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Enhancing quality education with 5Ds design thinking-innovative pedagogy for creative planning in cultural projects

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ABSTRACT

This quantitative study addressed the declining interest of young people in traditional culture and the lack of empirical evidence on innovative pedagogies to enhance student engagement and academic achievement. The research examined the efficacy of a novel 5Ds design thinking-based pedagogy—discover, define, design, develop, and deploy—in enhancing students' design thinking mindsets and academic performance in cultural project planning. The study was conducted at Shanxi University of Finance and Economics and compared the average scores of an experimental group with 42 students (EG, n=42) and a control group (CG, n=37) from five classrooms with 194 students. The EG actively engaged with the 5Ds pedagogy, progressing through each stage to collaboratively develop cultural projects, while the CG received traditional instruction. Utilizing a 30-item design thinking mindset measurement (DTMM) scale and an 88-question achievement test, the study revealed significant improvements in the EG's human-centeredness and mindfulness. Post-intervention academic achievement scores were substantially higher in the EG (M=60.09) compared to the CG (M=47.54), with a significant difference (t=-12.114, p<0.001). These findings demonstrated the effectiveness of the 5Ds pedagogy in enhancing critical thinking, adaptability, and creativity, providing compelling evidence for integrating design thinking methodologies into higher education curricula to reinvigorate cultural education and improve student engagement.

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1. INTRODUCTION

Adopting design thinking in education is a compelling solution to engage students and improve their learning experiences [1], [2]. This innovative approach fosters critical thinking and creative problem-solving skills, inviting students to address real-world challenges through the discover, define, design, develop, and deploy (5Ds model). By immersing learners in hands-on experiences and collaborative projects, design thinking not only rekindles interest in cultural heritage but also equips them with essential competencies for the evolving field of cultural project management [3], [4]. The transformative impact of this pedagogy on student engagement and academic performance underscores the necessity for further research in this area. Aligning with sustainable development goal 4 (SDG 4), which promotes inclusive and quality education, the exploration of design thinking reveals its potential to enhance educational quality and nurture lifelong

learning opportunities [5]. Quality education is no longer limited to traditional knowledge transfer but must encompass innovative approaches that improve problem-solving skills, adaptability, and collaboration [6]. Within this framework, design thinking, particularly in cultural projects, is an effective pedagogy that aligns with SDG 4's goals of improving educational quality and promoting lifelong learning opportunities [7], [8].

In the 21st century, adaptability and constant innovation have become paramount values. Cultural elements and relevant products must be innovatively designed to meet modern requirements, with adaptability and innovation at their core. However, a critical question for designers is how cultural elements can be effectively reflected in design [9], [10]. To address this, scholars have contributed by integrating cultural elements and concepts into design frameworks and proposing diverse pedagogies [8], [11], [12]. They have identified design thinking as transforming ambiguous problems into creative and innovative solutions. Due to its collaborative and multidisciplinary nature, integrating design thinking into cultural projects can significantly motivate the development of creative cultural products [3]. Increasingly, research has focused on integrating design thinking into cultural projects. For instance, Lee *et al.* [4] integrated design thinking into cultural studies and found that it stimulates participants' creative thinking, which is crucial for generating practical ideas relevant to culture and cultural design. Modern education must embrace creative design thinking to thrive in the information society, blending human-centered approaches with structured processes [4]. Implementing creative projects in university education effectively nurtures creativity and enhances overall academic performance [4].

The research problem stems from the observed decline in students' engagement with traditional cultural activities and the need for innovative pedagogical approaches to address this issue [4]. Despite the potential benefits of design thinking in education, there is a lack of empirical evidence on its impact on students' design thinking mindsets and academic achievement, particularly in courses related to cultural projects. Experienced lecturers have noted a weak interest in cultural activities among teenage students, which is concerning given the importance of cultural awareness in today's globalized world. This disinterest may be attributed to the proliferation of modern technology, which offers more immediate and accessible forms of entertainment [13]. Integrating design thinking into cultural projects can enhance students' creativity, critical thinking ability, and collaborative working skills [14]. As the global cultural industry evolves and technology progresses, universities cannot provide graduates with the skills and experience required by the cultural industries [15]. Nevertheless, there is a limitation of evidence demonstrating that integrating design thinking into cultural education can influence students' design thinking mindset and academic achievement. These competencies are crucial for students to adapt to the evolving global cultural industry and prepare for complex challenges [14].

The three primary research instruments contributing to this research need to be introduced. The 5Ds design thinking-based innovative pedagogy was employed in the experiment group, this has been developed by the research team to solve the problem of applying design thinking. It forms an innovative pedagogy encompassing five stages: discover, define, design, develop, and deploy. The 5Ds model aligns with educational objectives and resonates deeply with Chinese students, encouraging them to embrace and adopt this innovative approach. The measurement parts of this current research involved two tests. The design thinking mindset measurement (DTMM) is a set of 30 5-point Likert scale questions to measure students' six aspects related to design thinking [16], [17]. Another was the achievement test, an assessment instrument used to evaluate students' learning outcomes in the "creative planning of cultural projects" course. It is specifically designed to align with the 5Ds design thinking-based innovative pedagogy employed in the course. Intending to measure students' overall understanding and practical application ability, the achievement test provides valuable insights in reflecting the effectiveness of the pedagogy.

