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The Effect of Digital Learning Tools on College Students' Online English Learning

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Abstract: With the accelerated advancement of digital transformation, higher education institutions globally have undergone profound changes in their pedagogical teaching models, curriculum content, and instructional methodologies. The widespread application of digital learning tools has not only fundamentally transformed students' learning approaches but also significantly impacted the cultivation of their innovative capabilities and critical thinking skills. This comprehensive study examines a diverse cohort of 1,082 undergraduate students selected from three universities at different academic levels in eastern China. By employing rigorous questionnaire surveys and quantitative empirical analysis, the research aims to explore the underlying influence mechanisms of advanced information technology and intelligent educational tools on student innovation capabilities within the broader context of digital transformation. The empirical research findings clearly indicate that digital transformation significantly enhances students' innovative thinking and complex problem-solving skills. This enhancement is achieved by promoting highly personalized learning experiences, strengthening interactive and collaborative learning environments, and substantially improving overall learning efficiency. However, significant challenges such as uneven technology adoption across different demographics, insufficient faculty training resources, and outdated innovation education concepts continue to persist during this transitional process. Consequently, the study further analyzes these critical challenges in depth and proposes strategic pathways for optimizing innovation capability development in higher education institutions under ongoing digital transformation. Ultimately, this research aims to provide robust theoretical support and actionable practical guidance for future educational reform initiatives.

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

1. Introduction

With the rapid advancement of information technology, digital transformation has deeply influenced every industry, including education. As a cornerstone for talent cultivation, higher education institutions are experiencing significant shifts in their teaching models, content, and methodologies [1]. In particular, the integration of digital tools has created new opportunities for fostering students' innovative capabilities. By utilizing intelligent learning platforms, online courses, virtual laboratories, and other advanced tools, universities can offer students personalized learning experiences tailored to their individual needs. These tools also provide broader creative spaces, enabling students to explore and develop their innovative potential in ways that were previously unattainable. Such transformations are reshaping the educational landscape, emphasizing the importance of adaptability and innovation in modern learning environments.

While digital transformation has introduced numerous opportunities, effectively leveraging these technologies to enhance students' innovative capabilities remains a critical challenge for higher education institutions. Developing innovation skills requires more than just updating curriculum content; it necessitates a holistic optimization of teaching methodologies, educational resources, and learning environments. This study

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undertakes empirical research to investigate the specific impacts of digital transformation on students' innovative abilities. It also examines the current challenges faced by universities in this context and explores potential pathways for optimization [1, 2]. By analyzing these factors, the study aims to provide actionable insights that can guide the advancement of innovation education reforms. These reforms are essential for equipping students with the skills needed to thrive in an increasingly digital and innovation-driven world.

2. Literature Review

2.1. Impact of Digital Transformation on Higher Education

The digitalization of higher education represents a critical aspect of educational modernization, with universities playing a pivotal role in cultivating high-level innovative talents essential for national development. The rapid evolution of digital technologies has significantly reshaped traditional learning paradigms, introducing profound challenges to the conventional models of talent cultivation within higher education institutions. Digital transformation has facilitated a progressive shift from traditional face-to-face instruction to more dynamic online teaching and blended learning methodologies [3]. This transition not only enhances the efficiency of learning processes but also provides students with access to a broader array of educational resources and interactive opportunities. By enabling greater flexibility in knowledge acquisition, learners can now engage in personalized learning experiences tailored to their unique interests and needs. This adaptability serves as a foundation for fostering innovative capabilities, equipping students with the skills necessary to thrive in an increasingly digitalized world.

In the context of the ongoing implementation of the National Education Digitalization Strategy, higher education has officially progressed from the informatization phase to a more advanced stage of digital transformation. Current research underscores the importance of enhancing students' innovative capabilities as a central focus of this transformation. However, much of the existing literature remains theoretical in nature, with a notable lack of large-scale empirical studies to quantitatively assess the relationship between digital tools and the development of innovation capacity. Addressing this gap requires a more robust integration of empirical methodologies to evaluate the tangible impacts of digital transformation on educational outcomes [4]. Such efforts would provide valuable insights into optimizing digital tools and strategies to better support the cultivation of innovative talents in higher education.

