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Paradigm Transformation of Integrating Design Thinking into Curriculum Teaching - Reconstruction of Teaching Model Based on Cognitive Science

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Abstract: *With the continuous improvement of higher education's requirements for students' comprehensive innovation ability, traditional curriculum teaching has problems such as fragmented design process, single evaluation method and insufficient student participation. To this end, this paper introduces the design thinking paradigm and integrates artificial intelligence and Internet of Things technologies to reconstruct the course teaching process from the six stages of "understanding-observation-definition-concept-prototype-testing". Artificial intelligence is used to assist in creative generation, sentiment analysis and user portrait modeling, while the Internet of Things supports real-time collection and feedback tracking of user behavior data during prototype testing, thereby achieving full-process, visual learning evaluation and teaching regulation. Through comparative analysis, the experiment found that the teaching model after integrating technology significantly improved students' performance in key ability dimensions such as creative expression, problem solving, interdisciplinary integration and collaborative communication. The experimental group was slightly better than the control group in most dimensions, especially in ability improvement and collaborative experience, reflecting the positive role of design thinking-oriented teaching in promoting students' emotional investment and cognitive acquisition. First, in terms of course participation, the experimental group scored an average of 4.6 points, while the control group scored 3.55 points. The experimental group had a slightly higher proportion of "high score frequency" (5 points), indicating that its teaching activities were more attractive and participation-driven.*

Keywords: *Design Thinking Teaching; Curriculum Paradigm Reconstruction; Artificial Intelligence; Internet of Things; Higher Education*

1. Introduction

Under the current background of the transformation and upgrading of higher education, cultivating students' innovation ability, practical ability and interdisciplinary comprehensive quality has become an important goal of curriculum reform. As a creative method that emphasizes user orientation and problem solving, design thinking has gradually been introduced into the teaching field due to its strong practice orientation and cognitive construction characteristics, and has become an important path to promote the reconstruction of curriculum paradigm. However, in specific practice, traditional courses often remain at the stage of "linear task drive" and "result-oriented evaluation", with problems such as weak student participation, limited creativity generation, and delayed process feedback, which cannot fully stimulate students' learning motivation and innovation potential.

Based on this, this paper constructs and implements a teaching model that integrates the design thinking paradigm and digital intelligence technology support for higher education scenarios. Starting from the six stages of "understanding-observation-definition-concept-prototype-testing", the system embeds AI and IoT tools to achieve digital reshaping of the teaching process, process-based upgrading of the evaluation system, and visualization support for learners' cognitive paths. Through experimental comparison and verification, the model shows significant advantages in improving students' innovation ability, practical ability, scientific thinking, etc., this further confirms the feasibility and practical value of the design thinking paradigm in the higher education system.

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2. Related Works

In recent years, education reform and curriculum reconstruction have become hot topics in global education research. Many scholars have explored diverse innovation paths and empirical strategies from different dimensions, such as teaching design, teacher development, classroom practice and technology integration.