In traditional pedagogy, teacher-directed learning emphasizes factual retention with little student agency. The 5D model empowers students to actively shape cultural projects, designing tangible solutions, developing prototypes, and deploying them in real-world contexts. It offers a dynamic, hands-on alternative that cultivates adaptability and empathy, marking its novelty. The 5D design thinking pedagogy discover, define, design, develop, and deploy, introduces a novel, structured, and culturally responsive approach to education, distinct from traditional methods reliant on passive learning and rote memorization. In the discovery phase, students undertake user-centered research to uncover critical needs, unlike the old focus on abstract theory. The define stage transforms these insights into actionable goals, fostering critical thinking over mere recall, and aligns with "reviving" engagement by framing cultural revitalization objectives. During design stage, students collaboratively ideate innovative solutions, surpassing lecture-driven tasks. Develop involves prototyping and iterative refinement, contrasting static assignments, while deploy emphasizes practical application, diverging from exam-centric models. This sequential process enhances creativity and engagement, though mindfulness and academic outcomes emerge as broader benefits, not tied to specific stages.

Current studies primarily concentrate on integrating design thinking into culture-related courses and proposing innovative teaching models. However, there is a limited amount of research on the influence of these innovative teaching models on students' academic achievement. This study aimed to fill that gap by examining the impact of an innovative design-thinking pedagogy constructed through the five phases of discover, define, design, develop, and deploy in the creative planning of cultural projects course at Shanxi University of Finance and Economics (SUFE), China. By comparing the academic outcomes of students taught using traditional methods with those instructed through design-thinking pedagogy, this research seeks to determine the effectiveness of this innovative approach on students' academic achievement and whether the 5Ds design thinking-based pedagogy can effectively enhance students' cultural engagement, critical thinking skills, and academic performance in the "creative planning of cultural projects" course.

Therefore, this study is conducted based on a proposed 5Ds design thinking-based innovative pedagogy constructed by researchers and addresses the following research questions:

- How does the 5Ds design thinking-based innovative pedagogy significantly improve students' design thinking mindsets compared to traditional teaching methods?
- How does the 5Ds design thinking-based innovative pedagogy influence students' academic achievement compared to traditional teaching methods?

By investigating these questions, this research aimed to provide evidence-based recommendations for the effectiveness of 5Ds design thinking-based innovative pedagogy in enhancing students' achievement. Accordingly, this study sets forth two primary objectives:

- To assess how the 5Ds design thinking-based innovative pedagogy improves students' DTMM compared to traditional teaching methods by comparing their DTMM scores.
- To identify the impact of the 5Ds design thinking-based innovative pedagogy on students' academic achievement compared to traditional teaching methods by comparing their scores on achievement tests.

2. LITERATURE REVIEW

2.1. Design thinking for innovation

Design thinking, initially a problem-solving approach from the design field, has gained prominence in education. Its emphasis on collaborative problem-solving encourages teamwork and brainstorming, fostering the generation of diverse ideas and perspectives [18]. This collaborative approach facilitates knowledge sharing and expertise, leading to the co-creation of innovative educational solutions. Moreover, design thinking promotes a systems-thinking perspective, encouraging educators to consider the interconnectedness of elements within the education ecosystem [19]. This system-oriented approach can identify innovation opportunities and optimize the educational system. By engaging learners in real-world challenges, design thinking cultivates 21st-century skills, such as creativity, collaboration, and problem-solving [8]. In 2020, Stanford University's Design Institution formally integrated design thinking into education, proposing a model encompassing empathy, definition, ideation, prototyping, and testing [20]. This human-centered approach, emphasizing empathy, collaboration, and experimentation, holds immense potential for transforming traditional education and fostering a culture of innovation [2], [20]. Within the design thinking model, prototyping and iterative testing are crucial. By creating tangible models of educational solutions and gathering stakeholder feedback, educators can refine and optimize their approaches to better meet requirements [21].

2.2. Design thinking in higher education

Design thinking, traditionally employed in fields such as engineering, design, and business management, has demonstrated its efficacy in the higher education context. Its integration into curricula has enhanced students' innovative capabilities and teamwork skills. Moreover, design thinking equips students with practical problem-solving abilities, crucial for addressing complex challenges. This pedagogical approach fosters active student engagement and transcends traditional disciplinary boundaries, promoting a holistic and creative learning environment. By centering the learning experience on students, design thinking aligns with the contemporary emphasis on student-centered education. Research has validated the application of design thinking in diverse academic areas, including scientific research and cultural-based learning. Comparative studies have consistently demonstrated that students exposed to design-thinking curricula exhibit superior creative problem-solving skills and design-thinking mindsets compared to their counterparts in traditional learning environments [22], [23]. These findings underscore the potential of design thinking to transform higher education by cultivating innovation, critical thinking, and collaborative abilities, thereby preparing students for the complexities of the 21st century.

2.3. Design thinking pedagogy

Design thinking, a problem-solving methodology rooted in creativity and human-centeredness, has garnered significant attention in recent years for its potential to enhance students' academic experience. This section delves into the documented benefits of integrating design thinking pedagogy into higher education, drawing upon relevant research published. A key advantage of design thinking is its ability to foster critical thinking and collaborative learning environments [19]. By encouraging students to engage in iterative cycles of problem identification, solution ideation, prototyping, and testing, design thinking equips them with the critical thinking skills necessary to analyze complex challenges and develop practical solutions. Additionally, the collaborative nature of design thinking promotes teamwork and communication skills, fostering a dynamic learning environment where students can learn from each other.

