Teaching Design and Practice of Artificial Intelligence Fundamentals Based on the BOPPPS Model and Project-Based Learning

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Abstract: Amid the rapid proliferation of artificial intelligence technology, general education in AI for non-computer science majors in higher education faces practical challenges including theoretical abstraction, weak practical application, and low student engagement. This study deeply integrates the BOPPPS teaching model with project-based learning methods. Using the machine learning and image classification modules from the “Fundamentals of Artificial Intelligence” course as the teaching vehicle, it constructs an integrated teaching process of “theoretical instruction + project practice + collaborative inquiry” through six stages: introduction, goal setting, pre-assessment, participatory learning, post-assessment, and summary. Teaching practice demonstrates that this model effectively reduces students' comprehension barriers to AI knowledge, enhances classroom engagement and knowledge internalization, while simultaneously cultivating computational thinking, problem-solving abilities, and teamwork awareness. It provides a referenceable practical paradigm for teaching reform in university-level AI general education courses.

Keywords: BOPPPS teaching model; project-based learning; fundamentals of artificial intelligence; general education; instructional design

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Introduction

With the rapid proliferation of artificial intelligence technology, societal demand for interdisciplinary talents with AI literacy continues to rise, making artificial intelligence fundamentals a crucial general education course in higher education. However, current teaching remains predominantly theory-based, featuring abstract content and insufficient practical application. Non-computer science students generally lack programming and mathematical foundations, struggle to grasp core concepts such as models, training, and prediction, exhibit low learning initiative, and achieve suboptimal teaching outcomes. The BOPPPS model offers a comprehensive structure emphasizing interaction and immediate feedback, while project-based learning drives task-oriented, practice-focused inquiry. Integrating these approaches can effectively address the aforementioned challenges. This paper constructs a teaching design combining BOPPPS with project-based learning using the machine learning and image classification module as a vehicle. It explores AI teaching pathways suitable for general education, providing practical references for enhancing teaching quality.

1 Overview of Relevant Teaching Models

The BOPPPS model comprises six progressive stages—Introduction, Objectives, Pre-test, Participatory Learning, Post-test, and Summary—forming a complete instructional cycle. This student-centered approach emphasizes achievable learning objectives and measurable outcomes, enabling instructors to pace lessons effectively and monitor student progress in real time. Project-based learning uses concrete projects as learning vehicles, enabling students to acquire knowledge and enhance skills through the complete process of planning, inquiry, creation, presentation, and reflection. It is particularly well-suited for practical engineering and information technology courses. In AI general education, single-dimensional theoretical instruction struggles to spark interest, whereas project-based learning transforms abstract concepts into tangible, actionable tasks, allowing students to grasp technical principles through hands-on engagement.

Integrating project-based learning into the participatory learning phase of BOPPPS achieves complementary advantages. Instructors design lightweight, accessible mini-projects aligned with learning objectives, while students complete tasks in small groups, grasping key concepts through collaborative inquiry. This approach preserves the rigorous classroom structure of the BOPPPS model while granting students ample space for independent exploration. It transforms learning from passive reception to active construction, aligning with the pedagogical demands of general education.

2 Analysis of Target Audience and Course Content

This instructional design is intended for lower-division undergraduate students majoring in fields other than computer science. These students possess basic computer operation skills and have some understanding of artificial intelligence application scenarios, but their knowledge of underlying technical principles is relatively limited. Most students have not been exposed to algorithmic concepts or programming training and have limited capacity to grasp complex theories. Therefore, the instructional design should minimize mathematical derivations and code implementation, while emphasizing the understanding of processes and logical reasoning. The instructional content focuses on the machine learning and image classification modules within the fundamentals of artificial intelligence. This section serves as a critical link between foundational concepts and practical applications, offering strong practical and comprehensive value.

The instructional focus is set on understanding the basic workflow of supervised learning and recognizing the impact of data on model performance; the instructional challenge lies in helping students grasp the underlying logic of model training and establish a comprehensive understanding of the process from data to results. To address this challenge, the instructional design combines a visualization platform with lightweight projects, allowing students to gradually comprehend core concepts while completing the projects, thereby lowering the learning threshold.

3 Designing the Teaching Process Based on BOPPPS and Project-Based Learning

3.1 Introduction

The course begins by introducing common real-life applications of artificial intelligence. Short videos demonstrating handwritten digit recognition, facial recognition, and object classification are shown to provide a visual demonstration of the practical applications of AI technology. The teacher poses questions to guide students in thinking about the basic logic behind how machines perform recognition functions, thereby sparking their interest in exploration. Subsequently, the teacher introduces the learning task for this lesson: to understand the basic process of machine learning by completing a small-scale handwritten digit recognition project, ensuring students clearly understand the learning objectives and the direction of the task.

