*Education Insights*

*Article*

# Exploration and Practice of a Hybrid Teaching Model for Computer Organization Principles Based on the BOPPPS Framework and Ideological-Political Education

**Mingxuan Yang [1,*], Yuxuan Dong [1], Yantao He [1] and Wenxiang Song [1]**

[1] Department of Computer Science, Guangdong University of Science and Technology, No. 2, Songshan Lake Section, Dongguan, China
* Correspondence: Mingxuan Yang, Department of Computer Science, Guangdong University of Science and Technology, No. 2, Songshan Lake Section, Dongguan, China

**Abstract:** With the deepening of information technology and ongoing higher education reforms in China, the course Computer Organization Principles faces challenges such as abstract content, a disconnect between theory and practice, and difficulty integrating ideological and political education. To address these issues, this study develops a hybrid instructional model that integrates both online and offline components, combining the BOPPPS teaching framework with blended learning strategies. In the pre-class phase, clearly defined learning objectives and diagnostic pre-assessments are delivered online to stimulate autonomous learning; during class, contextualized case studies and collaborative group activities support participatory learning; in the post-class phase, laboratory reports and reflective summaries close the loop between knowledge and values. A diversified evaluation system ensures fairness and comprehensiveness, offering valuable insights for the ongoing improvement and refinement of the teaching model. Empirical results from a controlled experiment with two cohorts demonstrate that this blended model not only enhances students' technical competencies but also effectively cultivates their values, indicating strong potential for broader implementation.

**Keywords:** blended learning; BOPPPS teaching model; course ideological and political; Computer Organization Principles

Published: 07 May 2025



## 1. Introduction

In the curriculum system of computer science and related disciplines, Computer Organization Principles is a fundamental yet abstract and theory-intensive course that also demands practical application. It serves as a critical link between basic subjects like digital logic and advanced topics such as assembly language, operating systems, and computer architecture. Similar to how artificial intelligence has been leveraged to support non-native learners in mastering complex language systems, innovative instructional strategies are needed to make abstract computing concepts more accessible, engaging, and value-integrated [1-3]. Through this course, students develop a systematic understanding of core concepts such as computer system structure, instruction sets, data paths, and control unit design, thereby laying a solid foundation for future work in hardware design, system optimization, and engineering practice.

However, in actual teaching practice, the course faces several significant challenges. First, the content is abstract and heavily theoretical, involving complex concepts such as logical reasoning, binary operations, control logic, and structural design, which students often find difficult to comprehend and internalize. Moreover, the course is highly systematic and logically coherent, with tightly interconnected knowledge points. Weak foundational understanding in one area can easily lead to learning disruptions in others. In addition, due to limitations in teaching resources, instructional tools, and curricular structure, the practical component of the course often fails to integrate effectively with theoretical teaching, depriving students of the opportunity to reinforce their understanding through hands-on experience. As a result, a common issue arises: students excel in theory but lack practical skills.

Furthermore, traditional teaching models predominantly rely on lecture-based instruction, in which students passively receive information with limited classroom interaction [4,5]. This hampers the development of critical thinking and self-directed learning skills. At the same time, under the educational initiative of moral and value-based education in the curriculum, an urgent challenge is how to integrate value-oriented education into a technically rigorous course such as Computer Organization Principles, thereby achieving both knowledge transfer and moral education [6].

In the context of educational reform in the new era, transforming classroom instruction and enhancing the overall educational effectiveness of courses have become core objectives for higher education [7,8]. The BOPPPS model, a structured teaching framework that emphasizes student-centered learning, has been widely adopted across disciplines. Meanwhile, blended teaching — integrating online and offline instruction — represents the deep convergence of modern information technology with traditional pedagogy, breaking the constraints of time and space and enabling more flexible and personalized learning experiences. The concept of integrating moral and value-based education into the curriculum calls for professional courses to not only impart technical knowledge but also foster students' moral development. The integration of these three approaches — BOPPPS, blended learning, and moral education — promises to build an effective bridge between theory and practice, between knowledge and values, thereby enhancing the overall educational impact of the course [9,10].

