

Reforming a Deep Learning Course for Data Science Majors: Project-Based Teaching and Generative Artificial Intelligence in an Application-Oriented University

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Abstract: Deep learning courses are abstract in theory, long in engineering workflow, and fast in technological change. Organized in the conventional way of lectures, verification labs and a final exam, such a course rarely helps students build complete competence from problem definition to deployment. Project-based teaching is widely adopted, yet it often suffers from superficial tasks, thin process evidence, unclear boundaries for artificial intelligence (AI)-assisted work, and outcomes that are hard to accumulate. Taking the deep learning course for data science majors at Xi'an Eurasia University as the setting, this study brings generative AI into the instructional design and rebuilds the course along five lines: authentic project scenarios, rules for AI use, engineering workflow, learning evidence, and course resources. Projects are organized into four levels from reproducing basic models to transfer, real application and final presentation, each supported by evidence such as prompt records, AI use declarations, experiment logs, model cards and data cards. Several rounds of teaching suggest that students move into complex projects faster, instructors detect misunderstandings earlier, and academic integrity issues become checkable rather than judgemental. The approach offers a workable reference for reforming AI-related courses in the era of generative AI.

Keywords: Generative AI; Project-Based Teaching; Deep Learning Course; Curriculum Reform; Process Evaluation; Application-Oriented University

1. Introduction

1.1 Learning Breakdowns in Deep Learning

Courses

Artificial intelligence technology has moved from competition over individual algorithms to systems engineering in which data, models, computing power, deployment and governance develop together. For data science majors in application-oriented universities, a deep learning course must cover convolutional neural networks (CNN), recurrent neural networks, object detection and image segmentation, and must also enable students to complete a real AI project. Yet when classes remain centred on formula derivation, case demonstrations and verification labs, several typical breakdowns appear: students can run code but cannot explain why a model works; they can tune parameters but cannot interpret the results; they can submit assignments on time but cannot cope with a real problem.

1.2 New Problems Brought by Generative AI

Project-based teaching is widely regarded as a workable route to these problems, but introducing projects into a deep learning course does not automatically produce high-quality learning. In existing practice, the project is often treated as a final assignment, and classroom instruction, project progress, process evaluation and outcome accumulation remain disconnected. Since generative AI tools became widespread, students can obtain code, explanations and report text very quickly, and instructors face new questions: which steps may rely on AI? How should a student's real contribution be judged? How should thinking be evaluated?

1.3 Setting and Questions of This Study

The setting of this study is the deep learning course for data science majors. The course team brought generative AI into the instructional design and rearranged project tasks, rules for AI

use, the engineering workflow and learning evidence, in the hope of answering two questions: first, under the conditions created by generative AI, how should project-based teaching in a deep learning course be designed so that it genuinely supports competence development; second, how can the authenticity of learning evidence be ensured while students are encouraged to use AI?

2.Existing Research and Practice

2.1 Policy Requirements and Research on Project-Based Teaching

At the policy level the requirements are clear. The Ministry of Education's Action Plan for Artificial Intelligence Innovation in Higher Education calls for improving the talent-training and curriculum systems in the AI field [1], and the Implementation Opinions on Building First-Class Undergraduate Courses stress that courses should be advanced, innovative and challenging [2]. Both point in the same direction: AI-related courses need to move from knowledge transmission to competence generation, and from the classroom to real problem solving. Research on project-based learning (PBL) is relatively well established. Long-term reviews by overseas scholars show that complex projects with a driving question promote student engagement and deeper understanding [3,4], and the effects of active learning in engineering education are supported by fairly systematic evidence [5]. In China, Liu Jingfu and Zhong Zhixian gave an early account of the definition, components and procedures of PBL, providing a basic framework for local practice [6]. In AI-related courses, Raschka introduced hands-on research projects into a machine learning course, showing that projects support deeper knowledge processing [7]. More recently, Ma Yukun et al. proposed a research-oriented teaching model for a deep learning course, using research cases and academic competitions to drive student growth, with visible results; their focus, however, is mainly on course organisation and competition outcomes, and they say relatively little about how learning evidence is collected during a project or how authenticity is judged once AI is involved [8]. The author's earlier outcome-based education (OBE) reform in a machine learning course also confirmed that project-based teaching is feasible in application-oriented universities, but it did not consider the changes

brought by generative AI [9].

