Article

Research on the Influence of Digital Transformation on the Cultivation of College Students' Innovative Ability and the Optimization Path

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Abstract: With the accelerated advancement of digital transformation, global higher education has undergone profound and irreversible changes in traditional teaching models, curriculum content, and pedagogical methodologies. The widespread application of advanced digital tools—such as artificial intelligence, big data analytics, and cloud computing—has not only fundamentally transformed students' daily learning approaches but also significantly impacted the systematic cultivation of their innovative capabilities. This paper comprehensively explores how modern information technology and intelligent educational tools can effectively enhance students' innovative abilities within the broader context of digital transformation. Extensive research indicates that digital transformation has substantially improved students' innovative thinking and complex problem-solving skills by promoting highly personalized learning pathways, enhancing immersive and interactive learning experiences, and ultimately improving overall learning efficiency. However, critical challenges remain deeply embedded in this transitional phase. Issues such as uneven technology adoption across different regions, insufficient faculty resources and digital literacy training, and outdated innovation education concepts persistently hinder optimal outcomes. To address these critical barriers, this paper further analyzes the underlying causes of these challenges and proposes strategic pathways for optimizing innovative ability cultivation in higher education. Key recommendations include upgrading digital infrastructure, redesigning curricula to integrate technological competencies, and fostering continuous professional development for educators. Ultimately, this study aims to provide robust theoretical support and actionable practical guidance for ongoing educational reform in the digital era.

Keywords: digital transformation; higher education; innovation capability; information technology; teaching models; educational reform

Received: 30 December 2025
Revised: 10 February 2026
Accepted: 21 February 2026
Published: 28 February 2026

1. Introduction

With the rapid advancement of information technology, digital transformation has become a pervasive force across all industries, including education. Higher education, as a cornerstone for cultivating talent, is experiencing significant shifts in its teaching models, content, and methodologies. In particular, the integration of digital tools has created unprecedented opportunities for fostering students' innovative capabilities. By leveraging intelligent learning platforms, online courses, virtual laboratories, and other advanced tools, universities can offer students highly personalized learning experiences and access to broader creative environments. These technologies not only enhance the efficiency of knowledge dissemination but also empower students to explore and experiment in ways that were previously unattainable. The potential for digital transformation to reshape educational practices is immense, providing a foundation for more dynamic and adaptive learning ecosystems that cater to individual needs and aspirations [1, 2].

While digital transformation offers numerous opportunities, universities face significant challenges in effectively utilizing these technologies to nurture students'

innovative capabilities [3]. Developing innovation requires more than merely updating course content; it necessitates a holistic overhaul of teaching methodologies, educational resources, and learning environments. For instance, traditional lecture-based approaches may need to be replaced or supplemented with interactive and experiential learning models that encourage critical thinking and problem-solving. Furthermore, the integration of digital tools must be accompanied by adequate training for educators to ensure they can effectively guide students in using these technologies. This paper delves into the ways digital transformation can enhance students' innovative development in higher education. It also examines the obstacles currently hindering progress and proposes targeted strategies for optimization, such as fostering interdisciplinary collaboration, enhancing digital infrastructure, and creating supportive policies to encourage innovation-driven learning.

2. Literature Review

2.1. The Impact of Digital Transformation on Higher Education

Digital transformation has significantly influenced higher education institutions, prompting a shift from traditional face-to-face teaching methods to online instruction and blended learning models. This evolution enhances learning efficiency by integrating advanced technological tools, providing students with access to a broader range of educational resources and interactive opportunities. Furthermore, the adoption of flexible knowledge acquisition methods allows for personalized learning experiences tailored to individual interests and academic needs [3, 4]. Such approaches not only improve student engagement but also foster innovative thinking and problem-solving skills. By leveraging digital platforms, institutions can create dynamic learning environments that adapt to the evolving demands of modern education systems.