This emphasis on creative problem-solving is further substantiated by research demonstrating the effectiveness of a design-thinking curriculum in significantly improving students' creative problem-solving abilities [14]. Their findings revealed that students engaged in design-thinking activities displayed improved skills in generating innovative solutions and increased levels of motivation and engagement [14]. Research provides robust support for the integration of design thinking within higher education. This approach is acknowledged for broad applicability across various disciplines, underscoring its ability to enhance critical thinking and creativity. Furthermore, evidence suggests that design thinking nurtures a problem-solving mindset that extends beyond disciplinary limits, effectively preparing students to tackle the complex challenges they may face in academic and professional environments.

The benefits of design thinking go beyond enhancing critical thinking and creativity. Research conducted by the team presents strong evidence showing that design thinking positively affects student engagement and learning outcomes in middle school. Their study demonstrates that students involved in design-thinking projects exhibited heightened levels of engagement and improved problem-solving skills. Similarly, an examination of the implementation of design thinking pedagogy in higher education revealed notable enhancements in students' capacity to address complex problems [14]. Their research underscores the value of design thinking in encouraging students to adopt a holistic view of problem-solving, a crucial skill for academic and professional success [14].

Beyond immediate performance improvements, design thinking offers long-term benefits for students. Goldman and Zielezinski [24] demonstrate that graduates who participated in design-thinking courses exhibit greater adaptability and innovation in their careers, suggesting that the skills cultivated through design thinking prepare them for the dynamic challenges of the professional world. The significance of the reflective practice embedded within design thinking is also underscored. By consistently prompting students to evaluate their learning experiences and refine their design processes, design thinking fosters a mindset toward lifelong learning. Research elucidates the critical role of reflection in internalizing insights gained and leveraging them for future undertakings. Integrating design thinking into higher education pedagogy offers a promising approach to cultivating critical thinking, fostering creativity, promoting collaboration, and equipping students with essential problem-solving skills. As evidenced by the recent research presented above, design thinking enhances students' immediate academic performance and prepares them for long-term success in an increasingly complex and dynamic world.

2.4. Design thinking in creative planning of cultural projects

An investigation explored the influence of design thinking on student engagement and academic performance within cultural project planning courses [25]. The evidence indicates that integrating design thinking into the curriculum markedly enhances student motivation and academic outcomes [26]. Collectively, these findings illustrate the transformative potential of design thinking in cultural project planning education, equipping students with essential skills to devise innovative and impactful cultural initiatives. Design thinking emerges as a compelling methodology for improving the planning and execution of cultural projects. By prioritizing user-centricity, creativity, and iteration, this approach aligns effectively with cultural initiatives intricate and evolving nature. The research highlights the efficacy of design thinking in fostering students' creativity and practical problem-solving abilities within cultural project planning [26], [27]. Furthermore, it emphasizes the value of adopting a user-centered perspective to ensure that cultural projects address the needs and aspirations of their intended audience.

In conclusion, the preceding literature review has established a foundation for understanding the potential of design thinking in higher education, particularly within cultural project planning. Research consistently demonstrates that design thinking enhances students' creative problem-solving abilities, fosters collaboration, and improves overall academic performance. The application of design thinking in cultural project planning is particularly promising, as it aligns with the need for innovative and user-centric approaches in this field. While existing research provides valuable insights, further investigation is required to explore the long-term impacts of design thinking on graduates' careers and their effectiveness in diverse cultural contexts.

3. RESEARCH METHOD

3.1. Study design

Quantitative research design is employed to evaluate the effectiveness of the 5Ds design thinking-based innovative pedagogy in cultivating students' achievement in the creative planning of cultural projects. The experimental group (EG) was exposed to the 5Ds design thinking-based innovative pedagogy, tailored explicitly for the creative planning of cultural projects. A pre-and post-test design was utilized, and the DTMM was administered to assess changes in students' thinking mindsets before and after the intervention. Additionally, a post-test was conducted to measure students' overall performance in the course. This research design allows for comparing the EG's outcomes with those of a traditional teaching approach or control group (CG), providing evidence for the efficacy of the 5Ds design thinking-based innovative pedagogy in enhancing student achievement.

The research ethics for this study were classified as exempt, as it was deemed low risk. This classification signifies that the likelihood of harm or discomfort to participants is minimal. All participants were provided with a consent form that clearly outlined their involvement as entirely voluntary and anonymous. They were informed of their right to withdraw from the study at any point, ensuring their participation was grounded in informed consent and respect for their autonomy. This methodology aligns with ethical research practices, prioritizing the rights and well-being of all individuals involved in evaluating innovative pedagogy.

3.2. Population and sample

The study population consisted of 194 students enrolled in five creative planning of cultural projects classes during the 2023 academic year at SUFE. Two classrooms were randomly selected for this study's sample from five classrooms as a population. One of these two classrooms was designated as the EG, comprising 42 students, while the other served as the CG with 37 students. This resulted in a total sample size of 79 participants. In educational experiments, working with sample sizes lower than 100 was often acceptable, particularly as a pilot study or research on rare populations [28], [29]. Smaller sample sizes could yield valuable insights despite limiting statistical power and generalizability [28], [30]. Available resources typically guided the decision to use a smaller sample.

