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A Project-Based Learning Approach Augmented with Generative AI in Interior Design Courses

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Abstract. This study explores the integration of generative artificial intelligence (AI) and project-based learning (PBL) in interior design education, aiming to foster interdisciplinary innovation and practical skill development by combining AI technologies such as large language models (LLMs), image generation tools, and multimodal human-computer collaboration to transform traditional teaching methodologies into a dynamic, data-driven process. The research emphasizes the coupling of "new agriculture + new design" disciplines, leveraging AI to bridge knowledge gaps and enhance creative problem-solving through a four-phase methodology: (1) Planning, where AI assists in generating task modules and visualizations to shift design thinking from "form-first" to "system-optimization"; (2) Identification, using AI to analyze user needs and spatial characteristics; (3) Presentation, enabling rapid prototyping through AI tools for 2D/3D modeling and video animations; and (4) Finalization, employing multimodal feedback for formative and summative evaluations. Empirical results demonstrate that AI-aided PBL enhances students' cross-disciplinary thinking, design efficiency, and innovation capabilities while supporting personalized learning through real-time data analysis, highlighting the potential of generative AI in constructing a green, low-carbon curriculum system, fostering "production-learning-research" collaboration, and cultivating interdisciplinary talents, with future directions focusing on optimizing AI-human synergy and expanding application scenarios to contribute to the digital transformation of design education in alignment with global trends in AI-driven educational innovation.

Keywords: Generative Artificial intelligence, Project-based Learning in interior design, Human-computer Collaboration.

1 Introduction

The advent of artificial intelligence (AI) technology as a novel form of productivity, characterised by digitisation, networking and intelligence, has engendered both unprecedented opportunities and challenges for design education. This study combines AI technology, big data, virtual reality, smart agriculture, and related

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technologies of interior design from an interdisciplinary perspective, exploring the innovation of the digital intelligence teaching method of "Golden Class". The integration of "generative artificial intelligence-assisted design + project-driven learning (PBL)" is a key component of the proposed approach. The integration of cross-disciplinary professional knowledge, multimodal human-computer collaborative teaching and generative digital technology application are identified as particularly important in the cross-fusion coupled teaching innovation of "new agriculture + new design".The integration of cross-disciplinary expertise, multimodal human-computer collaborative teaching and the application of generative digital technology are of particular significance. In the context of the eco-housing design project, the following methodology is proposed. Firstly, the basic big language model is employed in conjunction with knowledge map recommendation, personalised learning and basic model processing technology to generate the project task module list. The algorithm synchronous analysis is then presented in the form of visualisation, with the objective of promoting a shift in design thinking from "form priority" to "system optimisation". The process of enhancing the performance of a system by making adjustments to its configuration or parameters to achieve optimal functionality. The utilisation of AI image generative tools facilitates the expeditious generation of a multitude of design prototypes. These tools serve as a guide for students, instructing them in the utilisation of generative artificial intelligence data collection and information processing technology to accomplish learning services. Concurrently, they are tasked with the real-time feedback and analysis of teaching data. Finally, the multimodal intelligence of dynamic perception, instant feedback and co-creation under the human-computer interaction mode is utilised to reconstruct the design process of "generation-screening-optimisation" and establish diversified teaching evaluation strategies. The establishment of a green and low-carbon curriculum system for future interior design is predicated on the following: the realisation of cross-border cooperation in professional practice teaching; the coupling of social innovation service; and the cultivation of cross-border applied green design talents imbued with a sense of contemporary mission and a sense of service bearing.