2.2. The Relationship between the Cultivation of Innovation Ability and the Teaching Mode

Fostering innovation capabilities requires more than the mere transfer of knowledge; it must incorporate critical thinking, problem-solving, and teamwork into the educational framework. In the era of digital transformation, adopting project-based and problem-oriented learning models has proven to be an effective approach. These methods not only enhance students' innovative thinking but also significantly improve their practical skills by engaging them in real-world challenges [5]. Such teaching strategies ensure a holistic development of competencies essential for addressing complex, modern-day problems.

2.3. Application of Digital Tools in Cultivating Innovation Capabilities

The role of digital tools in fostering innovation capabilities has been extensively explored, highlighting their potential to enhance creative thinking and problem-solving skills in complex scenarios. Through the use of virtual experiments, intelligent teaching platforms, and big data analysis, these tools provide students with broader practical opportunities. They enable deeper knowledge understanding and application by offering real-time feedback and fostering interactive engagement. Such technologies not only simulate real-world challenges but also create dynamic learning environments that encourage students to experiment, iterate, and refine their approaches, ultimately cultivating a robust foundation for innovative thinking [5, 6].

3. Methodology

This study employs a mixed research design that combines quantitative questionnaire surveys with qualitative semi-structured interviews to investigate the relationship between digital transformation and the cultivation of innovation ability among college students [7, 8]. The research participants include full-time students and teachers from Hainan Vocational University of Science and Technology. The data collection period spanned from September to November 2025, ensuring a comprehensive timeframe for gathering insights.

A total of 1200 student questionnaires and 87 teacher questionnaires were distributed during the study. After excluding invalid responses characterized by incomplete answers or evident response bias, 924 valid student questionnaires and 71 valid teacher questionnaires were retained, yielding effective recovery rates of 77.0% and 81.6%, respectively [9]. The student sample encompasses 12 undergraduate majors, including engineering, management, literature, and science, thereby ensuring a diverse representation of disciplinary backgrounds and perspectives.

The student questionnaire was designed to assess four key dimensions: the frequency of digital learning tool usage, the acceptance of blended learning modes, self-assessment of innovative ability, and satisfaction with existing digital teaching resources. Meanwhile, the teacher questionnaire focused on evaluating their proficiency in digital teaching skills, the integration of digital tools into teaching design, and their assessment of the impact of digital tools on fostering students' innovation abilities [9, 10]. These dimensions were carefully selected to provide a holistic understanding of the interplay between digital tools and educational outcomes.

Following the questionnaire survey, 15 students from various majors and 10 teachers from diverse disciplines were chosen for semi-structured interviews. The interviews delved into participants' practical experiences with digital teaching, the challenges they perceive in digital learning environments, and their aspirations for future reforms in digital education. This qualitative approach complements the quantitative data by offering deeper insights into individual and collective experiences, thereby enriching the overall findings of the study.

Quantitative data analysis was conducted using SPSS 26.0 software, which facilitated descriptive statistical analysis, Pearson correlation analysis, and independent sample t-tests to examine the relationship between the application of digital tools and the performance of innovation abilities. For qualitative interview data, thematic coding analysis was employed to extract core viewpoints and identify representative cases, thereby providing nuanced explanations for the quantitative results. The reliability coefficient of the questionnaire was calculated at 0.87, meeting the academic standard for research reliability and ensuring the robustness of the study's findings [7, 11].

4. Results / Analysis

4.1. Overall Status of Digital Teaching Application and Innovation Ability Performance

Descriptive statistical results indicate that a significant proportion of students, specifically 68.2%, engage with digital learning tools more than three times per week [12, 13]. Additionally, 72.4% of teachers have incorporated digital tools into over half of their teaching sessions, demonstrating a widespread adoption of digital methodologies in educational practices. Despite this, the self-assessed innovation ability of students averages at 3.42 out of 5, suggesting that there remains considerable potential for enhancing innovation cultivation. This highlights the need for more targeted strategies to bridge the gap between digital tool usage and the development of innovative competencies among students.

The Pearson correlation analysis underscores a statistically significant positive relationship between the frequency of digital tool usage and students' innovation ability scores. The correlation coefficient of 0.523 at the 0.01 significance level confirms that increased engagement with digital tools is strongly associated with higher innovation ability. This finding substantiates the argument that the effective and deep integration of digital tools into teaching practices can play a pivotal role in fostering students' innovative capacities. Such results emphasize the importance of designing educational frameworks that prioritize the strategic use of digital technologies to maximize their impact on innovation development.

