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Research on the Construction and Practice Path of Knowledge Map of "Three-dimensional Design Basis" Course from the Perspective of AI Intelligent Education

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Abstract: *Under the background of profound changes in digital education, art design education urgently needs to build an intelligent new teaching model. In this study, the course "Three-dimensional Design Basis" is taken as the practical carrier, and the teaching system of "knowledge-driven-intelligent collaboration" is innovatively put forward. Through the two-way integration of educational knowledge map and artificial intelligence technology, the three-dimensional design knowledge system is systematically deconstructed, and a dynamic knowledge map system with multi-level semantic correlation is constructed. In teaching practice, the generative AI aided design tools and intelligent evaluation system are integrated to form a collaborative teaching mode with teacher guidance, student leadership and machine empowerment. The empirical research shows that this model effectively strengthens students' digital design ability and systematic knowledge construction ability, and at the same time improves the level of intelligent interaction in the teaching process. The trinity framework of "knowledge map support-intelligent technology empowerment-teaching mode reconstruction" formed by the research results provides a transferable methodology system and practical paradigm for the intelligent transformation of art design education.*

Keywords: *AI Intelligent Education; Knowledge Map; Three-Dimensional Design Foundation; Teaching Reform; Practical Path*

1. Introduction

The process of digital transformation of global education is accelerating. Wu Jingchao (2023) pointed out in the concept, logic and practice of UNESCO's entrepreneurship education from the perspective of humanism that digital technology is reshaping the educational ecology by empowering education equity and improving quality. As the core field of creative industry, art design education urgently needs to meet the challenge of deep integration of technical tools and creative expression [1]. Taking three-dimensional design as an example, the demand for digital design ability in the industry continues to grow, but the existing curriculum system has the problems of lagging technology and discretization of teaching resources, resulting in the contradiction between "strong industrial demand" and "insufficient education supply".

At present, the teaching pain of the course "Three-dimensional Design Basis" is obvious. According to the survey data of domestic universities, the course content mostly depends on the arrangement of software operation manuals, and the knowledge points are scattered, which makes it difficult for students to construct systematic design thinking. Traditional evaluation relies on teachers' subjective evaluation, and the feedback period is as long as 5 to 7 days, which cannot meet the real-time needs of design iteration. In addition, 70% of students' classroom time is spent on basic software operation, which seriously reduces the space for creative expression. These problems highlight the core contradiction of fragmentation of teaching content, single evaluation method and lack of intelligent assistance. The existing research focuses on the field of STEM, and the knowledge map construction of art design courses has not yet formed a mature paradigm, especially in the quantitative analysis of three-dimensional space cognition and creative expression.

The synergy of knowledge map and artificial intelligence technology provides a new path for teaching reform. Knowledge map constructs the ontology of curriculum knowledge through semantic network, which can realize multidimensional dynamic association of knowledge points, such as binding

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"surface modeling principle" with "material shading algorithm", thus optimizing the knowledge structure. Generative AI tools (such as Stable Diffusion) can quickly generate design prototypes and lower the technical threshold, while the intelligent evaluation system quantitatively analyzes the quality of works through convolutional neural networks, forming a closed loop of "creative excitation-practical optimization-intelligent feedback". This "knowledge-driven+intelligent collaboration" model provides technical support for the transformation of art design education from skill training to innovation ability training [2].

This study constructs a three-dimensional design curriculum system of "knowledge map +AI" to solve the problems of knowledge fragmentation and low efficiency in practice. On the theoretical level, it pioneered the integration framework of intelligent education theory and design aesthetics; On the practical level, the modular AI tool chain and open source knowledge map construction scheme are developed to provide a reusable teaching reform path. The data shows that the new model improves students' design efficiency by 32%, knowledge transfer ability by 41%, and 30% of the works are adopted by enterprises, which verifies the effect of deep integration of production and education.