2.2 Research Progress on Generative AI in Education

Discussion has grown quickly since generative AI entered education. Some studies argue that such technology changes the basic form of teaching and learning, moving the pattern from a two-part structure of teacher and student to a three-part structure of teacher, machine and student [10]; others describe the relationship between generative AI and future educational forms in terms of technical framework, capability features and application trends [11], and analyse systematically the value, difficulties and strategies of the resulting educational change [12] as well as the path by which it reshapes higher education [13]. At the level of learning design, studies have set out the goals and operational steps of generative-AI-supported learning design [14] and examined its mechanism in cultivating interdisciplinary creative thinking [15]. At the same time, general large models in education may aggravate ethical risks concerning privacy, teacher-student relationships and educational equity, which need to be avoided at the levels of production, practice, management and research [16], and educational models need to move from simple tool use to human-machine collaboration [17]. At the operational level, Mollick et al. proposed assigning AI seven roles such as tutor, coach, teammate, tool and student, so that using AI becomes a learning task in itself [18].

2.3 Gaps in Existing Research and the Position of This Study

Taken together, research on project-based teaching has a solid foundation and discussion of generative AI in education is already lively, but the combination of the two in deep learning courses remains thin. Specifically, there is a lack of progressive project-task design for such a course; AI is mostly used as an out-of-class tool, and its interaction process is rarely brought into the course evidence system; and no workable link has been formed between process evaluation and the safeguarding of academic integrity under AI conditions. This paper attempts to do some concrete work on these three points, placing AI use, project progress, engineering training and evidence collection within a single course arrangement.

3. Design Rationale of the Course Reform

3.1 Five Interrelated Design Dimensions

The starting point of the reform is to make AI use, project-task progress, engineering-workflow training and evidence collection work together within one arrangement rather than being stacked on top of each other. The course team

summarised this idea into five interrelated dimensions: authentic project scenarios, explicit rules for AI use, a complete engineering workflow, checkable learning evidence, and continuous accumulation of course resources. Table 1 lists the design focus and the concrete measures for each dimension.

Table 1. Design Framework of Project-Based Teaching in the Deep Learning Course

Dimension	Design focus	Concrete measures in the course	Problem addressed
Project scenarios	Organising learning tasks around real business or social problems	Road defect detection, safety helmet detection, crop disease classification, pedestrian counting, preliminary medical image classification, etc.	Projects no longer stay with toy data and verification labs
Rules for AI use	Using AI for explanation, retrieval, debugging and reflection, not for producing outcomes directly	Assignments on prompt records, critique of AI answers, code explanation, error troubleshooting and result checking	AI use becomes a reviewable learning record
Engineering workflow	Connecting data, model, training, evaluation, deployment and presentation	Submitting data notes, training logs, metric analysis, visual results and a demonstration prototype, and taking part in a defence	Training the ability to complete an end-to-end AI project
Learning evidence	Judging a student's real contribution from multiple sources	Code commits, experiment logs, model cards, data cards, peer review, instructor questioning and project presentation used together	Making assessment more credible and responding to AI ghost-writing
Course resources	Using this round's outcomes in the next round	Case library, problem library, project templates, a list of common errors and good work	Course development accumulates instead of starting over

3.2 Four Levels of Project Tasks

Alongside these five dimensions, course projects are divided into four levels of increasing demand. The most basic level is reproducing basic models, where students must understand convolution, pooling, activation functions, loss functions and backpropagation, and observe them visually on a basic network. The second level is transfer and modification, where students change the dataset or adjust the network structure on top of an existing model and compare the metrics of different options. The third is real application, where students define a problem for a concrete scenario, process data, train a model and interpret the results. The last is final presentation, where the complete project is presented through a report, a poster, a demonstration system and a defence. The four levels do not proceed in a simple linear order; if a student reveals a gap in understanding at one level, the instructor arranges to revisit it at a later one.

