ISSN 2522-6398 Vol. 8, Issue 7: 151-157, DOI: 10.25236/FER.2025.080722

A Blended Online-Offline Model for Cultivating High-Order Engineering Ability in "Automotive Parts Design and Modeling"

Han Lu

Panzhihua University, Panzhihua, Sichuan, 617000, China
luhan51280@outlook.com

Abstract: *Aiming to address the issues of single teaching methods, the lack of students' subjectivity, and insufficient personalized guidance in automotive parts design and modeling, this paper constructs a mixed teaching system: "three-dimensional module drive + dual-track integration implementation + whole-process quantitative evaluation." By dividing three modules: theoretical study, literature reading and practical application, the closed-loop teaching of "preview on the front line of class-deepening off the middle line of class-project expansion after class" is realized by relying on the online platform, and a multi-dimensional evaluation mechanism is established. Practical data show that after the reform, the average score of students' courses has increased by 8.87 points, the passing rate has increased by 19.06%, and their interest in learning and autonomous learning ability have been significantly enhanced. This paper provides an operable implementation path a practical basis for the mixed teaching reform of engineering practical courses.*

Keywords: *Mixed Teaching, Auto Parts Design, Practical Teaching, Teaching Reform*

1. Introduction

1.1 Current Situation and Problems of Course Teaching

As the core course of the vehicle engineering specialty, "Automobile Parts Design and Comprehensive Modeling" aims at cultivating students' ability to analyze and solve automobile parts design and modeling problems. Through systematic study of automobile parts design methods, three-dimensional modeling technology and practical application, students master the general rules and operation skills of chassis parts modeling. However, the traditional teaching mode has obvious shortcomings:

Practical teaching means are single, relying on classroom teaching and concentrated experiments, and it is difficult to visually present the dynamic process of parts modeling, which leads to students' weak understanding of the relationship between "design theory-software operation-engineering application".

The interaction between teachers and students is insufficient, one teacher needs to face more than 100 students, and can't achieve refined management in answering questions and correcting homework, and does not make full use of the network platform to carry out online interaction, so students' learning initiative and interest are low.

The evaluation method is limited, and there is a lack of objective assessment methods for students' learning results. The evaluation system based on final assessment is difficult to reflect the process performance of practice links, and can not comprehensively measure students' engineering application ability.

1.2 The Application Value of Mixed Teaching

Blended teaching provides a feasible way to solve the above problems by integrating the convenience of online resources and the depth of offline interaction [1].

There has been considerable work done on blended teaching reform. Luo et. al., highlighting the application of Moodle-based blended learning in medical statistics, emphasize the importance of

ISSN 2522-6398 Vol. 8, Issue 7: 151-157, DOI: 10.25236/FER.2025.080722

assessing knowledge, attitudes, and practices (KAP) related to e-learning. Their study employs the entropy method to quantify these aspects and utilizes a mixed linear model to analyze influencing factors, demonstrating a data-driven approach to evaluating blended learning outcomes [2]. In the context of language education, Wang discusses the implementation of online and offline blended teaching for college English within the Internet environment [3]. The study notes that ongoing educational reforms have led to the emergence of innovative teaching concepts and models, which are effective in improving the quality and efficiency of modern education. Similarly, Pan constructs a college English blended teaching system based on multisource data fusion, integrating traditional methods with modern educational technology [4]. This approach reconstructs the teaching mode by focusing on object, content, environment, and evaluation, thereby promoting a more comprehensive and data-informed teaching process. Further exploring the integration of technology, Dong introduces a "three-dimensional" blended ideological and political course model grounded in deep learning [5]. The study develops a recommendation system utilizing hybrid collaborative filtering algorithms, addressing traditional shortcomings such as low efficiency and weak adaptability, thus enhancing the effectiveness of ideological education through innovative design. The role of advanced technologies in enhancing blended teaching is also emphasized by Han et. al., who examine the impact of "Internet+” 5G information technology on blended learning [6]. Their counterfactual analysis of undergraduate internship data reveals that 5G technology significantly influences the effectiveness of blended teaching, providing valuable insights for classroom reform in the era of rapid technological advancement. Research on student satisfaction and psychological factors further enriches the understanding of blended teaching reform. Cheng et. al. develop an index system based on constructivist and phenomenological theories to evaluate factors affecting student satisfaction in higher education [7]. Their survey of 598 students identifies key factors influencing satisfaction, offering a basis for targeted improvements in blended learning environments. Moskalenko et. al emphasize the psychological dimensions, particularly motivation, as critical to successful blended learning implementation, highlighting the importance of addressing students’ psychological needs to optimize educational outcomes [8]. Innovative teaching reform paths are also explored through the lens of big data and artificial intelligence. Liang employs association rules and support vector machines to analyze online learning behaviors in ideological and political education, proposing data-driven models to inform teaching strategies and learner profiling [9]. Additionally, Li investigates the application of AIGC technology in finance and economics education, suggesting that such technological integration can facilitate personalized instruction and elevate the overall quality of blended teaching [10]. Overall, the reviewed literature demonstrates a consensus that blended teaching, supported by technological advancements and data analytics, plays a pivotal role in educational reform. These studies collectively advocate for continuous innovation in teaching design, technological integration, and psychological support to realize the full potential of blended learning in diverse educational contexts.