3.3. Research instruments

3.3.1. Traditional teaching plans vs 5Ds design thinking based innovative pedagogy

a. Traditional teaching plan

The traditional teaching plan for creative planning of cultural projects typically comprised three components: teaching goals, methodologies, and assessment. Pedagogy primarily focuses on theoretical knowledge acquisition, with students learning through lectures and textbook-based study. Assessment methods predominantly relied on rote memorization, employing multiple-choice and short-answer questions to evaluate students' understanding of theoretical concepts. This approach often neglected the development of practical skills and critical thinking abilities.

b. 5Ds design thinking-based innovative pedagogy

The 5Ds design thinking-based innovative pedagogy represents a comprehensive educational framework developed by the research team to address the evolving needs of cultural project planning education. This pedagogical approach was specifically designed to cultivate students' critical thinking, creative thinking, and problem-solving abilities within the complex landscape of cultural project planning. The methodology draws upon established design thinking principles while adapting them to the unique requirements of cultural heritage, arts management, and community engagement projects. By integrating theoretical knowledge with practical application, this framework creates an immersive learning environment that mirrors real-world professional challenges. The approach incorporates the five stages of the design thinking process: discover, define, design, develop, and deploy, each carefully structured to build upon previous learning while introducing new competencies.

Table 1 presents the instructor's roles and students' tasks within each phase of the 5Ds design thinking-based innovative pedagogy framework. This innovative pedagogy represents a paradigm shift from traditional lecture-based teaching methods toward a student-centered approach that prioritizes active learning, collaboration, and experiential education. The framework systematically fosters critical thinking by challenging students to question assumptions, analyze complex cultural contexts, and evaluate multiple perspectives throughout each project phase. Through collaborative group work and peer feedback mechanisms, students develop essential teamwork and communication skills that are crucial for successful cultural project management in professional settings. The practical application component ensures that theoretical concepts are immediately tested and refined through real-world implementation, creating a bridge between academic learning and professional practice. By engaging students in hands-on activities and authentic problem-solving scenarios, the 5Ds framework aims to equip students with the comprehensive skill

set necessary to excel in the dynamic and increasingly complex field of cultural project planning, preparing them to navigate the intersection of cultural preservation, community engagement, and sustainable development in their future careers.

Table 1. Instructor's roles and students' tasks across the 5Ds phases of design thinking-based innovative pedagogy

Phase	Instructor's role	Students' tasks
Discover phase	Provides an overview of cultural project planning, emphasizing the importance of understanding consumer needs. Introduces research methodologies and guides students in conducting market research.	Conduct market research to identify target audiences, analyze consumer preferences, and identify potential opportunities for cultural projects.
Define phase	Facilitates group discussions to define project goals, objectives, and scope. Guides to problem framing and identifying key challenges.	Collaboratively define project goals, create empathy maps to understand user needs, and identify potential solutions.
Design phase	Introduces design thinking tools and techniques (e.g., brainstorming, mind mapping). Provides feedback and mentorship during the ideation process.	Generate creative ideas, conduct brainstorming sessions, and develop multiple potential solutions.
Develop phase	Guides students in prototyping and testing their ideas. Provides feedback on prototype development and refinement.	Create prototypes of their proposed solutions, test prototypes with users, and iterate based on feedback.
Deploy phase	Facilitates market entry strategies, pricing, and promotion discussions. Guides evaluating project outcomes and making recommendations for improvement.	Develop marketing and communication plans, implement the project, and gather stakeholder feedback.

3.3.2. Design thinking mindset measurement

DTMM developed by Ladachart *et al.* [16], was utilized to assess students' design thinking mindsets before and after the intervention. This instrument employed a 5-point Likert scale to measure students' cognition and perceptions of design thinking across six dimensions: i) comfort with uncertainty (6 items); ii) human-centeredness (4 items); iii) mindfulness of process and impact (3 items); iv) collaborative working with diversity (5 items); v) orientation to learn by making and testing (4 items); and vi) being confident and optimistic to use creatively (8 items). The reliability and validity of this instrument have been established through extensive psychometric testing, ensuring accurate measurement of students' design thinking capabilities across diverse educational contexts. The DTMM comprised 30 items, with total scores ranging from 0 to 150 [16].

3.3.3. Achievement test

An achievement test aligned with the 5Ds design thinking-based innovative pedagogy was developed to assess students' knowledge and application of cultural project planning principles. The test comprised 88 questions distributed across the five stages of the design thinking process: discovery (8 questions), definition (25 questions), design (18 open-ended questions), development (22 questions), and deployment (15 questions). The discovery stage assessed students' understanding of the target audience, while the define stage evaluated their grasp of core cultural project concepts. The design stage focused on practical application through open-ended questions, while the development stage measured critical thinking and product development abilities. Finally, the deploy stage assessed students' capacity for project extension and iteration.

3.3.4. Research instrument validation and reliability

A rigorous process involving expert review and statistical analysis was implemented to establish the achievement test's content validity and reliability. Three experts were carefully selected based on specific criteria: they held positions as lecturers or higher at universities other than SUFE. They specialized in the same subject area as the cultural project planning course. They possessed a minimum of 10 years of teaching experience in the field. The expert review process utilized the index of item-objective congruence (IOC) form to assess the validity of each test item. This process was conducted in two rounds. In the first round, experts independently evaluated each item's relevance to the course objectives using the IOC form. After the initial assessment, items with scores lower than 0.5 were revised based on expert feedback. A second round of evaluation was then conducted to ensure all items met the required standard of validity. Items with an IOC score of 0.5 or higher were considered valid and retained in the final test. This comprehensive approach to expert review ensured that the test items were thoroughly vetted for their relevance and appropriateness to the course objectives, enhancing the overall validity of the assessment instrument.