2 Literature Review

2.1 Integration of Interdisciplinary Expertise in Design Education

The utilisation of deep learning algorithms enables AI teaching aids to analyse and effectively connect the knowledge barriers between design and computer science, engineering, sociology, psychology and other disciplines, thereby facilitating the formation of a new disciplinary knowledge map. To illustrate this point, one need only consider the numerous innovative majors and courses, as well as joint training programmes, which the Royal College of Art has introduced abroad. Among these are Global Innovation Design (GID), Information Experience Design (IED), and Innovative Design Engineering (IDE) (Paul Thompson, 2022). The Product Service System Design (PSSD) programme, initiated by the School of Design at the Politecnico di Milano in Italy, acknowledges the significance of collaborative design as a pivotal skill in the PSSD course . The programme adopts an innovative approach to teaching "data-driven design," drawing upon the methodologies developed at the MIT Media Lab. The course has been developed to optimise the design process through the utilisation of augmented reality (AR), virtual reality (VR) and the Internet of Things (IOT) technologies, with a particular emphasis on the integration of interdisciplinary teaching and research entities. The course optimises the design process through the utilisation of augmented reality (AR), virtual reality (VR), and the Internet of Things (IOT) technologies, the significance of innovative thinking and future exploration within interdisciplinary teaching and research entities, as exemplified by the MIT Media Lab. As posited by the MIT Media Lab (2025), design functions as a conduit between engineering, computer science, cognitive science, biology, and other disciplines. This serves to provide inspiration for new technologies and ideas, whilst also establishing the foundations for interdisciplinary talent development in the domain of "art + science" .

Among Chinese universities, Tsinghua University has taken the lead in proposing the concept of education development that integrates art and science, taking “new engineering + new design” as the core, and promoting the cross-fertilization of disciplines such as mechanical engineering, automation, and art and design. The LLM multi-intelligent body interaction system is developed in the artificial intelligence technology-assisted design planning course, realizing “three-phase” AI-assisted teaching (Tian Li, 2024). The School of Design and Creativity of Tongji University focuses on the combination of design disciplines and artificial intelligence, and devotes itself to the application of data, algorithms and the Internet in the field of design and creativity (Li Jie, 2023). This study relies on the cross-fertilization research of “new agriculture” practice teaching and “new liberal arts” design teaching to construct a multimodal practice teaching system. Taking the interior environment design course as the research object, firstly, we strengthen the cross-fertilization of “new agriculture + new design” professional courses and industry-academia projects, sink the practice teaching, and strengthen the practical educating function of the “second classroom”. Secondly, the artificial intelligence technology-assisted design link is added to enable students to grasp the cutting-edge technology and innovation trends in the professional field in a timely manner, and to demonstrate the accuracy and efficiency of AIGC technology in the construction of complex scenes. Thirdly, updating the path of digital intelligence project practice, using AIGC tools for creation and problem solving in course practice can not only cultivate students' cross-disciplinary thinking and practical ability, but also effectively enhance the efficiency and creativity of the design practice teaching through the programmed innovative methods in the AIGC human-computer cooperative scenario. The off-campus diversified education alliance platform and school-enterprise project cooperation built by the school and local linkage can realize the cross-border applied green design talent cultivation with the integration of “production, learning, research, use and creation”.

2.2 Multimodal Human-Computer Collaborative Instruction

Generative artificial intelligence technology assists interior design teaching, and generates a multimodal agent with dynamic perception, real-time feedback and collaborative co-creation. Firstly, educators have the capacity to optimise and adjust the initial interdisciplinary knowledge base in accordance with the specific teaching environment and individualised needs. The chain of thought is regarded as the fundamental mechanism for coordinating the collaboration of multiple intelligences (Wei J, Wang X, 2022). The integration of teaching resources is achieved by constructing a logical reasoning framework for constructing prompts, generating recommendations and evaluating results among the intelligences. In the interdisciplinary instructional design support model, five basic "intelligences" are constructed sequentially and connected through the chain of thought to form a complete collaborative system. These "intelligences" are: theme design intelligence, concept group intelligence, goal group intelligence, task group intelligence and evidence set intelligence. The purpose of constructing these "intelligences" sequentially is to optimise teaching scenarios. In conclusion, the integration of multimodal and human-computer collaboration in teaching has been shown to contribute to the enhancement of teaching-student interaction (Ma J, 2024). This integration combines project-based teaching, immersive experiences and adaptive feedback, as observed by means of reflective observation. The focus is directed towards difficult and important knowledge, and the formulation of scientific and reasonable summative evaluation schemes for teachers. It is evident that the implementation of this point-face evaluation strategy has resulted in the establishment of a comprehensive and systematic evidence set that fulfils the criteria associated with interdisciplinary theme teaching. This development consequently signifies an essential update to the prevailing teaching evaluation system.