Based on this background, we took the course "Computer Organization Principles" as the research object and proposed the design and implementation of a hybrid teaching model that combines the BOPPPS framework with ideological and political education, aiming to stimulate students' interest and participation, improve teaching effectiveness, and achieve synergy between knowledge acquisition and moral development.

## 2. Preliminaries

In this chapter, we introduce two key instructional technologies that underpin our teaching model: the BOPPPS framework and blended learning techniques.

### *2.1. The BOPPPS Teaching Model*

The BOPPPS framework (Bridge-in, Objectives, Pre-assessment, Participatory Learning, Post-assessment, Summary) is a systematic and structured instructional design approach that centers on learners and continuous formative evaluation [11]. Its six components serve distinct pedagogical functions:

1) Bridge-in: Capture students' attention and contextualize new content by presenting real-world cases, challenging scenarios, or current events, thereby stimulating intrinsic motivation and framing the learning task.
2) Objectives: Articulate clear, hierarchical goals encompassing knowledge acquisition, skill development, and value cultivation. This clarity enables learners to monitor their own progress and align their efforts with expected outcomes.
3) Pre-assessment: Diagnose prior understanding and identify knowledge gaps through quizzes or diagnostic surveys. The results guide differentiated instruction and targeted support during subsequent learning activities.
4) Participatory Learning: Engage students in active knowledge construction via collaborative discussions, hands-on experiments, case analyses, and project-

based tasks. This "learning by doing" strategy deepens comprehension and fosters critical thinking.

5) Post-assessment: Provide immediate feedback on learner performance using class polls, quizzes, or peer review. Timely insights allow instructors to adjust teaching strategies and help students reflect on their learning.
6) Summary: Consolidate key concepts and reinforce both cognitive and affective goals through instructor-led or student-generated summaries, ensuring a dual focus on technical understanding and embedded values.

By delineating each phase and embedding ongoing feedback loops, the BOPPPS model enhances student engagement and instructional precision. Its effectiveness has been validated across engineering, language education, and management courses, offering a solid theoretical foundation for this blended teaching study.

### *2.2. Blended Learning Techniques*

Blended learning combines the strengths of online and face-to-face instruction within a three-stage cycle — pre-class, in-class, and post-class — to create a flexible, learner-centered experience [12]:

1) Pre-class: Learner's access micro-lectures, digital readings, and formative quizzes at their own pace. Learning analytics track engagement and performance, enabling instructors to tailor in-class activities to diverse learner needs.
2) In-class: Classroom time is devoted to resolving difficulties, facilitating peer collaboration, and conducting practical exercises. Methods such as flipped classrooms, team-based projects, and instant response systems foster dynamic interaction among instructor and students.
3) Post-class: Online discussion forums, assignment platforms, and capstone projects extend learning beyond the lecture. Reflective writing and peer assessment encourage deeper processing and reinforce concept mastery.

This integrated approach transcends traditional temporal and spatial constraints, bolsters learner autonomy, and maximizes instructional impact. By aligning with the BOPPPS structure, blended learning provides the optimal environment for implementing a participatory, feedback-rich pedagogy in the Computer Organization Principles course.

## 3. Design and Implementation of the Instructional Model

This chapter details the instructional design and implementation strategy of our hybrid teaching model, with a focus on aligning pedagogical structure, operational workflows, and ideological integration. By refining each phase of the teaching process — pre-class preparation, in-class activities, and post-class consolidation — we aim to create a replicable, scalable, and effective model that simultaneously advances technical competencies and ideological education.

### *3.1. Framework and Workflow*

Our approach seamlessly blends the BOPPPS framework with a three-stage blended learning cycle — pre-class, in-class, and post-class, as illustrated in Figure 1.

