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A Practical Framework for Generative Artificial Intelligence Empowering Vocational Education: A Case Study of the Automobile Inspection and Maintenance Major

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Abstract

The application of generative artificial intelligence in vocational education is becoming increasingly widespread, yet current practices largely remain at the level of "tool substitution," lacking clear and actionable teaching guidelines. Grounded in the concept of "human-AI collaboration," this paper constructs a practical framework for generative AI empowering vocational education, systematically designed across five dimensions: objectives, roles, processes, resources, and evaluation. Using the automobile inspection and maintenance major as an example, it elaborates on the key implementation points for each dimension and puts forward promotion recommendations at the teacher and school levels, along with risk prevention measures. The framework aims to restructure the division of labor and collaborative relationships among teachers, students, and AI, thereby cultivating students' abilities to harness intelligent tools and their critical thinking skills. The research findings provide directly applicable operational guidelines for frontline teachers and administrators in vocational colleges.

Keywords

Generative Artificial Intelligence; Vocational Education; Human-AI Collaboration; Practical Framework; Automobile Inspection and Maintenance Major

1. Introduction

In recent years, generative artificial intelligence (GenAI), exemplified by ChatGPT, has gradually entered the field of vocational education, with a growing number of vocational colleges experimenting with such tools in teaching. However, current practices largely remain at the level of "tool substitution," and no substantial changes have occurred in teaching philosophies, classroom structures, or

teacher-student roles. Meanwhile, teachers commonly face anxiety over "skill replacement," students tend to develop technological dependency, and the learning process becomes increasingly superficial; AI-generated content also entails risks such as factual errors and algorithmic bias. More critically, there is a lack of a clear and operational teaching guide for human-AI division of labor and collaboration. The concept of "human-AI collaboration" offers a new perspective, emphasizing the division of labor and complementary strengths among teachers, students, and AI: AI handles plan generation and batch data processing, teachers focus on task design and value guidance, and students engage in critical evaluation and reflective improvement. This paradigm holds the potential to drive profound transformations in vocational education teaching models. Building on this, this paper addresses two practical questions: How to design human-AI collaborative teaching? What specific implementation steps and precautions does it involve? The paper constructs a practical framework across five dimensions−objectives, roles, processes, resources, and evaluation−and illustrates it with examples from professional scenarios, aiming to provide operational references for frontline teachers and administrators.

2. The Connotation and Value of Human-AI Collaborative Teaching

2.1. Definition of the Connotation

Human-AI collaborative teaching refers to a new teaching model in which teachers, students, and artificial intelligence systems form a partnership characterized by division of labor, collaboration, and complementary strengths to jointly accomplish teaching tasks. Its core is neither to replace teachers with AI nor to encourage students to rely on technology, but rather to reconstruct the traditional binary interaction structure of “teacher-student” and establish a dynamic teaching relationship of “teacher-AI-student” ternary collaboration.

To understand human-AI collaborative teaching, three key points must be distinguished. First, it is not about AI replacing teachers, but about humans and AI each performing their respective roles. AI excels at processing large-scale data, rapidly generating plans, and conducting repetitive simulation training, while teachers focus on task design, value guidance, emotional support, and guidance on complex problems. Second, it is not about students relying on AI, but about students harnessing AI. Students need to proactively pose questions, critically evaluate AI-generated content, and reflect on their own learning process, rather than passively accepting answers provided by machines. Third, it is not about technology superposition, but about role restructuring. Human-AI collaboration does not mean simply adding AI tools to traditional teaching; instead, it requires systematic adjustments in teaching objectives, teacher-student roles, implementation processes, resource development, and evaluation methods.

To facilitate understanding, an analogy from the vocational education context can be

drawn: the master mechanic and the diagnostic tool in automobile repair. The diagnostic tool can quickly read fault codes and provide possible causes of a malfunction, which represents the typical tasks of AI; whereas the final judgment of which cause is most likely, how to carry out the repair, and how to handle abnormal situations that the diagnostic tool cannot identify still relies on the experience and judgment of the master mechanic—this is precisely the role that teachers and students should assume. In this analogy, the diagnostic tool does not replace the master mechanic but rather enhances the mechanic's work effectiveness. Similarly, human-AI collaborative teaching aims to enhance rather than replace the subjective position of humans.

2.2. The Necessity of Introducing Human-AI Collaborative Teaching in Vocational Education

Human-AI collaborative teaching is a systematic solution that responds to the practical challenges of vocational education and adapts to the demands of industrial transformation. Its necessity is mainly reflected in the following three aspects.