The integration of virtual reality and digital interactive technology has the potential to enhance the synergy of "sight-hearing-touch", thereby facilitating the construction of an intelligent teaching environment that integrates multimodal sensory channels. In the context of traditional interior environmental design courses, students are expected to engage in the practice of sketching and rendering designs, a process that demands a considerable investment of time and financial resources. This investment is further compounded by the necessity to repeatedly construct three-dimensional models, a task that can prove to be both time-consuming and costly. Consequently, this pedagogical approach can potentially diminish students' enthusiasm for design derivation during the creative phase of the learning process. Conversely, generative AI models and their derivative models furnish students with substantial generative and creative capabilities by leveraging text, images, models and even multimodal natural interactions (Luo Fang, 2024). The model input is in the form of graphics, video, animation, and so forth, and the model output can also collect data in the form of different representations, such as text, audio, and physiology, with the help of information collection devices. Through the fusion and analysis of multimodal data, it is possible to comprehensively understand the dynamic changes and characteristics of the learning process.

2.3 Generative Digital Technology Applications to Aid Design and Teaching

The utilisation of generative AI in interior design practice emphasises the profound integration of AI-driven modelling tools and mixed reality devices, thereby facilitating the expeditious validation of design concepts (Tu Huijun, 2025). The utilisation of prompt-driven functions, encompassing "text-to-diagram", "diagram-to-diagram", and "diagram-to-video", has been instrumental in facilitating students' development of visual presentations of design strategies intervened in the entire design process by means of the big language model (e.g. DeepSeek, ChatGPT) in the following manner. Firstly, the data-driven construction of user profiles in the pre-research stage was analysed. This process enabled a more comprehensive and accurate description of the characteristics and behaviours of the user group. Secondly, the big language model was used to mine project information, with the aim of generating the text of the interior design planning (Verganti R, Vendraminelli L, Iansiti M, 2020). The subsequent conceptual ideation phase builds on this by summarising keyword information and outputting Prompt, thereby enabling the platforms (Midjourney, Stable-Diffusion, DALL-E) to generate 2D images under a specific conceptual model based on the text or sketches. The purpose of this phase is to visualise and present the design concepts of the students in the ideation phase, and to explore the possibilities of multiple scenarios. Subsequently, the schematic design stage generates the spatial functional structure diagram (Haolan Zhang, 2025) through the utilisation of AI assistive tools and inputs, incorporating the functional scale, orientation layout, and structural relationshipto formulate the spatial floor plan.Finally, the effect presentation stage deepens the 3D model and visualisation design scheme according to scene patterns, functional requirements and morphological changes in the design scheme. The combination of sequential spatial scene images with the keywords of the design scheme in Stable Diffusion results in the instant generation of images, models and video multimodal effects that match the actual scene (Nauata, N. 2020). The spatial image generation platform was utilised to generate the conceptual model of the interior space. The keywords of the design scheme in Stable Diffusion were combined to create instant generation effects that matched the actual scene. This approach was undertaken to provide more feasible design solutions for the subsequent deepening of the design details.

The effect presentation stage deepens 3D modeling and visualisation design scheme according to scene patterns, functional requirements and morphological changes in the design scheme. The combination of sequential spatial scene images with the keywords of the design scheme in Stable Diffusion results in the instant generation of images, models and video multimodal effects that match the actual scene. The purpose of this is to assist in the design of the effect diagram rendering (Zhang Chengyu, N. 2024), specifically using spatial images to generate the spatial floor plan . The spatial image generation platform was utilised to generate the conceptual model of the interior space. The keywords of the design scheme in Stable Diffusion were combined to create instant generation effects that matched the actual scene. This approach was undertaken to provide more feasible design solutions for the subsequent deepening of the design details (shown in Table 1).

Table 1. Generative AI-assisted interior design tool model types.