The core advantage of mixed teaching is that it breaks through the limitation of time and space, so that students can flexibly access teaching videos, courseware and other resources [11], repeatedly learn parts modeling operations, and make up for the instantaneous defects of classroom teaching, Expand interactive channels, realize "key-board-style" discussion and answering questions through online platforms, fit students' communication habits, and enhance their participation in after-school learning, Relying on the platform to record students' learning track (such as resource access times, online time, etc.), track the whole process of students' learning, and provide data support for personalized guidance and objective evaluation.

Based on this, this study explores the application of mixed teaching mode in practical courses by taking the course of Auto Parts Design and Integrated Modeling as the carrier.

2. The Design and Implementation of Mixed Teaching Mode

2.1 Curriculum Module and Resource Construction

According to the practical attributes of the curriculum, three modules of "theoretical study-literature reading-practical teaching" are constructed, as shown in Table 1, and each module is subdivided into several units, forming a resource chain of "online preview-offline deepening-after-school expansion"[12].

Online resources rely on the construction of the Superstar Learning Integrated Platform, and each knowledge point is equipped with three-dimensional materials of "principle explanation + operation video + expansion case". Offline resources focus on deepening practice, and schools and enterprises

ISSN 2522-6398 Vol. 8, Issue 7: 151-157, DOI: 10.25236/FER.2025.080722

jointly develop gradient practice projects to simplify design tasks in production practice and adapt to teaching needs.

To enhance the interactivity and efficiency of online learning, a specialized "Automotive Parts Modeling" module was customized within the Chaoxing Learning Platform. This module not only integrates the multi-dimensional resources outlined in Table 1 (including theoretical explanations, operational videos, and extended case studies) but also incorporates an instant Q&A bot (powered by a common-question database) to provide students with preliminary troubleshooting support.

Additionally, the platform features a learning progress bar and a unit unlocking mechanism, requiring students to complete at least 80% of pre-class tasks (e.g., watching videos, finishing quizzes) to access subsequent learning content. This design effectively ensures the quality and engagement of pre-class preparation.

The introduction of these technical functionalities has significantly improved both the accessibility of online resources and the guidance structure of the learning process.

2.2 Teaching the Implementation Process

Adopt the closed-loop process of "autonomous learning on the front line of class-deepening interaction between offline and middle line of class-expanding project practice after class".

Table 1: List of course modules and resources.

Module type	Core unit content	Online resource allocation	Offline resource allocation
Theoretical learning module	Design principle, modeling method and steps of chassis parts	Micro-video (including modeling animation demonstration), electronic courseware, in-class quiz	Case analysis materials, cross-course knowledge association map
Literature reading module	Interpretation of Technical Standards and Frontier Design Cases of Automobile Parts	Document database link, industry standard interpretation video	Literature review template, group discussion guide
Practical teaching module	Three-dimensional software operation, comprehensive modeling project design and production	Operation demonstration video, enterprise simplified project task book	Experimental instruction, practical operation manual of three-dimensional modeling software
Practical teaching module	Three-dimensional software operation, comprehensive modeling project design and production	Operation demonstration video, enterprise simplified project task book	Experimental instruction, practical operation manual of three-dimensional modeling software

First, students preview on the front line of the class. Teachers publish the "Learning Task List" in advance, and students watch micro-videos and read courseware through the platform, and complete in-class quizzes and question feedback [13]. For example, in the "3D Modeling Software Operation" unit, students can watch the operation video recorded by teachers in advance and become familiar with the basic instructions and interface functions. The "Learning Task List" guides students to transform from "blindly watching videos" to "problem-driven learning." Data show that the 2021 students' average number of "question feedbacks" in pre-class preview was 3.2 per unit, 2.8 times that of 2017 students (who rarely raised questions before class). For example, in the "3D software sketching" unit, students proactively asked, "How to choose between constraint types (coincident vs. parallel) for complex curves," which became the focus of in-class discussion, making offline interaction more efficient.