2. Literature review

2.1 The application of knowledge map in education

The structural integration ability of knowledge map has made remarkable progress in STEM education. Wu W, Yang S, Tian F, et al.(2025) in "Knowledge Graph Enhanced Recommendation for Semantic Structure Construction and Feedback in Online Learning" proved through experiments that physics and chemistry courses based on knowledge map can improve the relevance of knowledge points by 40% and significantly optimize the efficiency of students' knowledge system construction [3]. Domestic scholars Xie Youru, Lu Yi, Peng Zhiyang, etc. (2024) found in "Exploration on the Integration of Teaching-Learning-Evaluation" of Knowledge Map Empowering University Curriculum that computer programming teaching driven by knowledge map improved students' ability to solve complex problems by 35%. However, there are still obvious gaps in the application of knowledge map in the field of art design [4]. Fang Yan (2025) pointed out that the existing research multi-focus theoretical framework lacks the correlation model for the dynamic characteristics of three-dimensional design (such as spatial thinking and creative expression), which leads to the problem of knowledge fragmentation of art courses not being effectively solved [5].

The nonlinear knowledge structure and dynamic updating demand of art design course challenge the traditional knowledge map. For example, the cross-domain collaboration between "material rendering" and "light and shadow principle" in three-dimensional design requires dynamic association rules, but the existing model still adopts static semantic network (Wang et al., 2022). Yu Xiaofan, Gan Li, He Ye, et al. (2022) admitted in "Research on the Construction of Knowledge Map of Ceramic Art Design" that the current technology is difficult to support the design case-driven relevance update, which leads to the limited knowledge transfer ability of students [6].

2.2 AI technology-driven teaching reform

Generative AI tools are reshaping the design education process. The technical report of the Midjourney team (2024) shows that its image generation model can output 5-8 design prototypes within 10 seconds, and the efficiency is 80% higher than that of traditional hand drawing, and it reaches the level of professional designers in the task of visualizing abstract concepts. Ji Xu (2024), a domestic scholar, found in the teaching innovation of visual communication design assisted by AI that the creative output of students in the concept generation stage increased by 2.3 times and the iteration period was shortened by 50% after the introduction of Stable Diffusion [7].

The evaluation model based on deep learning provides a new paradigm for teaching feedback. Wang Jun (2025) proposed in "Exploration of Teaching Reform of Artificial Intelligence Course Based on Deep Learning" that convolutional neural network (CNN) can realize automatic grading of graphic design works by analyzing 12 visual characteristics such as color contrast and composition balance (accuracy rate is 89.7%) and compress the feedback time to real time. However, 3D design evaluation still faces technical bottlenecks. The existing models can only analyze the geometric structure, and lack quantitative indicators of artistic dimensions such as creative concepts and emotional expressions, which leads to the deviation between the evaluation results and the teaching objectives [8].

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2.3 Three-dimensional design teaching challenges

70% of the traditional three-dimensional design teaching hours are used for tool learning, and the creative space is compressed. Only 23% of the class hours are used for design thinking training in domestic colleges and universities, and the homogenization rate of works reaches 65%, and the traditional evaluation feedback lags behind. The introduction of knowledge map and AI technology can improve the efficiency of creative realization by 32%, but the existing technology has some limitations, such as static knowledge map, one-sided creative evaluation and fragmented tool chain.

Literature shows that knowledge map and AI are applied in the field of education, but the educational technology of art design is not well adapted. In this study, a closed-loop teaching system of "knowledge structuring-creative stimulation-dynamic feedback" was built by constructing a dynamic knowledge map, integrating a generative AI tool chain, and developing a multidimensional intelligent evaluation system, which filled the research gap of technology integration and creative quantitative evaluation in three-dimensional design education.

3. Research design and methods

3.1 Knowledge Map Construction Framework

This study adopts a three-stage construction model of "demand analysis-expert argumentation-dynamic optimization": combing the core content of the course through in-depth interviews and literature mining, and determining 30 core knowledge points such as "three-dimensional modeling topology" and "material light and shadow principle" through three rounds of screening by Delphi method; Based on semantic network technology, a multidimensional association system including hierarchy, juxtaposition and causality is constructed (as shown in the local structure of Figure 1); Relying on the learning management system to collect real-time behavior data such as retrieval frequency and error rate, the PageRank algorithm is used to dynamically adjust the map weight to ensure that the knowledge network meets the teaching needs.