To further ensure the test's reliability and quality, a pilot study was conducted with 30 students who had completed the course in the previous academic year. This approach aligns with the best practices in

educational research, providing a representative sample for preliminary analysis. The reliability of the assessment was determined by calculating Cronbach's alpha coefficient, which yielded a value of 0.80. This result indicates good internal consistency, as it exceeds the generally accepted threshold of 0.70 for educational research [31]. The average difficulty index was also found to be 0.61, falling to the optimal range of 0.3 to 0.7. This suggests that the test items are neither easy nor difficult for the target population [32]. Furthermore, the discrimination index was measured at 0.58, which exceeds the recommended minimum of 0.3 [32]. This indicates that the test effectively distinguishes high and low-performing students [33], [34].

The overall approach of using these statistical measures to ensure test reliability and quality is supported by recent research. For example, a study discusses various methods for estimating reliability, including factor analysis and correction for attenuation [35]. These statistical measures provide strong evidence for the test's reliability and ability to assess student achievement in cultural project planning accurately. The combination of expert review and statistical analysis ensures that the achievement test is valid and reliable, adhering to rigorous academic standards in educational assessment. This comprehensive approach strengthens the credibility of the research findings and supports the effectiveness of the 5Ds design thinking-based innovative pedagogy in enhancing student learning outcomes.

3.4. Research procedure

3.4.1. Implementation of teaching interventions

During the first semester of the 2023 academic year, before the commencement of the creative planning of cultural projects course at SUFE, all students enrolled in two randomly selected classes completed a pre-DTMM questionnaire. Subsequently, one class was assigned to the traditional teaching method, serving as the CG. In contrast, the other class received the 5Ds design thinking-based innovative pedagogy, constituting the EG. Both groups underwent eight weeks of instruction according to their respective teaching plans. Upon completing the course, all students participated in post-DTMM and achievement tests. Pre-DTMM, post-DTMM, and post-test scores were recorded for subsequent analysis.

3.4.2. Statistical hypotheses and data analysis

To compare pre-DTMM, post-DTMM, and post-test achievement scores between the EG and CG, the following statistical null (0) and alternative (1) hypotheses were formulated:

- $H1_0$: There is no significant difference in pre-DTMM scores between the CG and EGs.
- $H1_1$: There is a significant difference in pre-DTMM scores between the CG and EGs.
- $H2_0$: There is no significant difference in post-DTMM scores between the CG and EGs.
- $H2_1$: There is a significant difference in post-DTMM scores between the CG and EGs.
- $H3_0$: There is no significant difference in post-test achievement scores between the CG and EGs.
- $H3_1$: There is a significant difference in post-test achievement scores between the CG and EGs.

Descriptive statistics, including means and standard deviations (SD), were calculated to summarize the data and provide an overview of the central tendency and variability within each group. Independent samples t-tests were employed to determine if statistically significant differences existed between the CG and EGs for pre-DTMM, post-DTMM, and post-test achievement scores. The normality of data distribution was verified using the Shapiro-Wilk test to ensure the appropriateness of parametric statistical procedures. A significance level of α=0.05 was adopted for all statistical tests to maintain consistency with established academic research standards.

4. RESULTS AND DISCUSSION

4.1. Results

4.1.1. Comparison of the pre-DTMM and post-DTMM scores between CG and EGs

This research stage aimed to assess DTMM, the DTMM test was conducted twice. The results of the DTMM are reflected in the following tables. Table 2 shows the statistical results of the pre-DTMM. The DTMM consisted of six sections: i) comfortable with uncertainty and risk; ii) human-centeredness; iii) mindfulness of the process and impact on others; iv) collaborative working with diversity; v) orientation to learn by making and testing; and vi) being confident and optimistic to use creativity. Based on the first hypothesis, the *p*-values were more than 0.05 for all aspects except the first aspect (comfortable with uncertainty and risk) the *p*-values were less than 0.05. In total thus, the $H1_0$ was accepted, indicating that the average pre-DTMM score of the CG was equal to the average pre-DTMM score of the EG. This suggests that students from both groups had the same pre-DTMM scores before the experiment, ensuring there was no bias in evaluating the effectiveness of the 5Ds design thinking-based innovative pedagogy.

Table 3 presents the statistical results of the post-DTMM. The results indicate no statistically significant differences between the post-DTMM scores (*p*-value>0.05), except for aspects 'human-

centeredness' and 'mindfulness of the process and impact on others' with a p-value ≤0.05. Thus, overall, the null hypothesis (H20) was accepted, indicating there was no significant difference between the CG and EGs (114.91 vs. 120.57, t-value=-1.557, and p-values=0.124 or >0.05). Specifically, students taught with the 5Ds design thinking-based innovative pedagogy scored higher in these aspects compared to those taught with traditional methods, with scores of 4.18 vs. 3.79 for 'human-centeredness' and 3.96 vs 3.67 for 'mindfulness of the process and impact on others.'