Model	**Foundation Models**		**Task-Specific Models**
Type	LLM	LVM	Density Model
Details	Generative Pre-Training Transformer (GPT): Pre-Training Based Language Models. Bidirectional Encoder (BERT): Pre-Training language modeling and Fine-tuning	Image generation models: DALL-E, Stable-Diffusion, Midjourney and others. 3D model generation models: Point-E, Stable Zero123, etc.	Generative Adversarial Networks (GAN): Adversarial training utilizes generator-discriminators to create realistic data images. Diffusion Model: Outperforms GAN and VAE with better image generation quality.

3 Practical paths for generative artificial intelligence-assisted interior design and teaching

In the process of cultivating students' design thinking through project-based teaching, this study has obtained a generative AI-enabled design course system teaching practice plan by optimising the design path of the traditional double-diamond model (shown in Figure 1), and a generative AI-assisted interior design teaching practice path by combining the process of AI-enabled design with the process of AI-assisted design teaching.

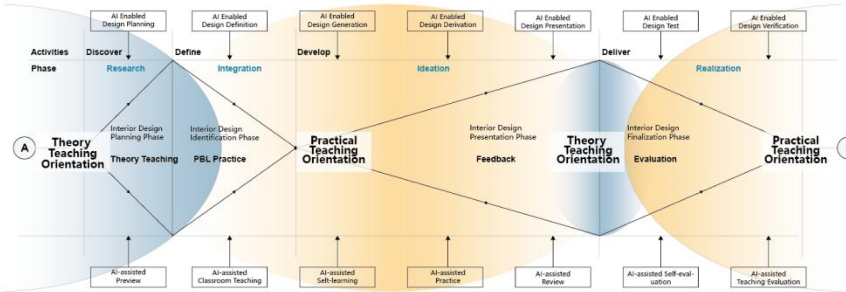


Fig. 1. AI-enabled teaching full flow map.

By integrating students, teachers (User), generative AI application forms (Object), and learning projects (Outcome), through the guidance of policy and professional social environment, combined with adaptive software and hardware environment, and accurately docking the project demand, we form the regional distinctive "User-Object-Outcome "Symbiotic teaching mode. Specifically empowering the whole process of course teaching implementation (before, during and after), realizing the whole process of AI-enabled theoretical teaching and practical teaching.

3.1 Interior Design Planning Phase

The course on generative artificial intelligence-assisted interior design involves a transition from an "experience-driven" to a "data-driven" approach in teaching methods. The present study proposes a novel integration of a large language model (LLM) with a knowledge graph recommendation system . This innovative approach seamlessly integrates LLM with personalized learning frameworks and basic model processing systems. The resulting integration of these elements enables the generation of project task module sheets, facilitating the organic incorporation of intelligent decision-making processes into innovative design thinking. This, in turn, assists students in more effective analysis, formulation, and implementation of design decisions that align with the expectations of the research object. The objective of fostering AI-driven innovative thinking is to guide students towards mastering data-aware, intelligent generation and human-machine collaborative approaches to innovation (shown in Figure 2).

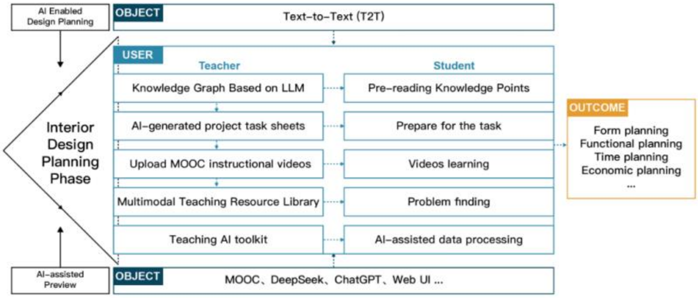


Fig. 2. AI-assisted Interior Design Planning Phase Model.

Synchronised analysis of AI algorithms in visual form (Smith, J. & Brown, A., 2022) has led to a shift in design thinking from "form-first" to "system-optimisation" (Melker, S., 2025). In the context of educational projects, teachers employ generative artificial intelligence (AI) to collect and analyse students' real-time learning data. This enables them to identify and address any issues that students encounter in a timely manner. Furthermore, generative AI provides personalised guidance and advice, tailored to the learning performance of each group working on a project. This real-time adjustment of teaching strategies is a key benefit of generative AI, allowing for continuous improvement in the educational process.

