

# Practical Path of “Three-Dimensional, Four-Drive” Integrated Teaching Reform under Digital-Intelligence Integration

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**Abstract:** The deep integration of digitalization and intelligence presents unprecedented challenges to traditional teaching models. To address common issues such as fragmented knowledge systems, weak practical links, insufficient personalized cultivation, and single evaluation mode, this study constructs a systematic reform framework of “concept–technology empowerment–mechanism innovation” based on the concept of digital-intelligence integration and vocational-undergraduate collaborative education. It proposes a four-dimensional implementation path: “driven by dynamic knowledge graphs, by project-flow simulation, supported by AI–human collaborative teaching, and guaranteed by an integrated practical teaching system.” The research specifically focuses on the construction of a higher vocational-undergraduate integrated practical teaching system, forming a progressive practical teaching closed loop of “basic skill training–comprehensive ability cultivation–innovative ability stimulation” through the construction of a cross-stage, cross-disciplinary, virtual-real combined practical platform. The results show that this system can effectively promote the transformation of theoretical knowledge into practical ability and enhance students’ comprehensive literacy and innovative spirit, providing a replicable systematic solution for higher education teaching reform under higher vocational-undergraduate cooperation.

**Keywords:** Digital-intelligence integration; Teaching reform; Dynamic knowledge graph; Project-flow simulation; AI collaboration; Higher vocational-undergraduate cooperation; Integrated practical teaching system

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## 1. Introduction

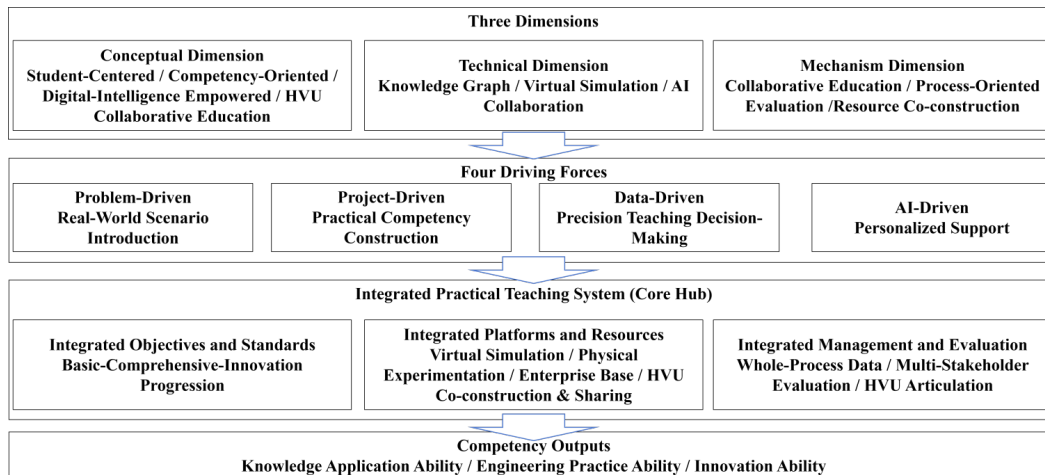
The fundamental mission of higher education is to cultivate high-quality talents who can adapt to the times

and possess an innovative spirit and practical ability. However, examining the current teaching situation in universities, there are still widespread structural contradictions: in teaching content, knowledge delivery often presents fragmented, isolated characteristics, with a lack of effective connection and integration between courses, making it difficult for students to build a systematic and complete knowledge system; in teaching methods, spoon-feeding theoretical instruction still dominates, and practical links are often weakened into verification-based, isolated experiments, detached from real, complex engineering or social problems, resulting in insufficient cultivation of students' ability to solve practical problems; in teaching evaluation, there is an over-reliance on summative exam results, neglecting the evaluation of the learning process, ability development, and comprehensive quality, failing to fully realize the diagnostic, motivational, and developmental functions of evaluation; in teaching organization, barriers exist between different grades, different disciplines, higher vocational and undergraduate institutions, and between schools and enterprises, hindering the mechanism of collaborative education and constraining the coherence and integrity of talent cultivation. The existence of these problems leads to a deviation between the quality of talent cultivation and the needs of economic and social development <sup>[1-3]</sup>.