Johann et al. designed and evaluated analogy-based cell membrane biology learning activities based on the educational reconstruction model and experiential realism. Through teaching experiments, it was found that analogy helps students connect daily experience with the "isolation and connection" function of the cell membrane, and promotes their conceptual understanding and reconstruction of the structure and function of the cell membrane [1]. Kamphorst et al. designed a teaching program that does not require advanced electromagnetic knowledge but retains Einstein's reasoning through educational reconstruction. The program guided middle school students to explore the principle of the constancy of the speed of light through thought experiments, thereby understanding the theoretical construction of the special theory of relativity. Experimental evaluation showed that this method effectively promoted students' understanding [2]. Yakavets et al. explored how teachers in Kazakhstan responded to the government's educational content update reform and found that teachers generally recognized the value of the reform, but their teaching practice changes were limited. The study emphasized the key role of teacher cooperation and social interaction in teacher agency in educational reform [3]. Suminar et al. used ethnographic methods to analyze how two primary schools reconstructed the child-friendly school program by strengthening the mutual assistance and cooperation dimension of Pancasila students. The results showed that the school reconstructed cooperation, care and sharing in terms of policies, teaching, teachers, facilities and home-school cooperation, and strengthened the spirit of mutual assistance and cooperation [4]. Yao et al. integrated the "Nursing + Anatomy" course through project-based teaching reform, and adopted teaching models such as BOPPPS (Bridge-in, Objectives, Pre-assessment, Participatory Learning, Post-assessment, and Summary) and "triple linkage" to improve the clinical application ability and independent learning ability of nursing undergraduates, and significantly improve students' academic performance, enthusiasm and course satisfaction [5]. Krepf and König analyzed 211 lesson plans of 106 pre-service teachers and constructed a standardized method to measure lesson structuring ability. They used the IRT (Item Response Theory) scale to verify its reliability and found that this ability was significantly improved during pre-service training, providing an empirical model for the evaluation of teachers' instructional design ability[6]. Godbold et al. discussed the multiple definitions and relationships between Scholarship of Teaching and Learning (SoTL), academic teaching and scientific research, and called for breaking the binary opposition between teaching and scientific research. They proposed a three-focus framework of "super-complexity, theoretical reconstruction and ethics of care", advocated multiple practical perspectives, and promoted the development and integration of SoTL [7]. Based on the perspective of situated learning, Dimitrieska used reflective dialogue heuristics to longitudinally explore the construction of identity of novice language teachers during and after the CELTA (Certificate in English Language Teaching to Adults) course, revealing the interactive changes in their cognition and learning, and emphasizing the role of this method in supporting teacher identity development [8]. Ridell and Walldén used multimodal analysis to explore how teachers in two first-grade classrooms used visual models and multimodal prompts to teach narrative genres. They found that teachers had different emphases in the use of language and visual resources, which affected the communication of narrative characteristics. Students showed interest in story dialogues, but teachers paid less attention to this [9]. Wang et al. used a mixed method to focus on teacher trainees with high levels of reflection in the Chinese context, identified their potential teacher leadership attributes, and proposed a new model that emphasizes continuous situational reflection to promote professional development, emphasizing the cultivation of teacher leadership during the teacher training stage to help them grow into excellent teachers [10]. Kuru Gönen and Zeybek designed and implemented a multimodal mobile-assisted language learning training model for Turkish English teacher trainees. After eight weeks of systematic training, the teacher trainees' teaching skills and technology integration capabilities were significantly improved, and the feedback was positive [11]. Although existing research has made positive progress in the practice and effectiveness of educational reconstruction, it generally faces bottlenecks such as fragmented theoretical frameworks, insufficient teacher initiative, and limited teaching transfer effects.

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3. Methods

3.1 Optimizing the Evaluation System of Design Thinking

The introduction of the "transdisciplinary" perspective has promoted the innovation of course content and also prompted the teaching evaluation system to evolve in a more fair, dynamic and comprehensive direction. The evaluation of design thinking courses should have process-based and interactive characteristics to fully reflect the development trajectory of students' abilities and enhance their learning enthusiasm and sense of participation, thereby ultimately optimizing teaching effectiveness.

(1) Process-based design of evaluation

Process-based evaluation emphasizes the continuous feedback mechanism throughout the entire learning cycle, rather than focusing only on the final results. Teachers should conduct evaluations from the stages of students' problem definition, data research, prototyping to solution implementation, and include multiple dimensions such as the degree of multidisciplinary integration, innovative expression, logical deduction, and system adaptability. Through this type of evaluation, teachers can timely capture students' bottlenecks in thinking and practice, provide immediate guidance, promote strategy adjustments, and ensure the internal generation of learning outcomes.

(2) Interactive construction of evaluation

Interactive evaluation advocates that the evaluation process becomes a platform for interaction and co-construction, including mutual evaluation and discussion between teachers and students, and between students. Its forms can include peer evaluation, group deliberation, public display, etc., which helps to enhance students' critical thinking and design expression ability. Through interactive feedback from different perspectives, students can have a deeper understanding of the essence of design, enhance the transferability of creativity, and improve collaboration and communication skills, laying a solid foundation for future comprehensive abilities.