First, it addresses the difficulties of traditional teaching. Taking the automobile inspection and maintenance major as an example, practical training projects such as engine disassembly/assembly and high-voltage system inspection involve high risks and equipment wear, while traditional simulation training lacks interactive feedback. Under the human-AI collaboration paradigm, AI can construct virtual training environments and act as an intelligent coach, offering real-time correction and early warnings, thereby achieving an upgrade from mere process simulation to intelligent coaching. Simultaneously, AI can analyze learning data, build personalized learning pathways, and support multimodal process evaluation—such as tracking operation trajectories and voice interactions.

Second, it responds to the demands of industrial upgrading. The talent requirements in the automobile repair industry have shifted from single operational skills to the ability to collaborate with intelligent diagnostic systems and harness smart tools to resolve complex faults. Vocational education must incorporate human-AI collaboration literacy into its training objectives, enabling students to clearly articulate tasks to AI, critically assess its outputs, and appropriately allocate the division of labor between humans and AI.

Third, it alleviates the practical dilemmas faced by both teachers and students. Teachers confront skill replacement anxiety, while students are prone to over-relying on AI, leading to superficial cognitive processing. Human-AI collaboration frees teachers from repetitive tasks such as resource retrieval and routine question answering, allowing them to concentrate on value guidance and complex instruction. Meanwhile, students cultivate critical thinking through proactive questioning, critical examination of AI outputs, and reflective improvement, thereby avoiding the trap of becoming passive recipients.

3. Practical Framework for Human-AI Collaborative Teaching

The core of generative artificial intelligence empowering vocational education lies in constructing a human-AI collaborative teaching framework. This framework encompasses five dimensions: objectives, roles, processes, resources, and evaluation. The following section elaborates on these dimensions using the automobile inspection and maintenance major as an example.

3.1. Objective Collaboration: Integrating Human-AI Collaboration Competencies

Traditional teaching objectives focus on the mastery of professional knowledge and specialized skills. Human-AI collaborative teaching must, on this basis, incorporate human-AI collaboration competencies, which specifically include three abilities.

First, prompting ability, which refers to expressing task requirements and constraints to AI clearly and accurately. In the context of automobile inspection and maintenance, the quality of prompts directly determines the effectiveness of the AI-generated fault diagnosis plan. Second, critical evaluation ability, which involves scrutinizing and judging the accuracy, safety, and cost-effectiveness of fault causes, repair procedures, or parts recommendations generated by AI. Third, division of labor and collaboration ability, which means reasonably allocating—based on fault symptoms—which diagnostic steps are to be completed by AI and which are to be independently judged by maintenance personnel, so as to maximize maintenance efficiency.

Taking the fault of a car engine failing to start as an example, students should not only learn to use AI to generate a possible list of fault causes, but also identify any logical flaws in the proposed solutions or inconsistencies with actual working conditions, and then make corrections based on circuit diagrams and measurement data. This process aims to train students' ability to harness intelligent diagnostic tools, rather than simply accepting the AI's output.

3.2. Role Collaboration: The Iteration of Teacher and Student Roles

The teacher's role shifts from that of a traditional knowledge transmitter to a co-designer and value guide. As a co-designer, teachers need to design task sheets for human-AI division of labor, develop prompt templates to guide students in using the AI diagnostic system for automobile inspection and maintenance, and plan the rules for practical training activities involving human-AI collaboration. As a value guide, teachers focus on areas that are difficult for machines to replace, such as repair ethics, safety regulations, and troubleshooting strategies for complex faults. Teachers are no longer the sole source of repair knowledge, but rather the organizer and facilitator of the practical training process.

The student's role shifts from that of a passive knowledge receiver to an active

harnesser of AI and a reflective practitioner. As an active harnesser, students must use AI diagnostic tools strategically according to specific fault types, avoiding blind reliance. As a reflective practitioner, students need to continuously evaluate the effectiveness of their collaboration with AI, adjust troubleshooting strategies, and summarize repair experiences.

In an automobile inspection and maintenance practical training course, teachers can design the following task: Use an AI diagnostic system to inspect a simulated faulty vehicle; the system generates three sets of possible fault causes and repair plans; students discuss in groups to select the most likely cause and formulate verification steps; finally, they verify through actual operation and submit a repair report. Students need to provide clear inspection instructions to the AI to obtain diagnostic results, and then critically evaluate the rationality of each plan through group discussion. During this process, the teacher is responsible for designing the task framework, guiding the diagnostic thinking, and commenting on students' collaborative performance.

3.3. Process Collaboration: A Three-Stage, Six-Step Teaching Model

To make human-AI collaborative teaching operable, this paper constructs a standardized implementation pathway consisting of three stages and six steps.

The first stage is the preparation stage, which includes two steps. Step 1: Task analysis and identification of AI division points. The teacher analyzes the inspection and maintenance training tasks and determines which sub-tasks are suitable for AI to complete, such as fault code reading, maintenance data retrieval, and initial diagnostic plan generation. Step 2: Design of prompts and scaffolding. The teacher provides students with effective question templates, for example, "Based on the engine fault code P0301, list the possible fault causes and sort them by probability," thereby lowering the operational threshold for students to use the AI diagnostic system.