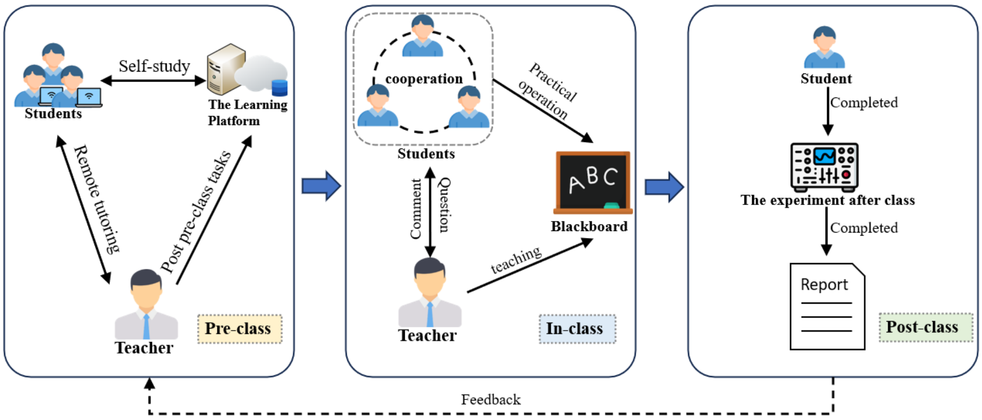


**Figure 1.** The Teaching Model of BOPPPS + Blended Learning.

1) Pre-class: We move the BOPPPS Objectives and Pre-assessment steps into the online environment, where they reinforce one another. Students watch a 3-5-minute micro-lecture on CPU evolution and domestic chip innovations via the learning platform. They then review the session's stated objectives (knowledge, skills, values) and complete a diagnostic quiz to gauge their prior understanding. Quiz results are returned immediately, enabling instructors to provide targeted, personalized guidance before the in-person session.
2) In-class: The BOPPPS Bridge-in and Participatory Learning steps occur during the live class. Students form teams of three to four and carry out the tasks assigned by the instructor. Each group presents its work on the board or projector. When difficulties arise, learners raise questions and receive on-the-spot support from the instructor or teaching assistant. At the end of class, the instructor leads a summary discussion, and student representatives reflect on both the technical achievements and the ethical responsibilities involved.
3) Post-class: We assign the BOPPPS Post-assessment and Summary steps as follow-up activities. Students complete a hands-on lab exercise, then write an experimental report detailing their procedures and insights. This report also serves as formative feedback for shaping the next session's objectives and pre-class diagnostic quiz.

Through this design, an integrated learning process is created that combines online preparation and diagnostics, in-class interaction and practice, and post-class feedback and reflection in a continuous cycle. This integration of blended learning and the BOPPPS framework enhances instructional effectiveness and promotes comprehensive student development, including both technical skills and moral growth.

### *3.2. Detailed Module Design*

Computer Organization Principles is divided into four progressive units, each of which combines technical content with moral and value-based education:

1) Unit 1: Introduction. This unit defines the course's scope, historical evolution, and learning objectives. Guided discussions prompt students to appreciate the importance of computer organization, followed by team presentations of learning expectations. Emphasis is placed on promoting a sense of technological responsibility and awareness of societal contributions.
2) Unit 2: Computer System Hardware Architecture. Covering bus systems, memory hierarchies, and I/O interfaces, students engage in hands-on hardware teardown demonstrations and online concept quizzes. The unit fosters collaboration and a diligent work ethic.

3) Unit 3: Central Processing Unit. Focusing on CPU internals, data paths, and control signals, learners build a basic ALU on an FPGA and present the CPU operational flow in groups. Reflection activities underscore innovation and a scientific mindset.
4) Unit 4: Control Unit. Exploring hardwired versus microprogrammed control, students design a simple instruction controller and participate in structured debates. Ethical considerations and social responsibility are highlighted throughout.

Table 1 below summarizes each unit's core topics, learning activities, and embedded ideological elements.

**Table 1.** Detailed Design Table of Each Unit of Computer Organization Principles.

| Unit | Core Topics | Learning Activities | Ideological Elements |
|---|---|---|---|
| Unit 1: Introduction | Course significance, historical development, objectives | Discussion: importance of computer organization; team expectation presentations | Cultivation of national pride and sense of responsibility |
| Unit 2: Hardware Architecture | Bus structures, memory hierarchy, I/O interfaces | Hardware teardown demonstration; online quizzes | Promotion of teamwork and diligent scholarship |
| Unit 3: Central Processing Unit | CPU components, data paths, control signals | FPGA-based ALU implementation; group workflow presentations | Encouragement of innovation and scientific attitude |
| Unit 4: Control Unit | Hardwired vs. microprogram control, control signal design | Instruction controller design challenge; classroom debate | Emphasis on technical ethics and social responsibility |

## 4. Assessment System and Teaching Effect

This chapter focuses on the model design and detailed unit design of computer composition principle based on BOPPPS + hybrid teaching mode, constructs an evaluation system and compares and discusses the teaching results.

