3): 1-6.
[6] Lin Jian. Reform of Curriculum System and Curriculum Construction of New Engineering Specialties. Research in Higher Education of Engineering, 2020(1): 1-13.
[7] Li Zhiyi. Analysis of the Outcome-oriented Concept of Professional Accreditation in Engineering Education. China Higher Education, 2014(17): 7-1.
[8] Prince M. Does Active Learning Work? A Review of the Research. Journal of Engineering Education, 2004, 93(3): 223-231.
[9] Thomas J. A Review of Research on Project-Based Learning. 2000.
[10] Blumenfeld PC, Soloway E, Marx RW, et al. Motivating project-based learning: Sustaining the doing, supporting the learning. Educational psychologist, 1991, 26(3-4): 369-398.
[11] Holmes W, Bialik M, Fadel C. Artificial intelligence in education promises and implications for teaching and learning. Center for Curriculum Redesign, 2019.
[12] Kasneci E, Sessler K, Küchemann S, et al. ChatGPT for good? On opportunities and challenges of large language models for education. Learning and Individual Differences, 2023, 103: 102274.

[13] Butler KT, Davies DW, Cartwright H, et al. Machine learning for molecular and materials science. Nature, 2018, 559(7715): 547-555.
[14] Liu Y, Zhao T, Ju W, et al. Materials discovery and design using machine learning. Journal of Materiomics, 2017, 3(3): 159-177.