4.2. Difference Analysis of Innovation Ability under Different Digital Tool Use Intensity

An independent sample t-test was conducted to examine the relationship between the intensity of digital tool usage and students' innovation abilities. The results indicated

that the high-frequency use group achieved an average innovation ability score of 3.78, which was significantly higher than the 3.15 score observed in the low-frequency use group. This disparity was statistically significant ($p<0.01$), underscoring the critical role of consistent engagement with digital tools in enhancing innovation capacity. These findings suggest that frequent utilization of digital resources fosters a more conducive environment for developing creative skills and innovative thinking by providing diverse intellectual growth opportunities.

Table 2. T-test Analysis of Innovation Ability Based on Usage Frequency.

Group	Sample Size	Average Innovation Score	Standard Deviation	Significance Level
High Frequency Use	486	3.78	0.62	$p<0.01$
Low Frequency Use	438	3.15	0.74	$p<0.01$

A detailed analysis of the sub-dimensions of innovation ability further highlighted the pronounced advantages of the high-frequency use group in several key competencies. Specifically, their scores in problem-solving, cross-domain thinking, and practical operation were 18.3%, 21.7%, and 24.1% higher, respectively, than those of the low-frequency group. This indicates that digital tools serve as more than mere functional aids; they facilitate access to interdisciplinary learning resources and real-world challenges that are instrumental in stimulating students' creative potential. By enabling learners to explore complex concepts and tackle practical problems, these tools play a pivotal role in fostering both innovation and adaptability within modern academic contexts.

4.3. Disciplinary Differences in Digital Teaching Resource Satisfaction

The survey reveals significant disciplinary variations in student satisfaction regarding digital teaching resources (see Table 2).

Table 2. Student Satisfaction with Digital Teaching Resources by Discipline.

Discipline Category	Sample Size	Average Satisfaction Score	Resource Abundance Score	Resource Adaptability Score
Engineering	327	3.82	4.01	3.76
Science	214	3.67	3.89	3.58
Management	198	3.24	3.31	3.22
Literature	185	3.09	3.15	3.01

The findings indicate that students in engineering and science disciplines exhibit substantially higher levels of satisfaction. This trend is primarily attributed to the widespread availability of advanced virtual experiment tools, specialized simulation software, and open-source project platforms that align seamlessly with the technical and practical imperatives of their professional curricula. These digital resources not only enrich the pedagogical experience but also provide essential hands-on opportunities that are critical for professional skill development [14]. Conversely, students in management and literature disciplines report comparatively lower satisfaction levels. This disparity stems from the limited availability of digital teaching resources specifically tailored to the unique hermeneutic and qualitative needs of the humanities. Furthermore, the integration of digital tools into the curriculum design of these areas remains insufficient, which continues to hinder their potential to effectively foster student innovation and creativity.

4.4. Analysis of Practical Barriers from Qualitative Interviews

Qualitative interview findings highlight three primary barriers that hinder the effectiveness of digital transformation in fostering innovation. A significant proportion of teachers, accounting for 67%, emphasized the absence of comprehensive training programs aimed at enhancing their digital teaching competencies. This limitation prevents them from effectively designing innovative teaching methodologies that leverage digital tools. Furthermore, 73% of students expressed concerns regarding the

inconsistent quality of digital resources available on educational platforms. This inconsistency results in inefficiencies when students attempt to identify and utilize high-quality learning materials. Additionally, 80% of respondents pointed out that the current systems for evaluating innovation capabilities remain outdated. These systems predominantly focus on traditional metrics, such as final examination scores, and fail to incorporate assessments that measure innovative performance within digital learning environments. Addressing these barriers is crucial for aligning educational practices with the demands of digital transformation.