### *4.1. Assessment System*

For a complete teaching activity, there must be not only a teaching process, but also a corresponding evaluation and assessment system. Therefore, in the assessment mode of the computer composition principal experiment course, personal performance assessment, stage test, and final examination are designed, and the proportion of each part accounts for 30%, 30%, and 40% of the final score. Among them, personal performance assessment is mainly composed of teacher evaluation, student self-evaluation, class evaluation, and group evaluation, accounting for 25% respectively. Group evaluation is mainly obtained by averaging the scores of other members of the group. The class evaluation score is the average score obtained by removing the scores of group members. The teacher evaluation is a comprehensive score given by the teacher based on the completion of the students' Supernova Learning Pass tasks, pre-test and post-test scores, attendance check-in, classroom performance and communication and interaction. The score of the final examination is the students' final exam results.

### *4.2. Teaching Effect*

In this experiment, the Computer Organization Principles course is taught over 32 class hours, and we conduct control experiments on students from different classes of computer majors in 2022. For students in Class 1, we use the BOPPPS and hybrid teaching model proposed in this paper for teaching, and integrate the course ideological and political education into each course unit in the detailed design for teaching guidance. For students in Class 2, we use the normal lecture teaching mode for teaching. The following Figure 2 shows the performance of the two classes in the final exam.

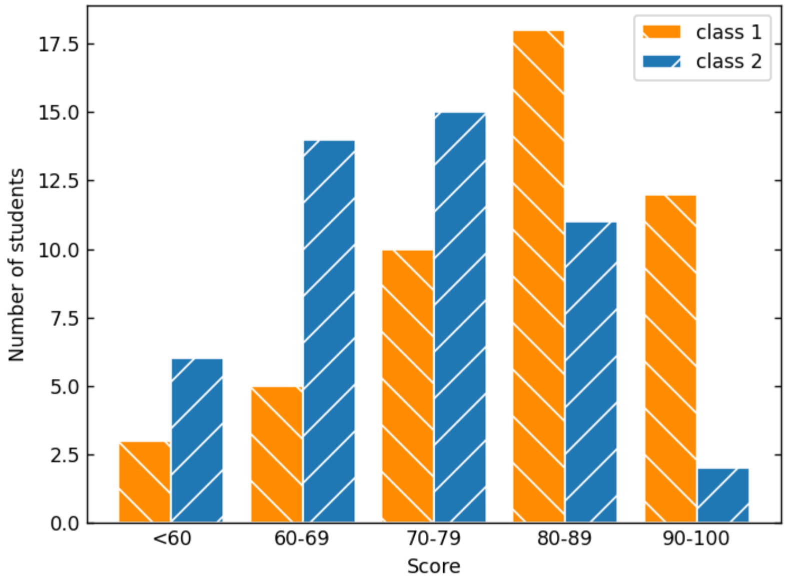


**Figure 2.** Comparison of Final Exam Scores.

It is evident from Figure 2 that the number of students scoring between 80 and 100 in Class 1 far exceeds that in Class 2, while the number of students scoring below 60 is significantly lower in Class 1 than in Class 2. These results demonstrate that our proposed teaching model significantly improves student performance when implemented.

## 5. Conclusions

This study developed and implemented a novel instructional model for the Computer Organization Principles course by integrating the BOPPPS framework with a three-phase blended learning approach and infusing ideological and political education into each unit. Comparative analysis between the experimental group (Class 1) and the control group (Class 2) demonstrates that our model significantly enhances students' conceptual understanding, practical skills, and classroom engagement through its closed-loop design of online goal-setting and diagnostics, in-class participatory learning, and post-class reflection.