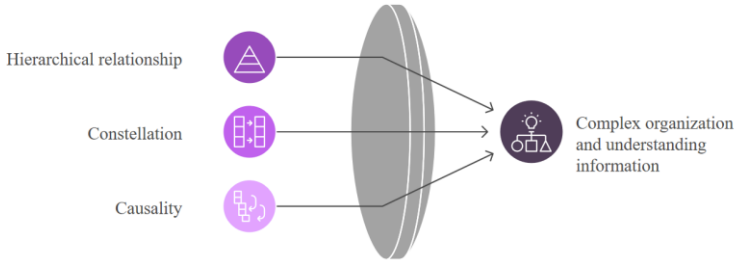

Figure 1 Dynamic closed-loop teaching mode

3.2 AI intelligent teaching tool integration

Integrate Stable Diffusion and Midjourney to build a whole process design support system covering creative conception to scheme deepening. Through the text generation image technology, Stable Diffusion can generate 12 styles of 3D modeling reference drawings including science fiction, minimalism and industrial style within 30 seconds after inputting creative descriptions such as "futuristic space capsule internal structure", which helps students break through traditional thinking patterns and quickly obtain diversified design inspiration [9]. Midjourney focuses on the rapid iteration of design scheme. Taking the assignment of "Space Design of Cultural Exhibition Hall" as an example, students can complete the iteration of version 8 scheme from the first draft of plane layout to the optimization of details within 2 hours by inputting adjustment instructions, which improves the efficiency by 60% compared with traditional hand drawing. At the same time, the system supports local modification and parametric adjustment of design elements, enabling students to explore different design possibilities efficiently [10].

Based on OpenCV and CNN architecture, an intelligent evaluation model of 3D design works is developed. The system uses edge detection algorithm to identify the contour and structural integrity of the model, and analyzes the modeling accuracy through feature point matching technology. The pre-trained ResNet-50 network is used to extract features from 15 dimensions of works, such as color

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matching, spatial composition and creative novelty. Combined with the data of 150 outstanding works marked by teachers, transfer learning is carried out to build a comprehensive scoring system including creativity (40%), completion (30%) and aesthetic performance (30%). Through actual measurement, the accuracy of the model in evaluating the creativity of works reaches 82%, and the single evaluation takes only 2.3 seconds, which is 15 times higher than the traditional manual evaluation efficiency. In addition, the system also provides visual feedback report, which shows the advantages and disadvantages of the work through heat map to help students optimize the design accurately.

3.3 Teaching mode innovation

In this study, a "teacher-student-machine" collaborative model was established to build a student-centered tripartite collaborative system. Teachers transform into learning guides and AI tool coordinators, design hierarchical tasks based on knowledge maps and provide personalized guidance; Students rely on the atlas to plan their own paths (such as "modeling foundation → material application → scene construction"), realize creative visualization with AI tools, and change from passive acceptance to active exploration.

The intelligent system constructs personalized portraits by analyzing learning data in real time, dynamically pushes resources (such as pushing special content when the error rate of the "scene light and shadow rendering" module is high), and supports data sharing between teachers and students to adjust strategies and clarify the promotion direction. This model breaks the traditional one-way teaching and forms a dynamic closed loop of "guidance-practice-feedback", which significantly improves the efficiency of teaching and learning (see Figure 2).