The vigorous development of digital-intelligent technologies such as artificial intelligence, big data, and virtual reality provides new possibilities for solving the above-mentioned dilemmas <sup>[4]</sup>. Technology is no longer merely an auxiliary teaching tool but should become the core driving force for reshaping the education ecosystem and promoting profound changes in teaching models. The deep integration of digital-intelligent technology with education and teaching, and the systematic reconstruction of teaching concepts, content, methods, and evaluation, have become an inevitable trend in higher education reform. Higher vocational-undergraduate cooperation is highly compatible with digital-intelligence integration. Based on this, this study proposes and explores a systematic reform path with “digital-intelligence integration” as the core concept, supported by higher vocational-undergraduate cooperation, and utilizes the “three-dimensional, four-drive” framework, with a particular emphasis on constructing an “integrated practical teaching system.” It aims to provide a set of universal and operable methodologies and practical guidelines for higher vocational-undergraduate cooperative education, as well as current and future higher education teaching reform <sup>[5]</sup>.

## **2. Conceptual remodeling: The logical framework of teaching reform driven by digital-intelligence integration**

Conceptual innovation is first and foremost behind the success of the teaching reform. This study introduces the three-dimensional, four-drive model (**Figure 1**), which uses digital-intelligence integration as the basis of its approach, and combines the undergraduate collaboration of higher vocational education in order to overcome the use of technology as an instrument and realize the ecological integration of technology and education, creating a synergy that can bring about a systematic change in teaching.



**Figure 1.** “Three-dimensional, four-drive” framework

Conceptual dimension is the soul of the reform. Its essence is the creation of a new educational approach based upon the idea of student development, competency output, digital-intelligence empowerment, and higher vocational-undergraduate cooperation. It implies that the purpose of teaching must change from the conventional dissemination of knowledge to the development of the higher-order abilities of the students, including critical thinking, complex problem-solving abilities, and innovative collaboration. The teaching process must be changed to the teacher unilaterally giving instructions to students actively inquiring, constructing collaboratively, and creating practically with the support of the digital intelligent environment. Assessing teaching should not be based on the static assessment of the results of learning but on the dynamic observation, multidimensional assessment, and developmental coaching of the learning process [6].

The technical dimension is what drives reforms. It is not a separate stack of technologies. On the contrary, it utilizes such a dynamic knowledge graph as the background system to arrange and present knowledge, project-flow simulation as such a bridge between theory and practice, and AI–human collaborative teaching as the central form of personalized learning assistance and smart assessment. They are organically intertwined in order to create together an intelligent, adaptive, virtual-real combined teaching environment. In this case, technology is deeply embedded in the overall teaching chain and has become one of the main forces in the reengineering of teaching processes [7].

The dimension of the mechanism is the assurance of reform. The focus here is on the means of breaking down barriers to organizations and creating a sustainable teaching and learning environment. It involves creation of interdepartmental collaborative education systems (e.g., Administrative Office of Academic Affairs, Information Center, faculties), interdepartmental (e.g., universities, enterprises, research institutions) and interstage (e.g., higher vocational schools and universities) systems of education; development of innovative incentive guarantee mechanisms in the areas of resource allocation, performance evaluation and achievement recognition; and enhancement of dynamic monitoring and continuous improvement systems of teaching quality with the help of information on the entire process [8].

The underlying concept behind the three-dimensional framework is the four-drive power model that triggers the process of the continuous teaching innovation: problem-driven power model that helps in developing endogenous motivation of learning by involving real world complex problems in the classroom; project-driven power model that allows integrating discrete knowledge and acquire ability construction in

solving composite tasks; data-driven power model that makes it possible to precisely teach by optimizing paths and strategies based on learning behavior data; and AI-driven power model that offers personalized support, increasing the scope and depth of the teaching. These four driving forces act together and work synergistically so as to enable higher vocational-undergraduate cooperative talent training, both of them pushing teaching to change its focus on standardization and scale towards personalization and precision <sup>[9]</sup>.

### **3. Path I: Reconstruction of knowledge system based on dynamic knowledge graph**

The basis of ability cultivation is knowledge. The conventional linear arrangement of knowledge as per the textbook chapters is unable to capture the underlying networked nature of knowledge pieces and their structure among them, and it provides poor navigation for individualized learning. The path to reconstructing the knowledge system based on a dynamic knowledge graph aims to make implicit, discrete knowledge explicit and systematic.