3.2 Interior Design Identification Phase

In the process of generative AI-assisted PBL project practice, through the logical relationship of “real situation - teamwork - iterative feedback” (Irina Engeness, 2025), the new model of instructional design is constructed sequentially to create a situation, inspire thinking, independent inquiry, collaborative experience, and reflective argumentation. Collaborative experience, and reflective argumentation of the new mode of instructional design (shown in Figure 3).

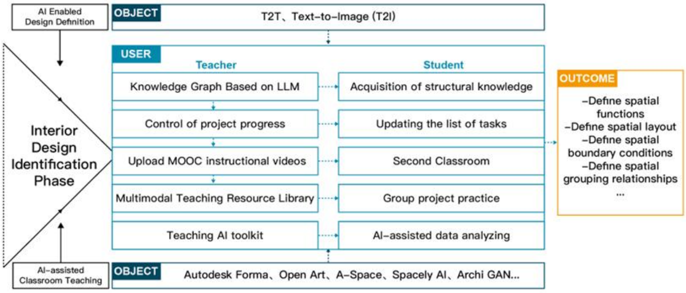


Fig. 3. AI-assisted Interior Design Identification Phase Model.

The programme is designed to facilitate the acquisition of a profound comprehension of user needs, spatial characteristics, and utilisation patterns within the context of the interior design process. The programme incorporates a supportive learning environment, ensuring that students receive adequate guidance from the instructor to successfully navigate hardware connections and software design. The utilisation of generative artificial intelligence facilitates the exploration of user elements, design elements, and scene-as-it-is elements, which are instrumental in the process of updating interior spaces. This approach assists students in accomplishing their task lists.

3.3 Interior Design Presentation Phase

The "project-based" training model utilises the project theme as the foundation for delineating task objectives, thereby establishing a modularised practice system. In the design performance stage, students are guided to master the AI auxiliary design toolkit, enabling them to independently utilise AI tools for design development. As illustrated in Figure 4, the process may involve the use of AI design sketches to create renderings, which are then developed into a model and subsequently converted into a video, among other applications. This multifaceted approach to design performance is enabled by AI, which significantly enhances the efficiency of the traditional design process.

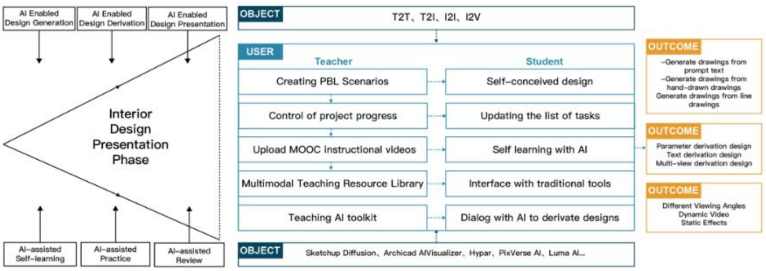


Fig. 4. AI-assisted Interior Design Presentation Phase Model.

3.4 Interior Design Finalization Phase

The feedback phase of generative AI-assisted course evaluation relies on the multimodal "intelligences" of dynamic perception, immediate feedback and collaborative co-creation to establish two dimensions of formative and summative evaluation. Formative evaluation is a process which assesses students' performance in the learning process by means of teamwork, work analysis, knowledge acquisition and self-evaluation (Brandmo, C., 2020). Summative evaluation, by contrast, appraises students' comprehensive application ability in solving the design process. The principal evaluation methods employed are theoretical testing, software application, results reporting and interdisciplinary integration ability assessment (Celiketal., 2022). This diversified evaluation method focuses not only on students' mastery of specific knowledge, but also on cultivating students' comprehensive application ability (shown in Figure 5).