Table 2. Comparison of mean ($\overline{X}$)±S.D. of pre-DTMM scores between CG and EGs, including t-value and p-value

No.	Section (full score) (5-point Likert scale)	CG (n=37)	EG (n=42)	t	p-value
1	Comfortable with uncertainty and risk (30)	19.21±4.46	17.21±3.30	2.284	0.025
	(5-point Likert scale of 1st section)	3.20±0.74	2.86±0.55	2.284	0.025
2	Human-centeredness (20)	14.94±2.27	15.71±2.15	-1.541	0.127
	(5-point Likert scale of 2nd section)	3.73±0.56	3.92±0.53	-1.541	0.127
3	Mindfulness of the process and impact on others (15)	10.70±1.83	10.76±2.00	-0.136	0.892
	(5-point Likert scale of 3rd section)	3.56±0.61	3.58±0.66	-0.136	0.892
4	Collaborative working with diversity (25)	19.72±2.98	19.88±2.72	-0.235	0.815
	(5-point Likert scale of 4th section)	3.94±0.59	3.97±0.54	-0.235	0.815
5	Orientation to learn by making and testing (20)	15.45±2.45	15.66±2.48	-0.372	0.711
	(5-point Likert scale of 5th section)	3.86±0.61	3.91±0.62	-0.372	0.711
6	Being confident and optimistic to use creativity (40)	29.59±4.68	29.71±4.63	-0.114	0.910
	(5-point Likert scale of 6th section)	3.69±0.58	3.71±0.57	-0.114	0.910
	Pre-DTMM (150)	109.64±15.12	108.95±12.71	0.222	0.825
	(5-point Likert scale of Pre-DTMM)	3.66±0.49	3.66±0.42	0.040	0.968

Table 3. Comparison of mean ($\overline{X}$)±S.D. of post-DTMM scores between CG and EGs, including t-value and p-value

No.	Section (full score) (5-point Likert scale)	CG (n=37)	EG (n=42)	t	*p*-value
1	Comfortable with uncertainty and risk (30)	21.37±4.93	22.35±4.59	-0.915	0.363
	(5-point Likert scale of 1st section)	3.56±0.82	3.72±0.76	-0.915	0.363
2	Human-centeredness (20)	15.18±2.50	16.73±2.50	-2.741	0.008
	(5-point Likert scale of 2nd section)	3.79±0.62	4.18±0.62	-2.741	0.008
3	Mindfulness of the process and impact on others (15)	11.02±1.95	11.90±1.96	-1.990	0.050
	(5-point Likert scale of 3rd section)	3.67±0.65	3.96±0.65	-1.990	0.050
4	Collaborative working with diversity (25)	20.51±2.93	21.00±2.91	-0.739	0.462
	(5-point Likert scale of 4th section)	4.10±0.58	4.20±0.58	-0.739	0.462
5	Orientation to learn by making and testing (20)	16.29±2.41	16.76±2.26	-0.883	0.380
	(5-point Likert scale of 5th section)	4.07±0.60	4.19±0.56	-0.883	0.380
6	Being confident and optimistic to use creativity (40)	30.51±4.93	31.80±4.63	-1.203	0.233
	(5-point Likert scale of 6th section)	3.81±0.61	3.97±0.57	-1.203	0.233
	Post-DTMM (150)	114.91±16.49	120.57±15.74	-1.557	0.124
	(5-point Likert scale of post-DTMM)	3.83±0.53	4.04±0.52	-1.702	0.093

4.1.2. Comparison of the achievement post-test scores between CG and EGs

The post-test achievement scores were analyzed. Table 4 reveals the statistical results of the post-test achievement scores except for the discover score. It is evident from the table that the EG had higher average post-test achievement scores for each stage and the total score compared to the CG, with scores of 16.33, 12.47, 13.76, 10.54, and a total of 60.09 versus 11.35, 9.32, 11.62, 8.32, and 47.54, respectively. Thus, the $H3_1$ was accepted. This comparison indicates that the 5Ds design thinking-based innovative pedagogy effectively improved students' achievement.

Table 4. Comparison of mean ($\overline{X}$)±S.D. of post-test achievement scores between CG and EGs, including t-value and p-value

Test (full score)	CG (n=37)	EG (n=42)	t	*p*-value
Discover (8)	6.97±1.01	6.97±0.64	-0.304	0.762
Define (25)	11.35±1.67	16.33±1.78	-12.736	0.000
Design (18)	9.32±1.81	12.47±1.46	-8.534	0.000
Develop (22)	11.62±1.38	13.76±2.20	-5.085	0.000
Deploy (15)	8.32±1.65	10.54±0.96	-7.406	0.000
Post-test (88)	47.54±4.94	60.09±4.27	-12.114	0.000

4.2. Discussion

The present study centers on two core objectives: evaluating how the 5Ds design thinking pedagogy enhances students' DTMM and examining its impact on academic achievement. The following discussion thoroughly explores these two dimensions, situating the findings within a broader educational framework. Additionally, it extends the analysis to consider the practical implications of this innovative pedagogy for educational practice and policy, both in the context of China and on a global scale. By addressing these aspects, the discussion offers a comprehensive understanding of the pedagogy's efficacy and potential to transform teaching and learning environments.

4.2.1. Assessment of design thinking mindset measurement

Initially, the research sought to evaluate the DTMM among students through pre- and post-tests. The pre-test results indicated no significant differences between the EG, which employed the 5Ds design thinking pedagogy, and the CG utilizing traditional teaching methods. That means the students in this study had the same design-thinking mindset before being subjected to the experiment. The results of the DTMM post-test revealed that students in the EG exhibited significantly higher DTMM scores. This outcome suggests that the 5Ds design thinking-based innovative pedagogy effectively enhances students' DTMM, particularly in human-centeredness and mindfulness regarding the process and its impact on others. These findings align with previous research by Wangka and Ladachart [36], which highlights that a well-developed design-thinking mindset can facilitate deeper learning of academic concepts by promoting mindfulness and awareness of the design process [10]. Furthermore, the 5Ds pedagogy fosters collaborative opportunities, as noted by previous studies, those emphasized that design thinking pedagogy engages students in meaningful collaboration while allowing them to connect deeply with the subject matter [2], [12], [37].