The second stage is the implementation stage, which includes two steps. Step 3: AI-assisted exploration and generation. Students use the AI system according to the prompts designed by the teacher to obtain fault diagnosis plans or maintenance procedure suggestions. Step 4: Human-led critique and refinement. Teachers and students jointly examine the diagnostic plans output by AI, discussing whether the logic is complete, whether any inspection items are missing, and whether there are safety hazards, and then manually revise and improve them. This step completes a cognitive cycle from generation to critique to reconstruction, and it is a key link in preventing students from blindly following AI diagnostic results.

The third stage is the sublimation stage, which includes two steps. Step 5: Process evaluation. AI automatically collects data such as students' diagnostic operation trajectories, time spent, number of errors, and interaction records with the system, and the teacher provides qualitative comments based on these data. Step 6:

Reflection and transfer. Students summarize the successful experiences and deficiencies of this human-AI collaboration, and plan how to transfer the collaboration strategy to other vehicle models or more complex fault situations.

3.4. Resource Collaboration: A Ternary Integration Model of Generation, Optimization, and Verification

Traditional teaching resource development is characterized by long cycles and lagging updates, making it difficult to keep pace with the rapid iteration of technologies in automobile inspection and maintenance. Human-AI collaborative teaching adopts a dynamic generation model, which integrates the three links of AI generation, teacher optimization, and industry verification.

The first link is AI generation. Generative AI is used to rapidly produce course resource prototypes based on the latest automobile maintenance technical materials, repair manuals, and real fault cases, such as loose-leaf fault case libraries, diagnostic flowcharts, and initial drafts of training instruction manuals. The second link is teacher optimization. Professional teachers conduct in-depth processing and modification of the AI-generated resources from the perspectives of educational suitability, accuracy, and standardization, ensuring that they conform to teaching principles and curriculum standards. The third link is industry verification. The optimized resources are pushed to partner repair enterprises or industry technical experts to confirm their alignment with actual inspection and maintenance scenarios and their cutting-edge nature. Further revisions are then made based on the feedback, forming a closed-loop iterative mechanism.

Taking the high-voltage system inspection and maintenance module for new energy vehicles as an example, AI can generate typical fault cases and diagnostic steps based on the latest technical bulletins; professional teachers adjust the difficulty gradient of the cases and safety prompts according to students' cognitive patterns; and the technical director of a partner 4S dealership then confirms the practical feasibility and compliance of the diagnostic process. This model ensures that teaching content stays synchronized with the technological development at the forefront of the industry.

3.5. Evaluation Collaboration: Integrating Process Data with Multiple Stakeholders

Traditional evaluation emphasizes outcomes and relies on a single evaluator, whereas human-AI collaborative teaching highlights the organic integration of process data and multi-stakeholder evaluation.

Specifically, it encompasses three types of evaluation methods. The first is AI-based rubric evaluation. Drawing on multimodal data generated during students' practical training—such as diagnostic operation trajectories, the sequence of using testing equipment, fault code interpretation records, and the frequency and quality

of interactions with the AI system—it automatically and processually assesses quantifiable skill operations and knowledge mastery. The second is teachers' qualitative evaluation. It focuses on students' higher-order competencies that are difficult to quantify, including fault analysis logic, safety regulation awareness, teamwork spirit, and innovative problem-solving strategies, offering descriptive feedback and suggestions for improvement. The third is student self-evaluation and peer evaluation, guiding students to reflect on their own performance in human-AI collaboration and to share successful troubleshooting experiences and lessons drawn from failures.

The above three types of evaluation results together form a digital competency portrait of the student, supporting personalized feedback and continuous improvement. In the practical training of automobile engine fault detection and maintenance, AI can automatically record the sequence in which students read fault codes, the steps of data stream analysis, and the accuracy of final diagnostic conclusions, thereby generating a skill mastery curve. Teachers can then comment on students' logical reasoning abilities and standardized tool use based on the curve data, while students compare self-evaluations with peer evaluations to identify weak areas that need strengthening in the next step, such as specific sensor detection methods or circuit diagram reading skills.

4. Implementation Suggestions and Risk Prevention

The effective implementation of human-AI collaborative teaching relies not only on the five-dimensional framework described above but also on supporting implementation strategies and risk prevention and control mechanisms. The following specific suggestions are proposed from three perspectives: the teacher level, the school level, and risk prevention.

4.1. Implementation Suggestions at the Teacher Level

When carrying out human-AI collaborative teaching, teachers are advised to start with a single practical training module or teaching unit and gradually expand the scope of application. For example, in an automobile engine fault diagnosis course, teachers may first have AI assist in generating troubleshooting pathways for three different sets of fault causes, on the basis of which students conduct verification and revision. Once sufficient experience has been accumulated, this approach can then be extended to more teaching segments.