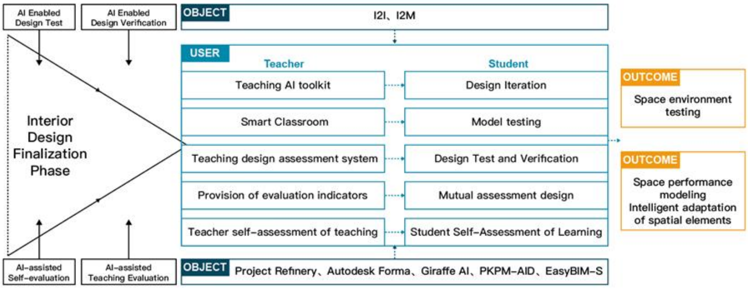
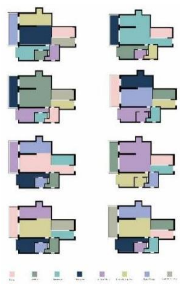


Fig. 5. AI assisted Interior Design Finalization Phase Model.

4 Validation of Teaching Practices in Interior Design Courses

4.1 Interior Design Planning Phase in Course

Table 2. Behavior during Design planning phase.

Teacher Behavior				Student Behavior
AI+PBL Practical	Task Indicators	Design Tool	Task Results	Spatial Simulation and Planar Generation
Design Planning Phase	Design Mapping: Design regulations, site environment, Lifestyle needs, use functions and other design bases are inserted into the AI platform, and the preliminary conceptual design planning text is obtained.	MOOC DeepSeek ChatGPT Web Ul	Ecological space design planning Text	

In the course of conceptual spatial design, the instructor utilises a MOOC teaching video to facilitate students' engagement prior to the commencement of the classroom session. The learning task assigned to students involves the analysis of the relationship between conceptual innovative thinking and spatial design from the perspective of "design thinking". This analysis is intended to construct a knowledge map, integrating design cases, spatial parameters, and lifestyle and behavioural data with AI teaching aids. The integration of these elements results in the automated generation of a multi-dimensional teaching resource library. The objective is to facilitate the automated generation of a multi-dimensional teaching resource library. It is imperative to nurture students' capacity for active thinking as they navigate the process of problem discovery, analysis and resolution (shown in Table 2).

4.2 Interior Design Identification Phase in Course

In accordance with the project task list that was proposed in the preceding stage, the teacher will guide students in the utilisation of data collection and information processing technology derived from generative AI. This will assist in the creation of project situations, prompting students to generate core driving questions for the project and to explore and contemplate the direction of interior design. Students are expected to engage in a sustained programme of research and scholarship, working closely with the generative AI system to explore contexts related to interior space system design. This programme is intended to facilitate the development of students' knowledge and understanding, with a view to enabling them to initially conceptualise interior design solutions (shown in Table 3).

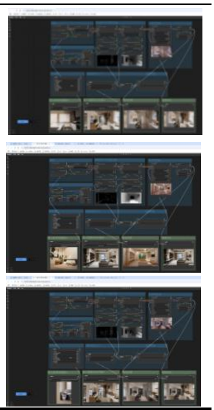
Table 3. Behavior during Design planning phase.

Teacher Behavior				Student Behavior
AI+PBL Practical	Task Indicators	Design Tool	Task Results	Spatial Generation
Design Identifica-tion Phase	2D Diagram : Based on the concept text,In the building layout generation cloud platform, residential information data is called to generate three-dimensional model of site, Enter the functional area, floor height, shape, layout and other parameters to generate multiple style indoor space layout schemes.	Autodesk Forma Open Art A-Space Spacely Al Archi GAN.	Interior design Floor plan, Elevation plan, Section plan, Detail drawings, Design analysis drawings	