3.2 Core Elements and Adaptive Structure of Design Thinking

Design thinking is an innovative methodology that is user-centric, emphasizes multiple solution paths and continuous optimization. Its essence is to apply the logic and tools of design to practical problem solving, and to achieve continuous evolution of solutions through iteration. This paper draws on the "Five-step Design Thinking Model" proposed by Stanford University and clarifies the following core steps:

(1) Raise questions

Through observation and interviews, it can deeply explore user needs and identify the root causes of the problem. This stage emphasizes the combination of data collection, background investigation and on-site observation.

(2) Define the problem

Based on information induction, this paper refines the essence of the problem and establishes the design goals. Students need to screen the core issues through logical sorting.

(3) Thinking about solutions

Open thinking and diverse exploration can be advocated, and multiple solution paths can be generated through brainstorming to promote the free generation of ideas.

(4) Prototyping and testing

The selected solution is concretized into a prototype model, and iterative optimization is carried out with the help of feedback mechanism. The cycle process of rapid testing and rapid improvement can be emphasized.

(5) Implementation and iteration

The final solution can be applied to practical situations and adjusted flexibly based on continuous feedback to ensure the effectiveness and adaptability of the design results.

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3.3 Transformation of Teaching Paradigm Model Empowered by Digital Intelligence Technology

The introduction of digital intelligence technology has injected new momentum into the design thinking teaching in higher teaching scenarios, effectively improving students' perception, data analysis and multimodal design capabilities. Based on the perspective of cognitive science, a six-stage teaching model of "understanding-observation-definition-concept-prototype-testing" suitable for higher colleges was constructed.

(1) Understanding

With the help of data mining tools and statistical analysis platforms, students can quickly grasp user needs, industry trends and social background, and achieve structured and systematic understanding of problems.

(2) Observation

This paper collects first-hand information through field research and user interviews, and uses mobile research tools, eye tracking and other digital intelligence methods to obtain user behavior data to enhance the authenticity and representativeness of the data.

(3) Define perspective

In the problem identification stage, this paper introduces data visualization technology and sentiment analysis tools to help students build a multidimensional cognitive model and extract design entry points and implicit needs from complex data.

(4) Conception

It can integrate AI creative tools and case generation systems to provide students with multiple channels for inspiration input. The design support platform can realize the automatic generation and optimization of design sketches, which helps students to quickly implement their ideas.

(5) Prototype

Relying on 3D modeling and AR/VR technology, students can quickly build and iterate design solutions in virtual space, while improving spatial perception and multi-angle verification capabilities.

(6) Testing

Through the deployment of user testing platforms and IoT devices, real-world simulation and data tracking of prototype functions, user experience and operation paths can be achieved, supporting the scientific and precise iteration strategy.

3.4 Scientific Thinking as the Cognitive Basis for the Development of Design Thinking

As a problem-solving method based on logical reasoning and empirical methods, scientific thinking provides a cognitive foundation for the development of students' design ability. From the perspective of individual development, scientific thinking can help students develop an inquiry spirit and autonomous learning ability, so that they have the ability to solve problems in a structured manner when facing complex tasks. In practice, students gradually establish an understanding of causal relationships and a systematic thinking framework through the process of hypothesis, verification, and feedback adjustment.

From the perspective of educational goals, scientific thinking helps to cultivate "adaptive talents" with judgment and decision-making abilities. Its stability and transferability enable students to apply the methods they have learned to the workplace and daily life after graduation, improving their overall quality of life and their ability to solve practical problems. The integration of design thinking and scientific thinking is essentially a collaborative expression of innovation and rationality, which can build a curriculum model with greater practical value and social adaptability.