2.2. Relationship between Innovation Ability Cultivation and Teaching Models

The cultivation of innovation capabilities relies not only on the transmission of knowledge but also on the integration of critical thinking, problem-solving skills, and teamwork into teaching practices. Universities are encouraged to leverage opportunities presented by the ongoing digital transformation in education, aligning their efforts with national strategies and policy directives. A key focus should be placed on nurturing high-level innovative talents who possess a global perspective, a strong sense of national commitment, interdisciplinary knowledge integration abilities, an innovative mindset, and practical skills [3, 5]. Teaching models that embrace digital transformation, particularly those emphasizing project-driven and problem-oriented learning approaches, have demonstrated significant potential in enhancing students' innovative thinking and practical operational competencies. These models foster an environment where students can actively engage with real-world challenges, thereby bridging the gap between theoretical knowledge and practical application.

A study targeting vocational college students revealed that project-based practical training and the integration of industrial resources during digital competency development significantly enhance students' ability to transfer innovative skills across contexts. These findings are equally relevant to the development of innovation education systems in regular undergraduate institutions [6, 7]. Reforming university teaching

models necessitates a comprehensive integration of digital technology characteristics, which includes breaking down traditional disciplinary boundaries and fostering interdisciplinary collaborative learning environments. Such environments encourage students to engage in cross-disciplinary problem-solving and teamwork, which are essential for cultivating innovative capabilities. By creating these collaborative spaces, universities can better prepare students to address complex, real-world problems, equipping them with the skills needed to thrive in a rapidly evolving global landscape.

2.3. Application of Digital Tools in Innovation Capability Development

The role of digital tools in fostering innovation capabilities has been extensively validated through multidisciplinary research [8]. Information technology has been shown to significantly enhance students' creative thinking and problem-solving skills, particularly in complex scenarios. This is achieved through the use of virtual experiments, intelligent teaching platforms, and big data analytics, which collectively provide expanded practical learning opportunities. Furthermore, digital tools enable real-time feedback and interactive engagement, allowing students to better comprehend, internalize, and apply knowledge in diverse academic and practical contexts. By leveraging these technologies, educational institutions can create dynamic learning environments that promote deeper understanding and skill development.

Case studies from academic institutions demonstrate that universities can establish "Internet + Innovation Training" bases to effectively integrate digital technologies into specialized practical education. This approach involves guiding students to skillfully utilize technology for tasks such as knowledge mapping, feasibility analysis of innovation projects, risk assessment, and industry demand forecasting. By fostering these competencies, the methodology creates a virtuous cycle of learning, technological mastery, knowledge internalization, and application implementation. This process significantly enhances students' innovative practical abilities, equipping them to address real-world challenges with greater proficiency and adaptability.

2.4. Challenges in Digital Transformation

During the digital transformation process, universities encounter significant challenges, including uneven adoption of technology, limited faculty resources, and reliance on outdated traditional teaching methodologies. Many innovation and entrepreneurship courses in higher education institutions continue to emphasize conventional theoretical instruction, focusing predominantly on basic entrepreneurial concepts and processes [9, 10]. This approach often neglects the integration of digital technologies, which are essential for aligning education with the demands of the modern digital economy. The curriculum framework frequently lags behind the rapid advancements in industries, creating a gap between the theoretical knowledge imparted to students and its practical application in real-world scenarios. This disconnect not only impedes the development of innovative thinking and entrepreneurial skills tailored to contemporary industry needs but also fails to address the diverse knowledge requirements of emerging sectors. Consequently, students are often ill-prepared to meet the challenges of a rapidly evolving digital landscape, which undermines their ability to contribute effectively to innovation-driven industries.

In terms of faculty qualifications, a significant proportion of instructors teaching innovation and entrepreneurship courses in higher education institutions are counselors, administrative personnel, or adjunct faculty members who lack comprehensive professional expertise and practical experience in innovation education. This limitation poses challenges in delivering high-quality instruction, as educators often struggle to incorporate real-world case studies and advanced concepts relevant to the digital era into their teaching. The absence of such integration diminishes the professional guidance provided to students, adversely affecting the overall effectiveness of these courses. Furthermore, a critical issue lies in the ability to utilize digital tools not merely to enhance learning efficiency but to genuinely foster creative and innovative thinking among students. Addressing this challenge requires a systematic overhaul of teaching

methodologies and the incorporation of cutting-edge digital technologies to ensure that students are equipped with the skills necessary to thrive in a rapidly changing global economy [11].