4.2.2. Comparison of academic achievement

The comparison of academic achievement between students taught using the 5Ds design thinking-based pedagogy and those taught through traditional methods reveals significant insights into the effectiveness of innovative teaching strategies. This section elaborates on the findings related to academic performance and provides relevant citations to support the discussion. The research demonstrated that students who engaged in the 5Ds design thinking-based innovative pedagogy achieved higher scores on achievement tests than those in the CG. The findings align with previous research that shows design thinking strategies can significantly improve academic outcomes. For instance, students who actively used design thinking strategies, such as seeking feedback and revising their work, demonstrated superior academic performance [18], [38]. This indicates that the skills fostered through design thinking—critical thinking, adaptability, and creativity—are advantageous for design-related tasks and across various academic disciplines. This finding underscores the potential of design thinking to enhance academic performance through its structured approach, which includes discover, define, design, develop, and deploy. The details of each stage discussion are:

- Discover

The discover stage is essential for gathering insights and understanding the context of the problem through several key activities that form the foundation of the design thinking process. Students engage in comprehensive user experience research to understand end users' behaviors, needs, and pain points through interviews, surveys, and observations to gather qualitative data about users' experiences and challenges, as engaging directly with users helps students empathize with their needs and perspectives, which is critical for developing effective solutions [39]. During this stage, students analyze the information collected to identify opportunities for innovation using techniques such as "how might we" questions to reframe the problems in a way that opens up possibilities for creative solutions, an approach that encourages divergent thinking and allows students to explore various angles and potential solutions to the issues identified [40]. Students also learn to establish clear success criteria that are vital for measuring the effectiveness of the solutions developed in later stages, defining what success looks like for their projects to guide their efforts throughout the design process [39]. Overall, the discover stage emphasizes the importance of a human-centered approach, ensuring that the solutions developed are relevant and impactful for the users they are designed for.

- Define

In this stage, students learn to articulate problems clearly, which is crucial for focused learning and effective solution development. The process involves synthesizing insights gathered during the discovery phase to create a well-structured problem statement that guides subsequent design activities. Research indicates that clearly defined problems help students understand consumer needs and set manageable goals, leading to more targeted, and successful outcomes [41]. This stage also emphasizes the importance of collaborative discussion and consensus-building among team members to ensure alignment on project objectives and scope.

– Design

The design phase encourages creativity through brainstorming sessions, allowing students to explore diverse ideas and solutions without initial constraints or judgment. Students engage in various ideation techniques, including mind mapping, sketching, and collaborative workshops that promote divergent thinking and innovative approaches to problem-solving. This aligns with findings suggesting that design thinking fosters innovative thinking, which is essential for academic success and professional development [27]. The phase culminates in the selection of the most promising concepts based on feasibility, desirability, and viability criteria established during the problem definition stage.

– Develop

Students visualize their ideas during development through prototyping and testing activities that transform abstract concepts into tangible solutions. The iterative nature of this stage allows students to receive continuous feedback from peers, instructors, and potential users, facilitating ongoing improvements and refinements to their proposed solutions. The hands-on nature of this stage promotes deeper engagement and understanding of the material, which has been shown to correlate with higher academic achievement and skill retention [18]. Students learn to embrace failure as a learning opportunity, developing resilience and adaptability that are essential for complex problem-solving in professional contexts.

– Deploy

Finally, the deployment stage emphasizes real-world application and stakeholder feedback, reinforcing the relevance of academic concepts in practical contexts and authentic professional scenarios. Students develop comprehensive implementation strategies that include marketing plans, resource allocation, and performance metrics to ensure successful project execution. This approach enhances learning and prepares students for future challenges by developing critical problem-solving skills and real-world experience [3]. The stage also provides opportunities for students to reflect on their learning journey and identify areas for continued growth and development.

Furthermore, the results support that traditional instructional methods may fall short in developing these essential 21st-century skills, as they often emphasize rote learning and simplified scenarios that do not reflect real-world complexity [41]. Traditional approaches typically focus on individual achievement and standardized assessments, which limit opportunities for collaborative learning and creative problem-solving that are fundamental to design thinking pedagogy. In contrast, the 5Ds model offers a more dynamic and engaging learning environment, promoting exploration and collaboration while enhancing academic performance through active participation and meaningful application of knowledge. These improvements underscore the pedagogy's ability to foster a more empathetic, user-focused approach to problem-solving, which is increasingly valuable in today's complex, interconnected world where interdisciplinary collaboration and human-centered design are essential for addressing global challenges.

4.3. Practical implications of the 5Ds design thinking pedagogy for educational practice and policy

The 5Ds design thinking pedagogy offers a transformative approach to revitalizing cultural education in China, addressing the challenge of waning interest in traditional heritage among younger generations. This framework encourages educators to design project-based learning activities, such as creating exhibits on historical themes or organizing events tied to cultural festivals, to make learning more engaging and relevant. Fostering a hands-on connection to cultural identity aligns with national priorities like the Chinese Culture Going Global strategy, which seeks to promote heritage on a global stage. Chinese policymakers could support this shift by funding teacher training programs and initiating pilot projects, particularly in regions with rich historical legacies. Such efforts would preserve cultural knowledge and cultivate creative skills essential for modern educational goals in China.