In the "Deepening Interaction" segment of the offline classroom, we have abandoned the traditional "teacher demonstration - student imitation" model. Instead, we adopt a combined approach of Problem-Based Learning (PBL) and Project-Based Learning (PjBL). For example, in the unit on "Suspension System Modeling and Dynamics Analysis," the teacher no longer directly explains operational steps. Instead, they pose a core question: "How to optimize a double-wishbone suspension model to balance both comfort and handling?" Students work in small groups. Leveraging the foundational skills and theoretical knowledge acquired during pre-class preparation, and utilizing resources provided in the offline lab, such as Adams multi-body dynamics simulation software and 3D-printed prototype test benches, they engage in scheme design, model construction, simulation analysis, and preliminary optimization. The teacher's role shifts to that of a "facilitator" and "collaborator". They move between groups, offering:

Brief group guidance on common issues (e.g., the impact of joint constraint settings on simulation results).

ISSN 2522-6398 Vol. 8, Issue 7: 151-157, DOI: 10.25236/FER.2025.080722

Individualized coaching for specific problems (e.g., techniques for complex surface modeling).

Post-class extended practical training. Students work in groups to complete comprehensive modeling projects. They submit design proposals and 3D models through the platform, where instructors provide online critiques and revision feedback. The post-class "Comprehensive Project Iteration" phase extends beyond online submissions and instructor feedback by incorporating a Peer Review (PR) mechanism. For example, during iterations for the "Electric Vehicle Brake Disc Modeling Project," the platform features a dedicated "Design Review Zone." After submitting revised versions, each group anonymously reviews proposals from two other groups, focusing on key dimensions such as design rationality, model standardization, reliability of simulation data, and documentation completeness.

Reviewers must provide actionable suggestions. Instructors oversee the quality of the peer review process and supplement final feedback.

This mechanism not only simulates the peer review workflows common in engineering practice but also develops students' critical thinking and communication skills. In one case, after receiving peer feedback highlighting "insufficient structural strength of an engine crankshaft," a group consulted literature, conducted new Finite Element Analysis (FEA), and ultimately optimized the design. This improved solution was validated by industry engineers, fully demonstrating how the iterative process enhances rigor in engineering practice.

2.3 Construction of the Whole Process Evaluation System

Student assessment and evaluation have also undergone corresponding changes. The original single indicator of "project design score" has been expanded into a whole-process assessment system [14]. Based on this methodology, a comprehensive evaluation framework has been established comprising:

Online Learning Performance (Weight: 40%), including resource access frequency (≥5 times/unit =passing), pre-class quiz accuracy rate, number of valid discussion forum posts/replies (≥3 posts/unit), timeliness and standardization of homework submission (e.g., model file naming, layer management).

Offline Practical Performance (Weight: 30%). Standardization of experimental procedures. Innovation and feasibility of project design proposals (Evaluated via peer evaluation + instructor assessment). Individual contribution within the group (Assessed through: self-evaluation + peer evaluation + instructor observation. Criteria include undertaking core tasks, effectively driving progress, resolving critical issues, etc.)

The final assessment weight accounts for 30%. Utilizes an open-ended project task that requires students to independently complete a relatively comprehensive component within a specified time limit. The process spans the entire workflow: requirement analysis → conceptual design → 3D modeling → key simulations → design documentation.

Additionally, it aims to foster students' interest in learning and expand their channels of knowledge acquisition. The assessment specifically focuses on evaluating students' ability to integrate and apply knowledge, adhere to engineering standards, and demonstrate innovative thinking.