The implementation of this path involves three major steps. The first step is domain knowledge modeling and graph construction. Technologies such as natural language processing and data mining are used to conduct in-depth analysis of curriculum standards, authoritative textbooks, academic literature, and classic cases in a subject field, automatically or semi-automatically extracting core concepts, principles, methods, and techniques as “entities,” and identifying and defining semantic relationships between entities (e.g., “prerequisite relationship,” “inclusion relationship,” “application relationship,” “contrast relationship”), forming an initial static knowledge graph. This step transforms subject knowledge from a flat list into a three-dimensional, interconnected network <sup>[10]</sup>.

The second step is the integration of knowledge, ability, and resources. Knowledge itself is not the goal; cultivating ability is key. Therefore, it is necessary to establish mapping relationships between knowledge entities and various ability indicators in the training objectives (e.g., analytical and computational ability, system design ability, communication and collaboration ability). At the same time, rich teaching resources (such as micro-lecture videos, teaching courseware, academic papers, exercise banks, project cases, simulation software, etc.) are intelligently associated and tagged with corresponding nodes in the knowledge graph. Thus, a three-in-one dynamic knowledge network of “knowledge node–ability requirement–learning resource” is constructed. When a student clicks on a knowledge point, the system can not only display its definition and attributes but also reveal its position in the entire knowledge system, its connections with other knowledge points, the ability goals it supports, and intelligently recommend related learning resources <sup>[5]</sup>.

Dynamic updating and personalized navigation is the third step. Knowledge graph is an active concept, not passive. It is manifested in two aspects: Firstly, content refreshment as the subject evolves and pedagogical feedback is obtained, additional knowledge points and connections may be constantly added and improved. Secondly, state refreshment the system keeps collecting and analyzing the learning behavior data of students (including online learning time, sequence of resource clicks, test accuracy rate, participation in discussion forums, project engagement, etc.) and evaluates in real time how well each student has mastered every knowledge node (e.g., not learned, learning, mastered, having difficulty) and it is presented visually (e.g., color depth, size of nodes) in the personal knowledge graph. This allows the system to use graph algorithms and recommendation algorithms to design the best learning path that suits the cognitive level and learning style of each student, which is known as the adaptive learning navigation of a thousand faces, a thousand paths. Through the heat map of the overall knowledge graph of the class, teachers can

also understand the difficult areas of teaching and common weaknesses of the class in general terms, and dynamically modify their teaching strategies accordingly <sup>[6]</sup>.

#### **4. Path II: Practical teaching closed-loop design driven by project-flow simulation**

Practice is an important part of the internalization process of knowledge and its ability cultivation. In response to the shortcomings of traditional practical teaching, where it is perceived as isolated and verification-oriented, the practical teaching closed-loop design process based on project-flow simulation highlights the importance of real-life, complex, and comprehensive projects as the vehicle to develop a practical education system that will span throughout the whole learning process, connect several courses, and combine various abilities.

The essence of the given path involves the creation of a hierarchical project repository. The project system operates in three stages: Basic-Comprehensive-Innovation. Level 1, which is known as the Basic Projects, concentrates on the individual application of core knowledge points, the development of fundamental operational skills, and the tool use capabilities of students, and tends to be coordinated with the theoretical study of a particular course. Level 2, the so-called Comprehensive Projects, involve the usage of knowledge and tools of several courses to address a fairly complex subsystem issue, the aim being the development of the students' system thinking and interdisciplinary knowledge integration. They are commonly established in brief semesters or intensive training weeks when a cluster of related courses has been completed. Level 3, Innovation Projects, are mostly open-ended, real, and important issues coming out of the industry frontiers or even real scientific investigation, and it is encouraged that students are allowed to select topics, team up, and innovate. They emphasize developing innovation consciousness in students, research competency, and engineering practice skills, and can take various formats, including graduation projects, discipline contests, or university student innovation and entrepreneurship schemes. The three levels of projects move in steps, where the preceding stage acts as the basis of the subsequent stage to form an ability cultivation channel that spirals up <sup>[7,11]</sup>.