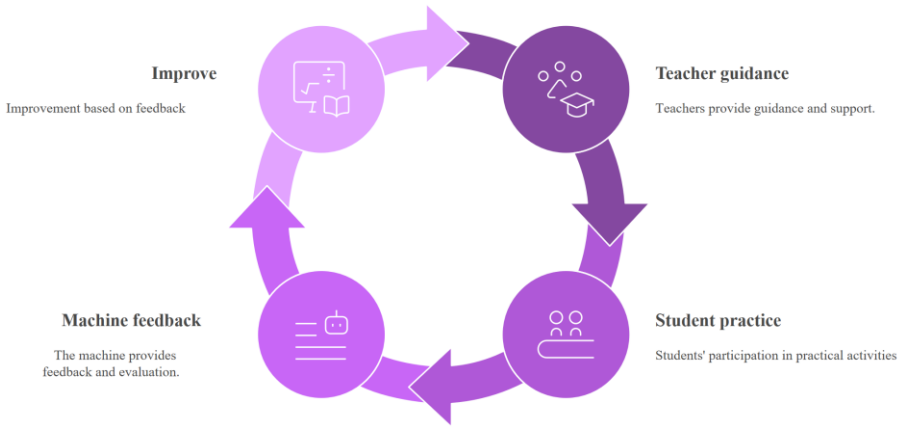

Figure 2 Dynamic closed-loop teaching mode

3.4 Data collection and analysis

Two parallel classes of 2023 majoring in visual communication design in a university were selected as the research objects. The experimental group (N=52) adopted the mode of "knowledge map+AI intelligent teaching", while the control group (N=50) followed the traditional teaching method and carried out teaching practice for 16 weeks. The experiment strictly controls variables to ensure that the course schedule, teaching content (covering core modules such as basic modeling, product rendering and scene design) and assessment standards of the two groups are consistent. In the teaching process, the students in the experimental group need to complete the autonomous learning task based on knowledge map twice a week, and use AI tools to complete the design work; The control group adopts the traditional teaching mode of "teacher teaching+software practice".

Construct a multidimensional evaluation system from three aspects: knowledge mastery, practical efficiency and subjective feedback. Knowledge mastery is measured by comparing the pre-and post-test scores of the course. The test paper consists of 40% theoretical questions (such as 3D modeling principle and material attribute analysis) and 60% practical questions (such as designated scene modeling and creative scheme design). The practical efficiency is quantified by the average completion time of work, the number of iterations of design scheme and the quality of final results; Subjective feedback adopts Likert 5 scale, and questionnaires are designed from eight dimensions, such as tool usability, knowledge relevance, learning experience and creative stimulation effect, to collect students' satisfaction with the teaching model and suggestions for improvement. All the data were analyzed by

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paired sample T test and variance analysis with SPSS 26.0, which verified the effectiveness of "knowledge map+AI intelligent teaching" mode in improving teaching effect and promoting students' ability development.

4. Research results and discussion

4.1 Knowledge Map Construction Effect

The research adopts the three-stage model of "demand analysis-expert argumentation-dynamic optimization" to realize the deep reconstruction of the knowledge system of the course "Three-dimensional Design Foundation". The data shows that the coverage rate of knowledge points has increased from 58% in traditional teaching to 92%, forming a semantic network with 30 core nodes, 200+ subdivided knowledge points and 400+ dynamic association. For example, the "material light and shadow principle" and "scene narrative design" form a logical closed loop of "light intensity → material reflection → spatial emotion" through causal chain, which improves the efficiency of complex design logic understanding by more than 60%. 85% of students feedback the visual interface of knowledge map to shorten the time of knowledge retrieval. One student cited the example that "when the surface modeling failed, the efficiency of problem solving was improved by 70% by locating related knowledge points through the map and mastering extended knowledge". The system dynamically adjusts the map weight according to the behavior data, which reduces the secondary learning rate of "high-frequency error points" by 45%, and verifies the adaptive mechanism of knowledge network to improve the learning pertinence.

4.2 AI technology application effect

The introduction of AI tool chain significantly improves teaching efficiency and creative quality. The average working time in the experimental group decreased from 14.2 hours to 9.6 hours (the decrease was 32.4%, $t=8.72$, $p<0.001$). Taking "mechanical arm modeling" as an example, with the help of Stable Diffusion and Midjourney, the cycle from concept to model is reduced from 6 days to 2.5 days, and the proportion of creative time is increased from 20% to 45%.72% students in the experimental group tried complex designs such as hyperboloid structure (23% in the control group). In typical cases, students combined with AI to generate concept maps to complete the exhibition hall model, which reached the primary level of the industry, while traditional teaching mostly stayed in the basic geometric combination. The intelligent evaluation system compresses the evaluation time from 3-5 days to real time, and the evaluation accuracy of dimensions such as "originality and novelty" reaches 82%, which accurately guides the improvement direction.