4. Results and Discussion

4.1 Experimental Subjects and Grouping

The experimental subjects are two classes of 2023 students from a certain college majoring in design, with a total of 80 people

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The grouping method is to randomly divide them into an experimental group (Group A) and a control group (Group B), with 40 people in each group

The teacher configuration is that the two groups of teachers are from the same teaching team to ensure consistency in teaching style

4.2 Teaching Content and Tool Configuration

Table 1 Teaching content and tool configuration

Teaching stage	Course content	Experimental Group Tool Support	Teaching method for control group
Understand	User research and problem background analysis	Data collection tools, questionnaire systems, keyword mining tools	Traditional literature lectures and research guidance
Observe	User behavior observation and user portrait construction	Mobile researchApp, eye tracker, audio transcription software	Student offline interviews and handwritten records
Definition	Identify design goals and pain points	Sentiment analysis tools,AISemantic classification and diagram generation system	Teacher-guided question refinement
Conception	Idea generation, sketching	AICreative recommendation, collaborative whiteboard, case library navigation system	Brainstorm+Hand-drawn sketches
Prototype	Solution modeling and presentation	Figma,3DModeling software,ARVisualization Tools	Sketch+PPTbriefing
Test	User feedback and optimization	User testing platform,IoTData collection system, online questionnaire system	Group Presentation+Verbal Evaluation

Table 1 shows the differences in content and tool configuration used by the experimental group and the control group in the design thinking course at each teaching stage. The experimental group used a variety of digital intelligence tools to assist learning, such as questionnaire systems, eye trackers, AI semantic analysis, Figma modeling, and IoT feedback collection, to strengthen data-driven and interactive practices; while the control group mainly used traditional teaching methods, such as lectures, hand-drawing, and offline discussions, with relatively limited tool support, reflecting the significant contrast between the two groups in teaching support systems.

4.3 Data Analysis

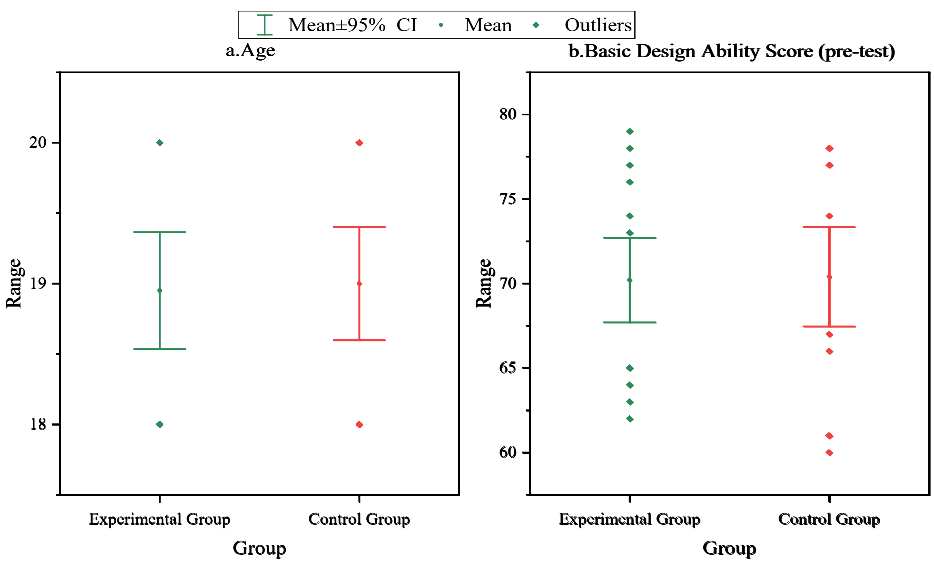

Figure 1 Basic information of students

In the pretest data analysis of this study, Figure 1 statistically compared the age and basic design ability scores of students in the experimental group and the control group to verify the homogeneity of

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the two groups before the experiment began.

The results show that the average age of the experimental group is 18.95 years old, with a 95% confidence interval of ±0.42 years old; the average age of the control group is 19.00 years old, with a 95% confidence interval of ±0.40 years old. The mean age of the two groups is almost the same, and the confidence intervals are highly overlapping, indicating that the age distribution difference is not significant and the samples are comparable.

In terms of basic design ability scores, the average score of the experimental group was 70.20 points, with a 95% confidence interval of ±2.50 points; the average score of the control group was 70.40 points, with a 95% confidence interval of ±2.94 points. The two were also close, indicating that the two groups had the same starting point in terms of basic design ability. Overall, the subject conditions before the experiment were well controlled, providing a solid foundation for the reliability and validity of the study.