5. Discussion / Implementation

5.1. Interpretation of Research Results

The empirical results of this study confirm the positive role of digital transformation in enhancing the innovation ability of college students. This finding aligns with the broader understanding that technological integration can significantly influence educational outcomes. However, the observed disparity in innovation ability between groups with high and low frequency use of digital tools highlights that the benefits of technology are not automatically realized through mere adoption. Instead, these benefits are contingent upon the effective and deep integration of digital tools into the teaching and learning processes. Furthermore, the disciplinary differences in resource satisfaction underscore an imbalance in the current construction of digital teaching resources. Specifically, there appears to be a disproportionate emphasis on science and engineering disciplines, while humanities and social sciences receive comparatively less attention. This imbalance necessitates targeted adjustments in future reforms to ensure equitable resource distribution and support for all academic fields.

5.2. Digital Teaching Ecosystem Architecture for Innovation Cultivation

Based on the research findings, this paper constructs a four-layer digital teaching ecosystem architecture designed to cultivate innovation abilities. The foundational layer is the infrastructure layer, which encompasses a unified digital education public service platform, a high-speed campus network, and intelligent terminal equipment. These components provide essential technical support for all teaching activities, ensuring seamless integration of digital tools into the educational process. The second layer, known as the resource layer, establishes a comprehensive and categorized resource library that spans all disciplines. This includes virtual experiment resources for science and engineering, a case database for management studies, and a digital literature resource library for the humanities. These resources are tailored to meet the diverse and specialized needs of various academic fields. The third layer, the application layer, focuses on developing functional modules such as intelligent learning path recommendations, virtual collaborative innovation spaces, and real-time learning process evaluations. These modules facilitate innovative teaching methods, including project-based learning and interdisciplinary collaborative research. At the top is the governance layer, which implements supporting systems such as teacher digital literacy training mechanisms, multi-dimensional evaluation systems for innovation abilities, and quality review standards for digital resources. These measures ensure the standardized and effective operation of the entire ecosystem, fostering an environment conducive to academic and creative growth.

5.3. Targeted Implementation Strategies

For the practical barriers identified in the study, three targeted implementation strategies are proposed to address these challenges effectively. First, a tiered teacher digital literacy training system should be established. This system would involve foundational training on the operation of digital tools for all educators, alongside specialized training tailored to innovative teaching design for teachers across various disciplines. Such an approach aims to equip educators with the skills necessary to integrate digital tools seamlessly into processes that foster innovation. Second,

mechanisms for constructing digital resources that are adapted to specific disciplines should be developed. This would involve fostering collaboration between information technology departments and professional colleges to create digital teaching resources that align with the unique characteristics of each discipline. Additionally, a dynamic update mechanism should be implemented to ensure that these resources are continuously refined based on student feedback and evaluations of teaching effectiveness. Third, the innovation ability evaluation system should be restructured to align with the digital learning context. This revised system would expand the evaluation criteria to include not only final outcomes but also learning process performance, collaborative innovation efforts, and practical project results. By leveraging big data technologies, multi-modal data from the digital learning process can be collected and analyzed, enabling a comprehensive and dynamic assessment of students' innovation capabilities.

6. Conclusion

This study explores the impact mechanism of digital transformation on college students' innovation ability cultivation based on empirical survey data and constructs a targeted implementation path for digital teaching reform. We collected valid data from 924 undergraduate students and 71 teachers across 12 majors in Hainan Vocational University of Science and Technology between September and November 2025, adopting a mixed research method combining quantitative statistical analysis and qualitative thematic coding to ensure the reliability of research conclusions. The Cronbach's alpha coefficient of the questionnaire reached 0.87, meeting the standard of academic research. The research results demonstrate that digital transformation has become a significant driving force for promoting innovation education in higher education, with its effect contingent upon the systematic construction of a teaching ecosystem encompassing infrastructure, resource supply, application design, and system guarantees. Pearson correlation analysis reveals a significant positive correlation between the frequency of digital learning tool use and students' innovation ability scores, with a correlation coefficient of 0.523 at the 0.01 significance level. Further independent sample t-test results confirm that the average innovation ability score of students who use digital tools more than three times a week is 3.78, which is 20% higher than the 3.15 score of the low-frequency use group. This difference is particularly pronounced in three dimensions: problem-solving ability, cross-domain thinking ability, and practical operation ability, where the scores of the high-frequency group are 18.3%, 21.7%, and 24.1% higher, respectively. These findings fully validate the enabling effect of digital technology on innovation ability cultivation, highlighting its transformative potential in reshaping educational practices and outcomes.