Moreover, the systematic incorporation of ideological elements fostered students' sense of national identity, innovative spirit, and social responsibility. A diversified evaluation system ensured fairness and comprehensiveness, providing actionable data for continuous refinement. Overall, this instructional model successfully balances technical competency development with value-oriented education, and shows strong potential for wider application in computer science and engineering courses. Future work may leverage learning analytics to further personalize instruction and extend this framework to other disciplines.

**Funding:** This work is supported by the Quality Engineering Project of Guangdong University of Science and Technology under Grant GKZLGC2024181.

## References

1. Z. Mo, "AI-powered language learning: Empowering non-native children to master Chinese," *J. Linguist. Cult. Stud.*, vol. 2, no. 1, pp. 24–33, 2025, doi: 10.70088/ev8tgr31.

2. Z. Mo, "AI-assisted strategies for improving Chinese proficiency in non-native AP exam takers," *J. Comput. Signal Syst. Res.*, vol. 2, no. 1, pp. 115–122, 2025, doi: 10.71222/4tksvc16.
3. Z. Mo, "Artificial intelligence in lifelong learning: Enhancing Chinese language instruction for non-native adult learners," *GBP Proc. Ser.*, vol. 2, pp. 141–146, Mar. 2025, doi: 10.71222/vxzcka39.
4. L. Du, L. Zhao, T. Xu, Y. Wang, W. Zu, X. Huang et al., "Blended learning vs. traditional teaching: The potential of a novel teaching strategy in nursing education—a systematic review and meta-analysis," *Nurse Educ. Pract.*, vol. 63, p. 103354, 2022, doi: 10.1016/j.nepr.2022.103354.
5. Y. Q. Jin, C. L. Lin, Q. Zhao, S. W. Yu, and Y. S. Su, "A study on traditional teaching method transferring to E-learning under the COVID-19 pandemic: From Chinese students' perspectives," *Front. Psychol.*, vol. 12, p. 632787, 2021, doi: 10.3389/fpsyg.2021.632787.
6. Y. Zhang, "Study on implicit ideological and political education theory and reform in higher vocational colleges," *Open J. Polit. Sci.*, vol. 5, no. 5, pp. 268–273, 2015, doi: 10.4236/ojpp.2015.55037.
7. W. Xiong, J. Yang, and W. Shen, "Higher education reform in China: A comprehensive review of policymaking, implementation, and outcomes since 1978," *China Econ. Rev.*, vol. 72, p. 101752, 2022, doi: 10.1016/j.chieco.2022.101752.
8. Z. Mo, "Artificial intelligence empowering online teaching of Chinese as a foreign language: Opportunities, challenges, and future prospects," *Educ. Insights*, vol. 1, no. 5, pp. 18–29, Dec. 2024, doi: 10.70088/nwwqch86.
9. Y. Li, X. Li, Y. Liu, and Y. Li, "Application effect of BOPPPS teaching model on fundamentals of nursing education: A meta-analysis of randomized controlled studies," *Front. Med.*, vol. 11, p. 1319711, 2024, doi: 10.3389/fmed.2024.1319711.
10. A. Kumar, R. Krishnamurthi, S. Bhatia, K. Kaushik, N. J. Ahuja, A. Nayyar, and M. Masud, "Blended learning tools and practices: A comprehensive analysis," *IEEE Access*, vol. 9, pp. 85151–85197, 2021, doi: 10.1109/ACCESS.2021.3085844.
11. P. Li, X. Lan, L. Ren, X. Xie, H. Xie, and S. Liu, "Research and practice of the BOPPPS teaching model based on the OBE concept in clinical basic laboratory experiment teaching," *BMC Med. Educ.*, vol. 23, no. 1, p. 882, 2023, doi: 10.1186/s12909-023-04822-z.
12. B. Bruggeman, J. Tondeur, K. Struyven, B. Pynoo, A. Garone, and S. Vanslambrouck, "Experts speaking: Crucial teacher attributes for implementing blended learning in higher education," *Internet High. Educ.*, vol. 48, p. 100772, 2021, doi: 10.1016/j.iheduc.2020.100772.