In this study, the performance of students in the experimental group and the control group in the six stages of design thinking (understanding, observation, definition, conception, prototype, and testing) was statistically analyzed. The results showed that the experimental group performed better than the control group in the overall design task advancement, especially in the middle and late stages.

Table 2 Stage scores

Group	Understanding stage scoring	Observation phase scoring	Define Phase Scoring	Ideation Stage Scoring	Prototype Phase Scoring	Testing phase scoring
Experimental Group	75.45 ± 11.83	79.80 ± 11.83	80.05 ± 11.23	86.75 ± 9.91	80.50 ± 10.74	81.45 ± 10.33
Control group	75.30 ± 9.84	76.80 ± 12.06	77.15 ± 13.04	80.40 ± 13.32	79.00 ± 12.00	77.30 ± 11.43

The experimental group scored an average of 86.75 points in the conception stage, significantly higher than the control group's 80.40 points, and with a smaller standard deviation, indicating that the experimental group not only had stronger creative generation capabilities, but also had more stable performance within the group. In addition, in the testing phase, the experimental group scored 81.45 points, also higher than the control group's 77.30 points, indicating that they had more mature design capabilities in product verification, feedback adoption, and problem iteration. These advantages are the core benefits of the emphasis on rapid prototyping and user feedback loops in design thinking teaching.

Secondly, in the prototype stage and definition stage, the experimental group also leads the control group with an average score of 80.50 and 80.05, respectively, compared with 79.00 and 77.15 of the control group. Although the gap is relatively small, it still reflects the better connection between early cognitive understanding and later practical execution.

In the early understanding and observation stage, the two groups performed relatively close, with the experimental group scoring 75.45 and 79.80 respectively, and the control group scoring 75.30 and 76.80, indicating that before the introduction of structured creative training. The two groups of students have roughly the same ability to analyze the problem background and collect information, which meets the basic conditions of "homogeneous pre-test" in the research design (as shown in Table 2).

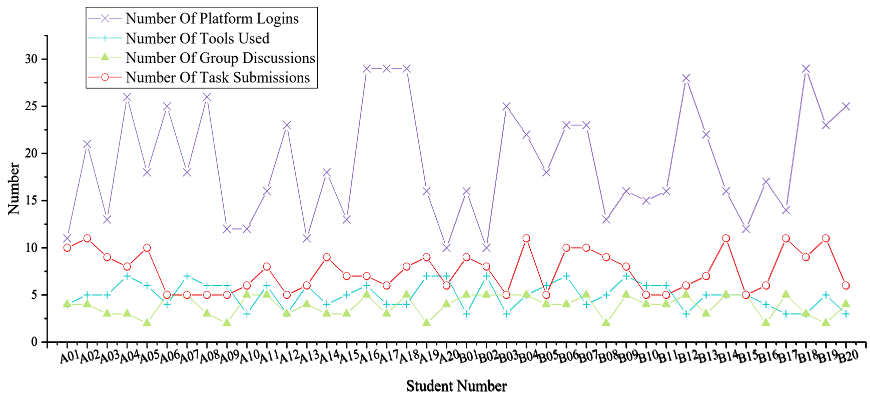

Figure 2 Learning behavior data

In terms of learning behavior analysis, Figure 2 compares the number of platform logins, tool usage,

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group discussions, and task submissions between the experimental and control groups to assess the depth of student participation and initiative during the course. The analysis results show that the experimental group is more active in platform usage and learning interaction, especially in terms of login frequency and task completion.

First, in terms of the number of platform logins, the average number of logins for the experimental group was 24.1, higher than the 19.4 for the control group. Although the difference is not large, it still shows that the students in the experimental group are more dependent on the platform and participate in online learning and data browsing more frequently. The difference in the number of task submissions is even more significant. The average number of submissions for the experimental group is 8.5, and for the control group is 6.15. Although the values are similar, the frequency distribution shows that more students in the experimental group have a submission frequency close to full marks, indicating that they show higher consistency and initiative in continuous task completion.