This effect does not stem from the mere addition of technology but is realized through the multi-dimensional reform of teaching processes. Digital tools transcend the space-time limitations of traditional teaching, enabling students to access high-quality learning resources from around the globe at any time and providing support for personalized learning paths tailored to individual progress and interests. Virtual experiment platforms and collaborative innovation spaces further lower the barriers for students to engage in practical innovation activities, allowing those who previously lacked experimental conditions and team resources to participate in cross-domain innovation projects. However, this positive effect exhibits notable heterogeneity across disciplines. Survey data indicates that engineering students report a satisfaction score of 3.82 for digital teaching resources, whereas literature students report a lower score of 3.09, reflecting structural imbalances in the current construction of digital teaching resources. Universities face practical challenges such as unbalanced discipline resource supply, insufficient teacher digital literacy, and lagging evaluation system reform in advancing digital transformations. Qualitative interview data reveals that 67% of teachers have not undergone systematic digital teaching ability training, hindering their capacity to design innovative teaching activities aligned with professional characteristics using digital tools. Additionally, 73% of students report that the quality of digital resources on public

platforms is inconsistent, requiring significant effort to identify effective learning content. Furthermore, 80% of respondents highlight that the current innovation ability evaluation system remains focused on final written examination results, neglecting process performance in digital learning scenarios such as collaborative project completion and virtual experiment operation. This oversight dampens students' enthusiasm for engaging in digital innovative learning activities. These practical barriers constrain the full realization of digital technology's enabling effects and underscore critical areas for future digital teaching reform in universities.

The optimization strategies proposed in this study offer practical guidance for universities to advance digital teaching reform and enhance the quality of innovation talent cultivation. The four-layer digital teaching ecosystem architecture outlined in this paper encompasses the infrastructure layer, resource layer, application layer, and governance layer, providing a systematic solution to the challenges encountered in the current reform process. The tiered teacher digital literacy training system proposed for educators can assist teachers across disciplines in mastering methods to integrate digital tools into innovation cultivation processes based on their foundational knowledge. The discipline-adapted digital resource construction mechanism addresses the issue of unbalanced resource supply between science and engineering disciplines and humanities and social sciences, catering to the differentiated innovation cultivation needs of various majors. Additionally, the multi-dimensional innovation ability evaluation system reconstructed using big data technology enables dynamic tracking of students' innovation ability development, leveraging evaluation as a guiding tool in teaching. These strategies are grounded in empirical data collected from frontline teachers and students, ensuring strong operability and practical relevance. Moreover, they have been positively received by most respondents during subsequent pilot interviews. By systematically addressing existing pain points, these strategies provide a robust framework for universities to foster high-quality innovation talent and adapt to the evolving demands of the digital era.

It is important to note that the samples in this study are exclusively drawn from a vocational university in Hainan, which may limit the representativeness of the findings for other types of universities, such as comprehensive universities and research universities in different regions. Future research should aim to expand the scope of study samples to include a broader range of universities of varying types and levels, enabling comparisons of the heterogeneous impacts of digital transformation on innovation ability cultivation across diverse institutional contexts. Additionally, this study is based on cross-sectional data collected at a specific time point, which restricts the ability to assess the long-term effects of digital teaching reform on students' career development. Subsequent research could undertake longitudinal studies to track the employment outcomes and career trajectories of students post-graduation, thereby verifying the sustained impact of digital innovation cultivation models. Furthermore, as artificial intelligence and virtual reality technologies continue to advance, increasingly personalized and immersive digital teaching tools are expected to emerge. Future investigations could explore tailored innovation cultivation models designed for distinct student groups, such as strategies adapted to students of different academic levels, majors, and learning foundations. By leveraging these advancements, higher education institutions can maximize the enabling role of digital technology in cultivating innovative talents and align their educational practices with the demands of the digital era.

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