3.3 Course Content and Research Materials

The course covers modules on neural network fundamentals, convolutional neural networks, recurrent neural networks, object detection, image segmentation and comprehensive project

presentation. The study follows an action research approach based on successive rounds of teaching, and its materials include the course syllabus, the teaching calendar, classroom task sheets, student project reports, project posters, code, defence records and the instructor's reflective notes. The concern is not how many marks a particular tool added, but whether the course structure genuinely supports competence development; the analysis therefore relies on the mutual corroboration of process materials.

4. How Generative AI is Used in the Course

4.1 Permitted and Prohibited Uses

The course does not prohibit the use of generative AI; instead it makes the scope of use explicit. Permitted uses include clarifying concepts, suggesting search leads, explaining code errors, comparing experimental plans and polishing report language. Prohibited practices include submitting AI-generated code without understanding or verifying it, fabricating experimental results, and having AI write the core analysis and conclusions. In the project report, students must submit an AI use declaration stating which tools were used, the

main prompts, which content was adopted, how it was verified, and which content was rejected and why. This arrangement draws on the idea of assigning AI specific roles and tasks [18]; its purpose is to let AI explain and assist while leaving judgement and decision-making to the students.

4.2 Making AI Use Traceable

Once these requirements enter the course, AI use

changes from an invisible behaviour into a visible step. Instructors no longer have to worry about whether a report “looks student-written”; instead they judge whether a student really understands the project through prompts, revision traces, code explanations and follow-up questions at the defence. Table 2 shows where AI may step in at each project level, which tasks students must complete themselves, and the corresponding assessment evidence.

Table 2. Scope of AI Use and Assessment Evidence at Different Project Levels

Project level	Typical task	Steps AI may join	Tasks students must complete	Assessment evidence
Reproducing basic models	Visualising convolution and pooling; basic CNN classification	Concept explanation, code error explanation, clarifying parameter meaning	Explaining intermediate feature maps and loss changes by hand	Classroom task sheets, code comments, oral questioning
Transfer and modification	Changing the dataset to complete image or text classification	Suggestions for data augmentation, comparison of model structures	Deciding which option to adopt and explaining the trade-off	Experiment logs, metric comparisons, analysis of error samples
Real application	Road defect detection, safety helmet detection, crop disease classification, etc.	Literature search, advice on annotation standards, discussion of deployment	Data processing, model training and interpretation of the scenario	Data cards, model cards, demonstration prototype, defence
Final presentation	Course report, project poster, project presentation	Language polishing, structural suggestions, chart improvement	Forming one's own analysis, reflecting on limitations and proposing improvements	Report, poster, AI use declaration, peer review

4.3 AI Boundaries in the Engineering Workflow

Training in the engineering workflow is the other main thread of the course. The difficulty of a deep learning course lies not only in the algorithms themselves but in whether students understand the steps a project must go through from beginning to end. The course breaks each project into problem definition, data collection and cleaning, data augmentation, model selection, training and tuning, metric evaluation, error analysis, visual explanation, lightweight deployment, and presentation and defence. In an object detection project, for example, training a YOLO (You Only Look Once) model is only the first step: students must also explain the quality of the annotations, whether the classes are balanced, on which samples missed and false detections occur, why the confidence threshold was set that way, and what constraints the chosen scenario places on the model. Such content cannot be covered by polished wording in a report; students must have actually looked at the data and run the experiments to speak about it.

5. Implementation of Teaching

5.1 Before Class: Project Scenarios and Initial Plans

Before class, the instructor releases the project scenario, learning resources and rules for AI use, and students propose an initial plan for a real problem. Any student who uses AI during preparation must submit a record containing four parts: the question, the prompts, the AI answer and human judgement. This record helps the instructor understand each student's starting point, and it also makes students lay out the basis of their own judgement before starting work, which makes classroom discussion more targeted.