In terms of the number of tools used, the experimental group used an average of 6.1 and the control group used 4.1, indicating that students guided by design thinking are better at exploring diverse design tool resources and forming personalized task paths. In terms of the number of group discussions, the two groups of students had similar means (4.05 times in the experimental group and 3.05 times in the control group), indicating that in the course organization structure, the collaboration mechanism is relatively balanced and the opportunities for communication within the group are relatively even.

In terms of students' subjective perception, this paper conducted a statistical analysis on the experimental group and the control group in four dimensions: "course participation score", "course satisfaction score", "perception of self-ability improvement", and "perception of teamwork".

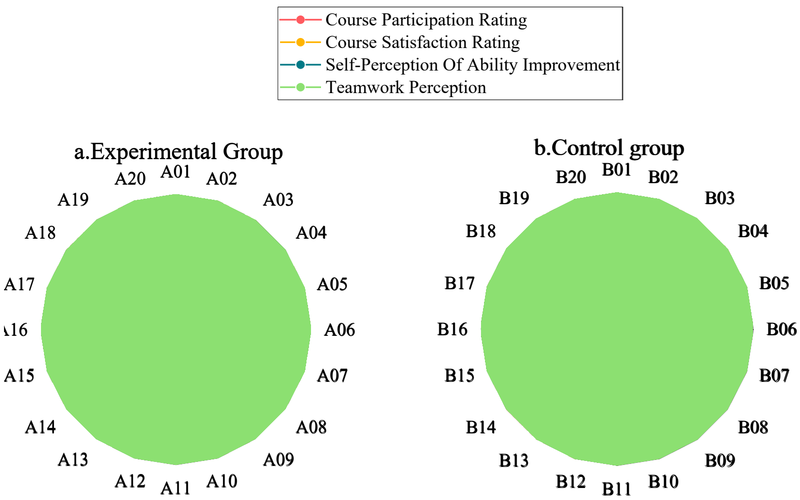

Figure 3 Student feedback questionnaire

The results in Figure 3 show that the experimental group is slightly better than the control group in most dimensions, especially in terms of ability improvement and collaborative experience, which reflects the positive role of design thinking-oriented teaching in promoting students' emotional involvement and cognitive acquisition. First, in terms of course participation scores, the experimental group scored an average of 4.6 points and the control group scored 3.55 points, the experimental group has a slightly higher proportion of "high score frequency" (5 points), indicating that its teaching activities are more attractive and participation-driven (as shown Figure 3a). In terms of course satisfaction rating, the experimental group scored an average of 4.7 points, the control group scored 3.55 (as shown in Figure 3b). In terms of self-perception of ability improvement, the experimental group scored an average of 4.65 points, higher than the control group's 3.55 points. Although this difference is not extreme, it reflects that the design thinking course is more effective in helping students identify and affirm their personal ability growth, such as innovative thinking, problem solving and expression skills. In the dimension of teamwork perception, the experimental group scored an average of 4.7 points, significantly higher than the control group's 3.45 points. This result is particularly prominent, indicating that the design thinking course is more effective in strengthening the collaboration mechanism and building group responsibility, and enhancing students' positive evaluation of teamwork.

5. Conclusions

This study focuses on "the paradigm shift of integrating design thinking into curriculum teaching", takes cognitive science as the theoretical basis, constructs a teaching model that integrates digital intelligence technology, and conducts empirical exploration in higher colleges. The paper first points out that the traditional design teaching model has problems such as rigid thinking path, insufficient student participation and static evaluation system, which makes it difficult to adapt to the learning style and ability structure of the new generation of students. To this end, the study started from the six stages of design thinking: understanding, observation, definition, conception, prototype and testing, and combined artificial intelligence, the Internet of Things and digital tools to build a new teaching paradigm with process, interactivity and intelligent characteristics. Overall, this study shows that the integration of digital intelligence technology and design thinking can effectively improve the process guidance, evaluation sensitivity and cognitive growth of teaching, and has a high practical promotion value. However, there are still some limitations, such as the limited number of samples, the short research period, and the differences in the adaptability of some students to intelligent tools. Future research can be expanded to more subject scenarios, enhance the depth of vertical tracking, and further improve the intelligent teaching support system and differentiated feedback mechanism.

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