3. Analysis of the Effectiveness of Teaching Practice

3.1 Expansion of Students' Learning Interests and Channels

The blended teaching model has significantly enhanced students' learning initiative, with students submitting assignments more actively. Post-class surveys show that "increased interest in learning" is the primary feedback from students. Compared to collective classroom discussions, students are more accustomed to "keyboard-based" online discussions and questions.

The channels for practical learning have expanded from "teacher guidance in class" to a diversified model of "online video learning + group cooperation + teacher Q&A." Students can review instructional videos from teachers at any time, and mutual progress is achieved through question-and-answer exchanges both within and between groups. During group discussions and project iteration reviews, the proportion of students able to raise well-founded questions and constructive improvement suggestions has greatly increased, reflecting the crucial engineering mindset elements of "reflection" and "optimization."

ISSN 2522-6398 Vol. 8, Issue 7: 151-157, DOI: 10.25236/FER.2025.080722

In the final comprehensive project, when faced with modeling errors not explicitly pointed out (such as failed interference checks), 85% of students were able to independently diagnose and correct the issues using their acquired knowledge and platform resources, whereas under the traditional model, students mostly relied on teachers directly providing solutions.

3.2 Correlation Analysis between Learning Behavior and Academic Achievement

The analysis of randomly selected 14 students shows that there is a significant positive correlation between academic performance and online learning investment: students with more than 80 points enter the course 81 times on average, read teaching materials 41 times, and the total time of online learning is 250 minutes. Students with scores below 60 enter the course 17 times on average, read teaching materials 14 times, and the total time of online learning is 29 minutes.

Taking Class One of Vehicle Engineering Specialty as a sample, the mixed teaching has achieved remarkable results after implementation. The "group collaboration contribution" index showed that 76% of 2021 students improved their collaboration skills, as reflected in "clear task division" and "effective conflict resolution." A contrast case: a 2020 group (traditional teaching) failed to complete the project due to an unbalanced workload, while a 2021 group used online shared documents (to track progress) and offline weekly meetings, successfully delivering a high-quality model, showing that the evaluation system encourages the development of team-based engineering capabilities.

The final assessment replaced traditional "software operation tests" and emphasized integrated applications. The 2021 students' average score in this assessment was 78.5, 15.3 points higher than in 2020, with 32% of them proposing innovative solutions (e.g., "modular design for easy maintenance")—indicating that the reform effectively promotes the transition from "skill mastery" to "comprehensive engineering problem-solving. The passing rate increased from 65% in 2020 to 84.06%.

4. The Direction of Teaching Reflection and Optimization

4.1 Summary of Reform Results

(1) Resource integration strengthens intuition. Through the multi-dimensional resources of "video + courseware + case", the abstract design theory is transformed into concrete content, which helps students understand the dynamic process of parts modeling.

(2) Interactive mode enhances participation. The online platform provides students with a convenient interactive channel. The "keyboard-style" discussion fits their communication habits, and the timeliness of answering questions and homework feedback after class is significantly improved.

(3) Evaluate the process of reform guidance. The whole process evaluation system pays attention to every link of learning, avoids the disadvantages of "final surprise review", and can objectively reflect students' real ability.

The blended teaching model—through modular resource chains, problem-driven interaction chains, and iterative project chains—effectively shifts learning focus from low-order knowledge memorization and software imitation to high-order competencies: engineering problem analysis, innovative solution design, and collaborative complex task resolution.

The whole-process assessment system acts as a conductor, orchestrating and reinforcing these high-order competencies. Students' demonstrated integration ability and innovation consciousness in final projects stand as the most compelling validation of the reform's efficacy.

4.2 Existing Problems and Improvement Measures

A few students have a low participation rate in online activities, so it is necessary to optimize the allocation of resources and improve the incentive mechanism to enhance their initiative. Some teaching cases fail to keep pace with the new technologies in the automobile industry promptly, so it is necessary to establish a school-enterprise cooperation mechanism and regularly update the practical projects and case base.

To address this, we propose designing engaging "micro-tasks" and implementing a "badge" system to incentivize participation. For instance, badges such as "Modeling Master" could be awarded for mastering complex modeling techniques, and "Collaboration Star" for providing high-quality peer

ISSN 2522-6398 Vol. 8, Issue 7: 151-157, DOI: 10.25236/FER.2025.080722

assistance.