3. Research Methods

This study conducted field research at three full-time higher education institutions of varying tiers in eastern China, including one comprehensive university, one science and engineering university, and one liberal arts university. The survey targeted undergraduate students across all academic years, employing stratified random sampling to distribute 1,200 questionnaires, with 1,082 valid responses collected, resulting in a high response rate of 90.17%. The sample composition included 421 science and engineering majors, 368 liberal arts majors, and 293 art majors. Additionally, the participants were distributed across academic years, with 287 freshmen, 276 sophomores, 269 juniors, and 250 seniors [3, 12]. Gender representation was balanced, with 524 male and 558 female participants, reflecting the typical demographic structure of university students in the region. This diverse sample ensured that the study captured a broad spectrum of perspectives and experiences, enhancing the reliability and generalizability of the findings.

The study utilized two established scales as data collection tools to ensure robust measurement of the variables under investigation. The first instrument was the Digital Teaching Engagement Scale, which assessed three key dimensions: frequency of digital tool usage, duration of online learning, and interaction frequency on digital platforms. This scale consisted of 12 items and demonstrated strong reliability, with an internal consistency coefficient of 0.87. The second instrument was the Williams Innovation Tendency Scale, which measured four dimensions: risk-taking propensity, curiosity, imagination, and challenge orientation. This scale comprised 26 items and exhibited excellent reliability, with an internal consistency coefficient of 0.92, meeting established psychometric standards. These tools provided comprehensive insights into the participants' engagement with digital teaching methods and their innovation tendencies, forming the foundation for subsequent data analysis.

Data analysis was conducted using SPSS 26.0 statistical software, employing a range of analytical methods to ensure the rigor and validity of the findings. Descriptive statistics were used to summarize the data, while independent samples t-tests facilitated comparisons between groups. Pearson correlation analysis was applied to explore relationships between variables, and linear regression analysis was utilized to identify predictive factors. To address potential common method bias, strict controls were implemented during the analysis process, including the Harman single-factor test. This test confirmed that no single factor accounted for the majority of variance, indicating that the data quality met the study's requirements. These methodological precautions ensured the reliability and accuracy of the results, providing a solid basis for interpreting the findings and drawing meaningful conclusions.

4. Result Analysis

The table below illustrates differences in innovation capability scores among students based on their usage frequency of various digital tools. Students were categorized into low-frequency, medium-frequency, and high-frequency groups according to weekly digital learning tool usage duration. Significant differences were observed across all dimensions of innovation capability scores among the three groups, with a clear upward trend correlating with increased usage frequency. The high-frequency group achieved an overall innovation capability score of 89.72 points, which was 15.47 points higher than the low-frequency group—a statistically significant difference [13, 14]. These findings underscore the importance of frequent engagement with digital tools in fostering innovation capabilities, suggesting that higher exposure to such tools may enhance cognitive flexibility and creative problem-solving skills. Table 1

provides a detailed breakdown of these scores, offering insights into the specific dimensions impacted by varying levels of tool usage.

Table 1. Comparative Analysis of Innovation Capability Dimensions Across Usage Frequency Groups.

divide into groups	number of people	Adventure dimension	Curiosity Dimension	dimension of imagination	Challenging dimension	Total Innovation Capability Score
Low-frequency group (less than 2 hours per week)	312	18.26	19.35	17.89	18.75	74.25
Medium frequency group (2-8 hours per week)	457	21.34	22.17	20.68	21.42	85.61
High-frequency group (more than 8 hours per week)	313	22.87	23.64	21.79	21.42	89.72
F price	-	42.36	37.59	29.47	31.25	58.63
P price	-	<0.001	<0.001	<0.001	<0.001	<0.001

The correlation analysis revealed a significant positive correlation ($r=0.472$, $p<0.001$) between the frequency of digital tool usage and the total innovation capability score [15]. The strongest correlation was observed with the curiosity dimension ($r=0.513$), indicating that digital tools most effectively stimulate students' curiosity. Regression analysis demonstrated that after controlling for demographic variables including gender, grade level, and major, the frequency of digital tool usage accounted for 21.3% of the total innovation capability score (regression coefficient: 0.428). This confirms that digital transformation exerts a significant positive predictive effect on enhancing students' innovation capabilities. These results highlight the transformative potential of digital tools in academic settings, particularly in fostering curiosity and other cognitive dimensions critical for innovation. The impact of digital transformation varies significantly across student disciplines. Science and engineering students demonstrate the strongest influence from digital tools on innovation capabilities, with a regression coefficient of 0.487. Art students follow closely with a coefficient of 0.436, while humanities students show the lowest impact at 0.372. All three groups exhibited statistically significant coefficients ($p<0.001$). These findings indicate that digital tools positively enhance innovation capabilities across disciplines, with particularly pronounced effects in fields requiring extensive hands-on practice and experimental exploration. The differential impact across disciplines suggests that the integration of digital tools should be tailored to the unique needs and methodologies of each field to maximize their effectiveness.