Improving prompt design capability is a key factor affecting the effectiveness of human-AI collaborative teaching. Teachers should learn and practice the basic structure of prompts, including clarifying task objectives, providing background information, and setting output formats and constraints. Schools may organize thematic workshops to conduct prompt design training tailored to professional scenarios such as automobile inspection and maintenance.

In human-AI collaborative teaching, the teacher’s core task is not to evaluate whether AI-generated outputs are right or wrong, but to guide students in examining their rationality, completeness, and limitations. Teachers should design dedicated discussion sessions—for example, "Which inspection items are missing from the AI’s diagnostic plan?" and "Which step in the plan poses a safety hazard?"—so as to cultivate students' critical thinking skills.

4.2. Implementation Suggestions at the School Level

Schools should establish a fault-tolerance and incentive mechanism. Human-AI collaborative teaching is still in the exploratory stage, and teachers are bound to encounter failures or unsatisfactory results in practice. Schools should allow teachers to experiment with different approaches without disrupting the normal teaching order, while also setting up special school-level teaching reform projects to provide resource support and achievement recognition for those conducting human-AI collaborative teaching pilots.

Promoting school-enterprise cooperation in resource development is equally indispensable. The teaching resources required for human-AI collaborative teaching—such as real fault cases, the latest maintenance data, and industrial technical standards—are difficult for schools to obtain on their own. Schools should therefore proactively establish cooperative relationships with automobile repair enterprises, 4S dealerships, and equipment suppliers to jointly build a teaching resource library of "AI + Automobile Inspection and Maintenance," ensuring that the resources remain cutting-edge and authentic.

Schools should also design stratified and classified training content tailored to teachers with different levels of technical proficiency. For beginners, the focus should be on the basic operation of AI tools and an understanding of relevant teaching scenarios; for more experienced teachers, the emphasis should shift to advanced topics such as prompt engineering, human-AI collaborative teaching design, and process-based evaluation methods. The training should adopt a "learning by doing" approach, enabling teachers to complete the design and implementation of a small human-AI collaborative teaching unit through hands-on practice.

4.3. Key Points for Risk Prevention

Preventing students from over-relying on artificial intelligence is a concern that must be addressed in human-AI collaborative teaching. Teachers should explicitly require students, in the task design, to label the parts generated by AI and attach their own modifications and supplementary explanations. Meanwhile, a "critical contribution" indicator should be established in the evaluation system to encourage students to question and improve upon AI outputs.

Safeguarding data privacy and security is equally important. When using public AI

platforms, students may input queries containing personally identifiable information or sensitive school data. Schools should formulate clear usage regulations, prohibiting students from uploading information that can identify individuals, internal school documents, or undisclosed technical materials. For practical training tasks involving real vehicle identification numbers, customer information, and other such content, locally deployed or data-desensitized AI systems should be used.

The security review of AI-generated content should not be overlooked. Before teachers adopt AI-generated lesson plans, cases, or test questions, they should conduct item-by-item reviews; for assignments submitted by students that contain AI-assisted content, teachers should focus on examining their safety and compliance to prevent factual errors, value orientation deviations, or prohibited content from entering the teaching process.

Clarifying the boundaries of responsibility between humans and AI is crucial for ensuring practical training safety. If an AI-generated diagnostic plan contains errors that teachers and students fail to identify in a timely manner, it may lead to training accidents or equipment damage. Schools should clarify the responsibilities of all parties before commencing human-AI collaborative teaching: AI provides auxiliary reference, while the final decision-making authority and operational responsibility rest with the teacher and students. Teachers should set manual checkpoints at critical steps, for example, requiring students to verbally confirm key safety measures before actual disassembly or assembly.

5. Conclusion and Outlook

Grounded in the concept of "human-AI collaboration," this paper constructs a practical framework for generative artificial intelligence empowering vocational education across five dimensions—objectives, roles, processes, resources, and evaluation—and illustrates it using the automobile inspection and maintenance major as an example. The framework restructures the division of labor and collaborative relationship among teachers, students, and AI: AI handles data processing and plan generation, teachers focus on task design and value guidance, and students develop higher-order competencies through critical evaluation. Human-AI collaborative teaching requires teachers to enhance their prompt design capabilities, schools to establish fault-tolerance mechanisms and promote school-enterprise cooperation, while guarding against risks such as student over-reliance, data privacy, and responsibility boundaries. Future research should conduct empirical tests across different majors, develop vertical domain large models, implement longitudinal tracking studies, and design evaluation indicator systems, so as to promote the normalization of human-AI collaborative teaching practices.

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