The implementation mode is also known as a virtual-real combination, a software-hardware complementarity blended practice. Virtual simulation, digital twins, and augmented reality are used in full capacity to build an extremely simulated, scalable, repetitive, and affordable virtual experiment environment. The students can safely and effectively do the principle verification, scheme design, parameter debugging, and performance analysis in the virtual world, finishing a rehearsal of complex systems or high-risk operations. Based on these considerations, students are led into physical laboratories, engineering centers, or enterprise sites to conduct equipment functioning, system integration, and fault diagnostics in the physical setting, achieving the transfer of abilities between the virtual and the real state. It is not only an extension of the temporal and spatial limits to practical teaching with reduced spending and risks, but much more significantly, by repeated trial and error and exploration of the virtual world, it enriches students' understanding of principles and their confidence and efficacy in working out solutions in the real world <sup>[12]</sup>.

In order to guarantee the quality of practical teaching, a multi-dimensional project evaluation mechanism covering the whole process is developed. The assessment is not limited to the end result of the project or the report of the project, but rather involves the overall process of implementing the project. Evaluation dimensions cover: the innovation and feasibility of the scheme design, the standardization and teamwork of the implementation process, the ability in problem analysis and solution, and the level of documentation

and oral presentation, etc. Evaluation subjects include teachers, enterprise mentors, peers, and student self-evaluation. At the same time, project management platforms, code hosting platforms, and collaborative design tools are used to record all digital traces of students during the project process (such as design scheme iteration versions, code submission records, discussion forum exchanges, task completion progress, etc.). This process data becomes an important basis for evaluating students' ability development, ultimately generating a "practical ability growth file" containing a capability radar chart and personalized development suggestions<sup>[13]</sup>.

## **5. Path III: Innovation of human-computer collaborative teaching mode empowered by AI**

Artificial intelligence technology provides unprecedented possibilities for achieving the unity of scale education and personalized cultivation. The AI-empowered human-computer collaborative teaching mode aims to redefine the relationship between teachers, students, and technology, building a new teaching community of "teacher-led, student-centered, AI-collaborative."

The AI is used as a super teaching assistant in the field of teaching, which does the boring and mechanical tasks of a teacher. As an illustrative example, a smart question-answer system using natural language processing technology can be available 24/7 to answer typical questions of students on fundamental course concepts, assignment specifications, and technicalities; moreover, it can promote deep thinking in students by conducting multi-turn dialogues instead of giving them answers directly, thus developing their independent learning skills. An intelligent grading system of assignments is able to rapidly and precisely evaluate subjective questions, programming questions, and even some of the short-answer questions, which can offer comprehensive error analysis and recommendations for improvement, which significantly relieve the burden of teachers in grading and enable them to channel most of their energies into instructional design and meaningful engagement with students<sup>[9]</sup>.

The AI learning partner is described as the student's personalized learning partner in the learning link. The AI learning partner is able to paint a precise picture of the learning situation of every student by analyzing the behavioral data of the students regarding their learning (including information about the mastery state of knowledge graphs, preference of learning paths, lengths of focused attention, error question patterns, etc.) and thus offer tailored learning services to students. As an illustration, the intelligent recommendation system recommends learning resources, practice questions, and supplemental reading materials that are most appropriate to match the abilities and interests of the student; the adaptive learning path engine will automatically deliver micro-courses, example analysis, or clues when students face challenges, or guide them to tackle more advanced tasks when they have no trouble with the material; the learning status monitoring and early warning system can quickly detect students who might be lagging and automatically inform them and their teachers<sup>[4]</sup>.

AI will act as an intelligent assessment analyst in the evaluation link, and the idea of transforming teaching evaluation from summative evaluation into process-based, developmental evaluation. It has the ability to combine all processes, multiple-mode learning information using various sources, including knowledge maps, project websites, and online learning systems (e.g., video watching behavior, interactive exercise history, code quality data, project collaboration data, forum data, etc.). It uses the methods of educational data mining and learning analytics to perform a complete evaluation of the knowledge mastery,

skill level, ability development, and emotional attitude of students in several aspects. The produced assessment report is not a mere score and ranking anymore, but a digital competency assessment report that includes the analysis of the ability development trajectory, the identification of strengths and weaknesses, and individualized learning recommendations assisting students to gain a clear picture of themselves and make plans regarding their further learning <sup>[6,9]</sup>.