4.3 Interior Design Presentation Phase in Course

It is imperative that students undertake teaching practice collectively, electing to undertake any one of the three modules of social practice, research projects and disciplinary competitions, in order to complete the PBL project-based design practical training. The integration of methodological and disciplinary thinking (i.e. reverse thinking and deconstructionism, respectively) within the context of mobile teaching practice is of particular interest. This integration is of particular relevance when considering the actual learning situation of students. Firstly, the integration of design practice with disciplinary competitions is imperative, as is the incorporation of sustainable concepts into competition works. Furthermore, there is a need to strengthen green innovation thinking training. The overarching design concept is predicated on three key tenets: "digital narrative, eco-symbiosis, dual-carbon strategy". The students are expected to engage in a process of continuous improvement in scientific research and to demonstrate a commitment to service through team-based activities. These activities are designed to facilitate the integration of academic disciplines and the competitive element, as well as to integrate scientific knowledge with educational methodologies. Additionally, design practice is integrated with deconstructivism, offering a multifaceted approach to learning and skill development. In the team-based educational praxis of "integration of courses and competitions, integration of science and education", students "practiced, strengthened scientific research and emphasised service", which comprehensively enhanced their innovative thinking, advanced ability, comprehensive logic and employability. The talent cultivation programme, enterprise cooperation practice and internship are all interdependent elements in the promotion of the integration of talent training in cross-border composite design, encompassing the aspects of industry, learning, research, use and creation (shown in Table 4).

Table 4. Behavior during Design presentation phase.

Teacher Behavior				Student Behavior
AI+PBL Practical	Task Indicators	Design Tool	Task Results	Spatial presentation
Design Presenta-tion Phase	3D Diagram : In the building structure layout optimization platform, the plan layout and structure selection are input to generate the structure model and preferred intelligent section. Combined with the 3D model generation platform, the core space image and text of the transparent environment are input to generate the 3D modeling.	Sketchup Diffusion Archicad AIVisualizer Hypar PixVerse Al Luma Al	Interior design 3D structure model, Axonometric drawings, Deconstructi on drawings	

	Space Effect,Animation：On the image generation platform, input three layout space block line drawings,Auxiliary environment, perspective, material, technology and other descriptive text,Aerial and human view effects are generated, and animations are generated through the video generation platform.		Interior design impression drawing A0 display board Video animation	  

Generative AI automatically evaluates the project results of each student group based on the learning data collected during project practice. Teachers can obtain evaluation feedback indicators from multiple dimensions, including the project implementation process, student performance, and evaluation results. A detailed evaluation report is generated in the course of the statistical analysis of project-related data. The purpose of this report is to facilitate a comprehensive understanding amongst teaching staff of students' performance in the implementation of the project. Generative AI integrates and filters relevant information and data to establish a four-pronged, two-way evaluation standard for teachers, students, peer experts and external reviewers. Generative AI has been demonstrated to facilitate self-assessment tools, which have been shown to promote self-reflection and improvement for teachers and students alike. It is evident from the evaluation results that the personalised suggestions provided for teachers' teaching are conducive to students' continuous improvement in future project-based learning.

5 Conclusion

Recent advancements in artificial intelligence (AI) technology have precipitated a new digital revolution. In order to promote the digital transformation of education and implement a strategy of developing the country by science and education, it is imperative to explore a greater number of application scenarios and collaboration modes. This will ensure that the country is strengthened by its talent and innovation-driven development. From the perspective of "generative artificial intelligence-assisted design + project-driven learning (PBL)", the present study proposes that the integration of cross-domain professional knowledge, multimodal human-computer collaborative teaching and the application of generative digital technology are particularly important in the coupled teaching innovation of "new agricultural science + new design" cross-integration. The application of generative digital technology is of particular importance. The integration of multidisciplinary professional knowledge application is facilitated by generative artificial intelligence technology. This development has two main benefits: firstly, it strengthens the systematic thinking and creative potential of student learning; secondly, it provides a strong technical support for practical teaching, thereby ensuring that the teaching results demonstrate a more significant academic depth and innovation dimension. The project-based practice system model is predicated on empirical projects, ranging from the intervention of basic large language models to the combination of generative AI image tools and online shared demonstration teaching. The model is designed to visualise the entire process of practice tasks, with students guided to employ generative AI data acquisition and information processing technology to achieve symbiotic learning service of "human-machine-object". Concurrently, real-time feedback and analysis of teaching data is conducted. The establishment of a foundation for the construction of green and low-carbon curricula is hereby proposed.

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