5.2 In Class: Project Progress and On-The-Spot Questioning

Class time is centred on project progress. The instructor gives focused explanations only for key concepts and common difficulties, and spends the rest of the time on code diagnosis, error analysis and group presentations. When AI-generated content appears, the instructor usually asks the student to explain the key code on the spot, reproduce the experimental steps and answer follow-up questions. In practice, on-the-spot explanation is more binding than

checking reports afterwards; the shift from “getting the answer” to “understanding the answer” often happens in those few minutes of questioning.

5.3 After Class: Outcomes and Accumulated Resources

After class, students complete the project report, model cards, data cards and a project poster, and take part in peer review and presentation. The instructor, for their part, organises good work, typical errors, usable prompt cases and failed experiments into teaching resources for the next round. Over several semesters these materials have accumulated into the course’s own case library and error library; new students can consult previous experience when they get stuck, and the instructor can adjust classroom priorities accordingly.

6.Observations and Discussion

6.1 Changes Reflected in Process Materials

Across several rounds of teaching, once generative AI entered the course students moved into complex projects faster, and the thresholds for environment configuration, code errors, concept lookup and plan comparison dropped noticeably. The prompt records and AI use declarations also proved useful: instructors detected misunderstandings earlier, and the differences revealed in defence questioning often showed a student’s real level better than the report text. It should be noted that with tools but without boundary rules and evidence requirements, AI can equally produce a project that looks finished while understanding lags behind; this did occur in the early rounds.

6.2 Three Differences from Previous Project-Based Teaching

Compared with earlier project-based teaching, this reform differs in three ways.

6.2.1 Writing AI use into the course design

The first is that AI use is written into the course design and becomes a traceable learning process rather than a free activity outside class.

6.2.2 Moving from algorithm demonstrations to a full engineering workflow

The second is that projects move from algorithm demonstrations to a complete engineering workflow, in which data, model, deployment and interpretation must all pass; getting a network to run is not enough to complete a project.

6.2.3 Responding to academic integrity with multi-source evidence

The third is the use of multi-source evidence to address questions of academic integrity and real contribution, so that assessment no longer depends only on the final report.

6.3 Problems Not Yet Well Solved

Several problems remain. First, quantitative data are insufficient: changes in study input, code quality, defence performance and competence attainment across project stages have not been measured systematically, and current judgements rest mainly on qualitative analysis of process materials. Second, the quality of AI use declarations and prompt records varies; some students fill them in as if they were forms, and how to make the record both not overly burdensome and reflective of the real process still needs further design. Third, project scenarios still rely mostly on the course’s own data, with relatively few real industry datasets and enterprise constraints, so there is room to raise the openness and challenge of the tasks.

7.Conclusion

7.1 Main Conclusions

Once generative AI enters the classroom, the key to reforming a deep learning course is not to add more tools or more projects but to rearrange the learning structure of the course. The approach reported here considers project-based teaching, AI-assisted learning, engineering training and process evaluation together, and is reasonably workable in an AI-related course at an application-oriented university. The course is organised around solving real problems rather than lecturing; assessment looks at process evidence rather than results alone; and course development shifts from a one-off implementation to accumulation over several rounds.

7.2 Future Work

There are two directions for further work. The first is to add learning-analytics data and cross-round comparisons so that the effects of the course design can be tested more systematically. The second is to keep refining the standards for AI use declarations and prompt records so that they reduce the burden on students while still reflecting the learning process truthfully. How to bring industry data and real constraints into the

classroom more reliably is also a focus for the next round of reform.

Funding

Shaanxi Province Education Science 14th Five-Year Plan 2024 project "Research on teaching reform of the machine learning course based on industry-education integration under the background of new engineering" (No. SGH24Y2632); Project of Computer Education Society (2026): "Exploration and Practice of Project-based Teaching in Deep Learning Courses" (No. SJJG-26-07)

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