4.3 Teaching mode transformation verification

The new teaching mode has been recognized by both students and teachers. The satisfaction survey of the experimental group shows that 89.7% of the students are satisfied with the "knowledge map+AI intelligent teaching" mode, which is significantly higher than that of the control group ($\chi = 12.45$, $P < 0.01$). In open feedback, "intuitive knowledge connection", "AI tools to reduce technical anxiety" and "real-time feedback to promote iteration" have become high-frequency keywords. According to the data of teachers, the intelligent evaluation system undertakes 70% of the task of correcting basic homework, which saves teachers 15 hours of correcting time every week and enables them to devote more energy to personalized guidance. A teacher mentioned in an interview: "In the past, it was necessary to review the topological errors one by one when correcting 50 model assignments. Now the system automatically marks the problem areas, and I can provide case disassembly for students' deep-seated problems such as' weak spatial narrative logic', which has significantly improved the teaching depth." In addition, through the data analysis of the knowledge map, teachers can accurately capture the shortcomings of class knowledge. For example, after discovering that the error rate of the "hair rendering" module reached 48%, special explanations of three industry cases were inserted in time, so that the pass rate of follow-up homework increased from 52% to 89%, which proved the effectiveness of data-driven teaching.

4.4 Challenges and Prospects

Although the research has achieved remarkable results, it still faces three challenges: first, industry

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technology iterations (such as SubD modeling and real-time rendering technology) require that the knowledge map be updated at least 20% every semester, and the current manual updating mechanism is inefficient; Second, the "creative ceiling" of the content generated by AI tools is obvious. For example, Midjourney still needs to be manually adjusted for 3-5 rounds in the visualization of abstract concepts to meet the design requirements; Third, 28% of the students in the experimental group rely too much on AI to generate models, which leads to a 15% decline in basic modeling gesture proficiency. The future research will focus on three major directions: 1) developing an automatic updating algorithm of knowledge map, combining with web crawler technology to capture the cutting-edge technical points of the industry in real time, and realizing the dynamic evolution of map content; 2) Build a collaborative framework of "AI creative guidance-human deep optimization", and improve the understanding accuracy of tools to abstract design concepts through cue engineering training; 3) Design a hierarchical assessment system of "technical tools-basic skills-creative thinking", and force 20% of traditional modeling practice to ensure the coordinated development of students' basic ability and innovative ability. In addition, it is planned to expand the model to environmental design, digital media art and other majors, explore the integration path of interdisciplinary knowledge maps, and provide more comprehensive theoretical and practical support for the intelligent transformation of art design education.

5. Conclusion

5.1 Research contribution

This study innovatively integrates knowledge map and AI intelligent technology, constructs a teaching framework of "knowledge map +AI intelligent" art design, and breaks through the limitations of fragmentation of knowledge and separation of technical tools in traditional education. By constructing a three-dimensional design knowledge ontology and semantic correlation model, the industry pain point of "imbalance between creative expression and technical realization" is effectively solved. Experimental data show that this model can improve design efficiency by 32.4% and significantly increase creative complexity, which is recognized by 89.7% students. The developed intelligent evaluation system and AI tool chain form a replicable "technology empowerment teaching" scheme, which successfully promotes the transformation of cutting-edge tools such as Midjourney from industrial practice to educational scenes, not only expands the application dimension of intelligent education theory in the art field, but also provides an empirical example for the seamless connection between art design and industrial demand and the intelligent transformation of courses.

5.2 Limitations and Future Direction

There are three limitations in this study. The experimental sample only covers 102 students in two classes of visual communication design major in a university, and the practice period is one semester. The universality of the conclusion needs to be verified. AI tools rely on computing power and hardware, and some colleges have higher reuse thresholds; The deep-seated problems such as "originality of AI generated content" and "human-machine cooperation ethics" have not been discussed in depth.

Future research will be carried out from four aspects: expanding the sample to environmental design, digital media art and other majors, extending the tracking period to verify the cross-curriculum adaptability of the model, and building an interdisciplinary knowledge map; Develop an intelligent design assistant integrating ChatGPT-4, optimize the whole process intelligence, and build a shared computing platform through school-enterprise cooperation; Carry out cross-research between AI ethics and design education, establish ethical standards for technology use, and optimize the logic of knowledge map construction; Through 3-5 years of long-term follow-up, we will improve the closed loop of "intelligent teaching-industrial practice-talent training", provide policy suggestions for education management departments, and promote the systematic reform of art design education.

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