5. Conclusion

The blended teaching reform of the "Automotive Component Design and Integrated Modeling" course effectively addresses the core challenges of traditional teaching models, such as monotonous teaching methods, lack of student agency, insufficient personalized guidance, and one-sided evaluation, by constructing a teaching system featuring "three-dimensional module drive (theory- literature-practice), dual-line integration implementation (online independent exploration + offline deep interaction), and whole-process quantitative evaluation (online + offline + final exam)". Practical data fully demonstrate that this model significantly enhances students' interest in learning (interest enhancement has become the primary feedback from students), autonomous learning ability (frequency of utilizing extracurricular resources has doubled), and academic performance (average score increased by 8.87 points, pass rate increased by 19.06%). Furthermore, it exhibits great potential in cultivating students' high-order engineering abilities (analysis, design, optimization, collaboration, innovation). The core value of the reform lies in achieving three key transformations:

The transformation of learning resources from "static and abstract" to "dynamic and concrete" (videos/cases/simulations) effectively bridges the gap between theory and practice.

The teaching process has shifted from "teacher-led, one-way transmission" to "student-centered, deep interaction" (online driving + offline exploration), fully unleashing students' subjectivity and collaborative potential;

The transformation of capability evaluation from "single-outcome, skill-oriented" to "multi-dimensional process, competency-oriented" (full-process quantification + high-order capability observation) provides precise guidance and ensures the effectiveness of cultivating high-order engineering capabilities

Acknowledgments

This study was funded by a school-level project of Panzhihua University [grant number 2023YB07]. We are grateful to the volunteer walkers who donated their time and patience.

References

[1] He, K. (2005). Viewing the new development of educational technology theory from Blending Learning. Journal of National Institute of Educational Administration, (9), 37–48.
[2] Luo, L., Cheng, X., Wang, S., Zhang, J., Zhu, W., Yang, J., & Liu, P. (2017). Blended learning with Moodle in medical statistics: An assessment of knowledge, attitudes and practices relating to e-learning. BMC Medical Education, 17, Article 169.
[3] Wang, X. (2021). Online and offline blended teaching of college English in the Internet environment. In Proceedings of the 2021 International Conference on Applications and Techniques in Cyber Intelligence (ATCI 2021) (pp. 123–131). Springer.
[4] Pan, A. (2022). Construction and application of a college English blended teaching system based on multidata fusion. Discrete Dynamics in Nature and Society, 2022, Article 8823451.
[5] Dong, H. (2022). Teaching design of "three-dimensional" blended ideological and political courses from the perspective of deep learning. Security and Communication Networks, 2022, Article 8877665.
[6] Han, C., & Huang, J. (2022). Effect of "Internet+" 5G information technology on blended teaching: A test based on counterfactual method. International Journal of Emerging Technologies in Learning, 17(12), 45–58.
[7] Cheng, X., Mo, W., & Duan, Y. (2023). Factors contributing to learning satisfaction with blended learning teaching mode among higher education students in China. Frontiers in Psychology, 14, Article 1098234.
[8] Moskalenko, L., Huleikova, I., Kushnir, H., Adamenko, S., & Yefimov, D. (2024). Psychological aspects of blended learning in Ukraine. Conhecimento & Diversidade, 16(1), 112–125.
[9] Liang, L. (2024). Exploring the teaching reform path of ideological and political education in colleges and universities in the context of deep learning. Applied Mathematics and Nonlinear Sciences, 9(1), 345–356.

ISSN 2522-6398 Vol. 8, Issue 7: 151-157, DOI: 10.25236/FER.2025.080722

[10] Huang, R., Zhou, Y., & Wang, Y. (2006). Theory and practice of blended learning. Higher Education Press.
[11] Meng, X., Niu, D., Ding, L., & Wang, L. (2024). Research on the effect of mixed teaching strategies on students' ambidextrous innovation. Studies in Educational Evaluation, 83, Article 101390.
[12] Leidl, D. M., Ritchie, L., & Moslemi, N. (2020). Blended learning in undergraduate nursing education—A scoping review. Nurse Education Today, 86, 104318.
[13] McCutcheon, K., O'Halloran, P., & Lohan, M. (2018). Online learning versus blended learning of clinical supervisee skills with pre-registration nursing students: A randomized controlled trial. International Journal of Nursing Studies, 82, 30–39.
[14] Yang, K. (2018). Theory and model of instructional design. Electronic Industry Press.