5. Discussion

The empirical findings of this study confirm the positive impact of digital transformation on college students' innovative capabilities, aligning with theoretical research conclusions. Digital tools provide students with extensive learning resources and open collaborative spaces, effectively overcoming the time and space constraints of traditional teaching methods. This enables students to independently explore knowledge

domains based on their interests, fostering innovative thinking. The results also reveal a significant positive correlation between the frequency of digital tool usage and innovation capability scores, offering quantitative evidence for universities to enhance investment in digital education.

The heterogeneity analysis results offer valuable insights for targeted policy implementation in higher education institutions. Science and engineering disciplines can expand the application scenarios of virtual experiment platforms, allowing students to perform more complex experimental operations and project designs using digital tools. Humanities disciplines may establish digital humanities research platforms, providing students with support tools such as big data analysis and digital content creation. Art disciplines could integrate technologies like virtual reality and digital modeling to broaden students' creative boundaries. Different disciplines must develop tailored digital transformation plans that align with their unique characteristics to maximize the benefits of technological empowerment.

The challenges identified during the digital transformation of higher education institutions require immediate attention [15]. Uneven technology adoption risks exacerbating disparities in educational resources across institutions and student demographics. Universities should strengthen technical support for underdeveloped disciplines and institutions in central and western regions, while creating inclusive digital teaching resource systems. Faculty competency gaps remain a critical bottleneck hindering transformation outcomes. Institutions should implement regular digital literacy training programs for educators, encourage participation in digital teaching initiatives, and enhance teachers' ability to integrate technology with innovative education approaches. Reforming evaluation systems is equally important. Universities need to develop innovation capability assessment frameworks that incorporate process data, comprehensively documenting students' creative behaviors and developmental trajectories during digital learning experiences. Moving away from traditional exam-oriented evaluation models will further support this transformation.

The optimization pathway proposed in this study demonstrates strong practical applicability. Universities should prioritize enhancing teachers' digital literacy and innovative education training by organizing regular professional development programs. Encouraging faculty participation in building digital education platforms and developing educational content will significantly improve teaching quality and innovation capabilities. Additionally, fostering interdisciplinary collaboration and project-based learning through problem-oriented initiatives is essential. By integrating knowledge from multiple disciplines, students can cultivate cross-disciplinary thinking and creative problem-solving skills. Digital platforms serve as ideal tools for collaborative projects, enabling students to engage in interdisciplinary teamwork and practice through online platforms, thereby strengthening innovation and teamwork competencies. Establishing a diversified innovation evaluation system is also critical. Comprehensive assessment criteria should encompass dimensions such as innovative thinking, critical analysis, and problem-solving abilities. Real-time data collection and feedback mechanisms can facilitate timely adjustments to teaching strategies, optimizing innovation education outcomes. Furthermore, enhancing practical learning resources through virtual experiments, simulation-based learning modules, and partnerships with enterprises and social organizations is vital. These initiatives allow students to apply theoretical knowledge to real-world problem-solving scenarios, effectively boosting their innovation capabilities [1, 14].

6. Conclusion

This study investigates the impact of digital transformation on cultivating students' innovative capabilities in higher education institutions through large-scale empirical research, while exploring optimization pathways. Against the backdrop of the education digitalization strategy advancing rapidly, higher education has formally transitioned from the informatization stage to a new phase of deep digital transformation. The

question of how to leverage digital tools to overcome the bottlenecks of traditional innovation talent cultivation has become a core issue of widespread concern in the education field. This research utilized 1,082 valid undergraduate samples from three different-tier universities in eastern China, encompassing comprehensive, science and engineering, and liberal arts institutions. The study employed the Digital Teaching Engagement Scale and Williams Innovation Tendency Scale for data collection and applied methods such as Pearson correlation analysis and multiple linear regression to explore the mechanisms through which digital transformation influences innovation capability cultivation. This approach addresses a significant gap in existing studies, which have predominantly focused on theoretical discussions and lacked large-scale quantitative empirical evidence. By providing robust data-driven insights, this research contributes to a deeper understanding of the interplay between digital transformation and innovation education.