## **6. Path IV: Systematic construction of an integrated practical teaching system**

Integrated practical teaching system is one of the fundamental institutional designs that will guarantee the realization of the aim of practical education in a systematic and coherent manner. The intention is to end the condition in which the traditional practical teaching exists in links, the content is fragmented, and management is divided, removing the higher vocational-undergraduate practical teaching barriers, and creating an organic whole with the same objectives, advanced content, combined resources, and organized management. Its development process is based on three main levels.

The first is the integrated design of objectives and standards. Based on the professional talent training objectives and industry occupational competency standards and higher vocational-undergraduate segmented training requirements, the overall objective of the practical teaching system is designed backwards and decomposed layer by layer into practical links in different academic years, semesters, and course modules. Graded and classified practical ability standards that run through the entire talent cultivation process are formulated, clarifying the practical ability requirements that students should achieve at each stage. This ensures that the objectives of practical teaching at each stage are clear, closely connected, and logically progressive, forming a higher vocational-undergraduate integrated practical teaching chain of “cognitive internship–course experiment–course design–comprehensive training–post internship–graduation project” that is interlinked and spirally ascending <sup>[8,11]</sup>.

The second is the integration and consolidation of platforms and resources. The dismantling of the boundaries between different departments and laboratories, in this research, is an organization of the higher vocational-undergraduate practical teaching resources and an organization of the university-level and faculty-level practical teaching platforms. Based on the principle of sharing basic platforms, specialized platforms, and openness of innovation platforms, several interdisciplinary, multifunctional, open, and shared public practice platforms (like engineering training centers, virtual simulation experiment centers, and innovation and entrepreneurship centers) are built. Meanwhile, extracurricular practical materials are being actively increased, and together with the main industrial companies, research organizations, and state bodies, a series of high-level extracurricular practical educational facilities, industry universities, and common laboratories are being constructed and shared. Information technology has been used to develop a cloud platform of virtual-real combined practical teaching resources, which comprises various digital resources, including manuals of physical equipment, virtual simulation experiment programs, actual cases of business, and good project outcomes, which can be made open and accessible to higher vocational and undergraduate teachers and learners and thus maximize the utility of quality practical teaching resources <sup>[7,12]</sup>.

The third is joint management and evaluation. There is formed a Practical Teaching Steering Committee of cross-higher vocational and undergraduate levels to oversee the implementation of the design, construction, operations, and evaluation of the practical teaching of the university. Common practical teaching management systems, quality standards, and safety requirements are developed. To control the

practical activities of students (such as applications to projects, recording their processes, submitting results, and evaluating grades), a whole-process practical teaching information management system that links both inside and outside the university and higher vocational and undergraduate levels is created. The practical teaching assessment system is being reshaped to create an assessment system based on ability output, with several participants, including school teachers, enterprise mentors, and industry experts, and process assessment and summative assessment combined. The possibility of introducing a practical credit bank system, which acknowledges and transfers credits spent on practical activities that include discipline competitions, innovation and entrepreneurship projects, vocational skill certificates, and social services that students engage in, is considered, which promotes diverse student growth<sup>[8,13]</sup>.

## 7. Conclusion

The present research methodologically suggests a practical approach to the “three-dimensional and four-drive” integrated teaching reform based on the idea of digital-intelligence integration to address the common pain points in university teaching. The path follows the “concept-technology-mechanism” three-dimensional model. Through dynamic knowledge graphs, it reconstructs the knowledge system, through project flow simulations, it deepens practical teaching, through AI-human interaction, it innovates the teaching mode, and through an integrated practical teaching system, it consolidates the education foundation. The four drives are symbiotic in their efforts to transform the deep aspect of teaching from being teacher-centered to student-centered, the transmission of knowledge to the development of abilities, and the standardized cultivation to individualized growth. The research not only offers a macro framework structure but also presents a number of executable implementation steps and guarantees, which create a full closed loop between theory and practice, design and evaluation. Initial practice confirms that this system can be very effective in stimulating knowledge construction, ability cultivation, and quality improvement among students. Of course, educational reform is a complex system project, and the path proposed in this study still needs to be continuously tested, corrected, and developed in broader practice. Looking to the future, with the continuous advancement of technology and the constant updating of educational concepts, digital-intelligence integration is bound to give rise to a more diversified, intelligent, and humanized new form of higher education.

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## Disclosure statement

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