3.2 Defining Learning Objectives

Based on the curriculum standards and student characteristics, instructional objectives are set across three dimensions: knowledge, skills, and competencies. The knowledge objective is to understand the basic process of supervised learning and recognize the roles of data, models, training, and testing in AI projects; the skills objective is to enable students to collaboratively complete simple AI project tasks, thereby enhancing their problem-analysis and teamwork abilities; the competency objective is to foster a rational understanding of AI technology and establish sound ethical perspectives on technology. The objectives are clearly and specifically stated to facilitate subsequent instructional activities and the assessment of learning outcomes.

3.3 Pre-test Phase

Before formally launching the project-based learning, the teacher distributes a brief pre-test via classroom interaction tools, covering topics such as basic understanding of machine learning and simple assessments of the role of data. The pre-test helps the teacher quickly assess students' prior knowledge levels and understand their initial grasp of relevant concepts, providing a basis for adjusting subsequent instructional content. At the same time, the pre-test helps students quickly enter a learning mindset, identify their knowledge gaps, and enhance the focus of their class participation.

3.4 Participatory Learning: Project-Based Learning Practice

Participatory learning is the core component of this lesson. The instructor integrates project-based learning by assigning handwritten digit recognition as the project task and guiding students to collaborate in groups to complete the practical work. The instructor first briefly explains the basic process of supervised learning, using everyday language to clarify core concepts such as data, models, training, and prediction, thereby reducing the difficulty of comprehension. Subsequently, each group follows the instructions to complete steps including data collection, data organization, model training, and performance testing.

Throughout the project, the teacher circulates to provide guidance, promptly addressing students' questions and emphasizing data standards and key operational procedures. Through hands-on activities, students gain a direct understanding of how data affects model performance and grasp the fundamental logic of model training. Students collaborate within their groups, exchanging ideas and working together to resolve operational challenges, thereby deepening their understanding of the subject matter through practical application. The project tasks were of moderate difficulty, aligned with the students' ability levels. This ensured that every student could participate while also allowing them to experience a sense of accomplishment upon completing the tasks, thereby boosting their confidence in learning.

3.5 Post-Test Phase

After the project was completed, the teacher administered a post-test to assess students' mastery of core knowledge. The post-test content closely aligned with the instructional objectives and included tasks such as identifying basic concepts, sequencing processes, and analyzing simple problems. At the same time, each group briefly presents their project outcomes and shares their discoveries and insights from the implementation process. The teacher conducts a comprehensive evaluation of student learning based on both the project outcomes and the post-test results, acknowledging strengths, pointing out areas for improvement, and helping students identify directions for further development.

3.6 Summary Session

The teacher leads students in reviewing the core content of the lesson, outlining the complete supervised learning process, and emphasizing the critical roles of data quality, model selection, and the training process in determining project outcomes. The summary highlights key points to help students construct a clear knowledge framework. After class, the teacher assigns tiered homework: the basic assignment involves organizing reflections on the project, while the advanced assignment involves attempting to modify the project content to further expand their learning. The summary session not only reinforces the knowledge learned in class but also provides students with opportunities for extended learning, effectively bridging the gap between in-class and out-of-class learning.

4 Teaching Outcomes and Reflections

Integrating the BOPPPS teaching model with project-based learning in the teaching of introductory artificial intelligence courses effectively addresses the shortcomings of traditional teaching methods. In the classroom, student engagement has significantly increased;

students actively participate in project-based activities and gain a more intuitive and thorough understanding of abstract concepts. Most students successfully completed the project tasks and accurately described the basic workflow of supervised learning, thereby achieving the predetermined teaching objectives. From the learning process perspective, group collaboration has enhanced students' communication skills and team spirit, while project-based practice has strengthened their interest in and sense of identification with AI technology.

At the same time, the teaching practice has also revealed some areas for improvement. Some groups experienced slow project progress due to lack of operational proficiency, indicating that classroom time allocation still needs further optimization; there were variations in the quality of project completion across different groups, suggesting that the targeted nature of tiered guidance needs to be strengthened. In future teaching, project steps can be further refined, more detailed operational guidelines provided, and differentiated instruction implemented for students of varying proficiency levels to enhance the adaptability and effectiveness of teaching.

5 Conclusion

For general AI education targeting non-computer science majors, teaching should adhere to the principles of intuitiveness, practicality, and simplicity. The integration of the BOPPPS teaching model with project-based learning provides a viable instructional approach for foundational AI courses. This approach ensures teaching order through a rigorous classroom structure and enhances student engagement through real-world project tasks, effectively helping students grasp core AI knowledge while improving their practical skills and overall competence. In the future, project design and teaching processes can be further optimized, and more AI teaching cases suitable for general education can be developed to continuously improve teaching quality and help students enhance their digital literacy and innovative capabilities.

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