Findings indicate that digital transformation not only enhances learning efficiency but also creates new opportunities for fostering innovation. Digital tools, such as intelligent learning platforms, virtual laboratories, and online collaborative systems, break the time and space constraints of traditional teaching. These tools provide students with personalized learning paths and access to global high-quality educational resources, fully stimulating their curiosity and willingness for autonomous exploration. Furthermore, project-based and problem-oriented teaching models supported by digital technology foster a more open and interactive learning environment. This enables students to integrate knowledge across diverse scenarios and enhances their practical problem-solving abilities. A significant positive correlation was observed between the frequency of digital tool usage and students' innovation capability scores. Specifically, the overall innovation capability score of the high-frequency user group (using digital learning tools for more than 8 hours per week) reached 89.72 points, which was 15.47 points higher than that of the low-frequency group (less than 2 hours per week). Regression analysis revealed that digital tool usage frequency explained 21.3% of the variance in innovation capability scores after controlling for demographic variables such as gender, grade, and major. This finding confirms the stable and positive predictive effect of digital transformation on the improvement of innovation abilities, underscoring its transformative potential in education.

The degree of impact varies across disciplines, with science and engineering students demonstrating the most pronounced improvement in innovative abilities. The regression coefficient of digital tools on innovation ability for science and engineering students reached 0.487, followed by art students with 0.436, and liberal arts students with 0.372, all of which were statistically significant at the level of $p < 0.001$. This variation is closely linked to the practical attributes of different disciplines. For instance, science and engineering majors benefit significantly from virtual experiment platforms and numerical calculation tools, which enable them to complete complex experimental designs, simulation verifications, and data analyses. These tools substantially lower the threshold for engaging in innovative practices. In contrast, liberal arts majors face limitations due to the insufficient development of digital humanities resources, which restricts the full realization of the enabling effects of digital tools. This disparity highlights the need for targeted interventions to ensure that all disciplines can equally benefit from digital transformation, thereby fostering a more balanced development of innovation capabilities across academic fields.

Current challenges in digital transformation include uneven technology adoption, faculty shortages, and outdated evaluation systems. The distribution of digital education resources remains significantly unbalanced across regions, institutions, and disciplines, potentially exacerbating the digital divide and widening gaps in innovation capability cultivation among different student groups. Many educators responsible for innovation education lack systematic digital literacy training and practical industry experience, making it difficult to integrate cutting-edge digital practices into their teaching. This disconnect between course content and industrial development needs further hinders the

effectiveness of innovation education. Additionally, traditional evaluation systems, which predominantly focus on final examination results, fail to capture the innovative performance of students during digital learning processes. This limitation restricts students' motivation to actively engage in innovative practices, as their efforts are not adequately recognized or rewarded. Addressing these challenges requires a comprehensive approach to reforming resource allocation, faculty training, and evaluation methodologies to create a more equitable and effective digital education ecosystem.

Universities need to advance reforms through coordinated efforts in faculty training, interdisciplinary collaboration, and evaluation system optimization. First, regular digital literacy and innovative education training programs should be organized for educators. These programs should encourage faculty members to actively participate in the development of digital teaching resources and enhance their ability to integrate digital technology with innovation education. Second, interdisciplinary digital practice platforms should be established to facilitate problem-oriented, cross-disciplinary collaborative projects. These platforms can guide students in using digital tools to address real-world complex problems, thereby cultivating their cross-domain thinking and teamwork abilities. Third, the innovation ability evaluation system should be optimized to include process data such as learning interactions, project participation, and practical achievements within digital environments. This approach would replace the traditional result-oriented evaluation model and better reflect students' innovative capabilities. Additionally, an inclusive digital resource supply mechanism should be implemented to prioritize support for underdeveloped disciplines and regions. This would help prevent the digital divide from becoming a new barrier to equitable innovation education development. By addressing these areas, universities can create a more supportive environment for fostering innovation and ensuring that all students have access to the tools and opportunities needed to succeed in a digitally transformed educational landscape.

During their digital transformation process, universities must consistently uphold a student-centered educational philosophy to ensure that technology adoption does not become superficial. Digital tools should be viewed as vehicles for enhancing educational quality, with the core objective remaining the cultivation of innovative talents aligned with societal development needs. Future research should delve deeper into the differentiated impacts of various digital tools, examining their specific roles in fostering innovation across diverse educational contexts. Additionally, more refined digital innovation education models should be developed to address the unique needs of different disciplines and student groups. These models should provide targeted theoretical frameworks and practical guidance to support higher education reform. By focusing on these areas, future studies can contribute to a more nuanced understanding of how digital transformation can be leveraged to overcome existing challenges and unlock new opportunities for innovation in education. This will ensure that digital transformation continues to serve as a catalyst for meaningful and sustainable advancements in higher education.

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