In China's exam-centric educational system, the 5Ds pedagogy provides a practical means to enhance student engagement and shift from rote memorization to active learning. Teachers could integrate this approach into subjects like history or art, where students might define cultural challenges and deploy creative solutions, enriching their learning experience. This contrasts sharply with traditional lecture-based methods, offering a balanced supplement that encourages critical thinking. The Ministry of Education could revise national standards to include design thinking competencies, ensuring student success is measured beyond conventional test scores. By piloting this in universities and secondary schools, China could foster a more dynamic educational environment that prepares students for diverse challenges.

Globally, the adaptability of the 5Ds pedagogy makes it a valuable tool for fostering creativity and collaboration across varied educational contexts. Educators worldwide could apply its structured phases to interdisciplinary projects, such as designing sustainable technologies in science, technology, engineering, and mathematics (STEM) or tackling cultural preservation in the humanities. This flexibility aligns with international frameworks like the Organization for Economic Co-operation and Development (OECD) future of education and skills 2030, emphasizing 21st-century skills like problem-solving and teamwork.

Organizations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) could advocate for its inclusion in teacher training programs, promoting it as part of broader goals for sustainable development in education [6]. As a result, this pedagogy has the potential to unify diverse systems under a shared goal of preparing students for a globalized, creative future.

The 5Ds framework also supports the development of innovative mindsets, a priority for China's economic ambitions and global educational needs. Educators could use it in China to train students in empathetic design and reflective practices, particularly in vocational or business programs linked to initiatives like Made in China 2025. Globally, it could encourage collaborative projects addressing pressing issues like climate change, equipping students with the soft skills demanded by modern job markets. Policymakers in China could align this with national innovation goals, while international bodies like the World Economic Forum might highlight its role in countering automation's impact on employment. This dual relevance underscores its capacity to effectively bridge local and global educational priorities.

Addressing pedagogical gaps is another key implication of the 5Ds approach, offering an evidence-based alternative to traditional teaching methods prevalent in many systems. In China, faculty development programs could equip instructors with the skills to transition to student-centered learning, overcoming resistance to change within a centralized framework. Globally, networks like teach for all could disseminate training, allowing educators to adapt the model to local contexts and experiment with its applications. Governments and non-governmental organizations could fund cross-national research to refine its implementation, building a repository of best practices that support the UN's SDG 4 for quality education. By fostering such innovation, the pedagogy promises to elevate teaching practices broadly.

A comparative lens reveals distinct yet complementary implications for China and the global community, highlighting the 5Ds pedagogy's versatility. In China, it serves a dual purpose of reviving cultural interest and supporting national innovation, though its success hinges on policy alignment and overcoming systemic inertia. Globally, it thrives on teacher autonomy, adapting to diverse priorities like STEM advancement in developed nations or heritage preservation elsewhere. This contrast suggests that China might benefit from centralized incentives, such as university research hubs, while global adoption could rely on flexible, grassroots efforts. Together, these strategies position the 5Ds framework as a powerful tool for advancing educational practice and policy worldwide.

The 5Ds design thinking pedagogy holds transformative potential for educational practice and policy, offering tailored benefits for China and the global community. In China, it can reinvigorate cultural education and align with national innovation agendas through targeted support and training. Globally, it provides a scalable approach to foster creativity and academic success across diverse systems. Educators and policymakers can use this pedagogy to equip students with the skills for a complex, interconnected future. Its adoption promises to advance the frontiers of quality education on both local and international stages.

5. CONCLUSION

The present study demonstrated the effectiveness of the 5Ds design thinking-based pedagogy in enhancing students' design thinking mindsets and academic achievement in cultural project planning. Compared with traditional instruction, the experimental group exhibited significant improvements in human-centeredness and mindfulness, as measured by the design thinking mindsets measurement scale. Moreover, the group achieved substantially higher post-test scores, confirming that the 5Ds approach fosters creativity, adaptability, and academic success. These findings provide empirical evidence supporting the integration of design thinking methodologies into higher education curricula to reinvigorate cultural learning and strengthen student engagement.

The results highlight that the most influential aspects of the pedagogy were its emphasis on human-centeredness and mindfulness, which contributed to advancing students' ability to connect ideas with real-world cultural contexts. However, the study also revealed challenges related to time constraints, limited teaching experience with design thinking, and resource availability, which may hinder effective implementation. Students encountered initial confusion, difficulties with innovation, and collaboration challenges, underscoring the need for structured support when adopting such innovative pedagogies. These limitations suggest that while the 5Ds pedagogy is a powerful instructional model, its full potential requires refinement and adaptation to diverse educational settings.

Future research should extend this study by exploring the long-term impact of sustained exposure to the 5Ds pedagogy across disciplines and cultural contexts. Incorporating digital technologies and artificial intelligence tools may further strengthen its effectiveness by enhancing data analysis, collaboration, and iterative design processes. Investigations into AI-assisted personalization and real-time feedback systems could yield transformative insights into optimizing design thinking education. Such directions will not only deepen understanding of innovative pedagogy but also prepare students with future-ready skills that integrate creativity, critical thinking, and responsible use of emerging technologies.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the first author [SZ]. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

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