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Research on Digital Ethical Dilemmas of Applied University Students in Beijing from the Perspective of AIGC-Empowered Education

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Abstract

The rapid development of Generative Artificial Intelligence (AIGC) has led to its widespread application in the field of education. While students in applied universities enjoy the technological convenience, it has also triggered a series of digital ethical challenges, including blurred boundaries of academic integrity, difficulty in distinguishing information quality, increased technological dependence, and leakage of private data. Currently, due to the imperfect construction of relevant laws, regulations, and institutional systems in both China and higher education institutions, students' understanding of digital ethics remains unclear, forming a dilemma of "technology application first, ethical norms lagging behind." This study focuses on students from applied universities in Beijing as the research subjects. Employing research methods such as web crawling, questionnaire surveys, and in-depth interviews, it collects primary data from applied universities in Beijing to deeply analyze the ethical issues students encounter while using AIGC tools and their underlying causes. The research identifies four major dilemmas faced by students in AIGC applications: unclear cognition, degradation of core competencies, lack of institutional norms, and insufficient educational guidance. In response to these issues, this paper proposes optimizing pathways including constructing a multi-level digital ethics education system, building a thinking cultivation system to prevent technological dependence, improving layered and categorized management systems, and strengthening the systematic development of teaching staff. It aims to provide theoretical reference and practical insights for applied universities to cultivate talents possessing both high professional competence and high digital literacy.

Keywords: Digital Ethics; Generative Artificial Intelligence; Applied Universities; AIGC

1. Introduction

The rapid development of the digital economy has made generative artificial intelligence, which creates new content such as text, images, videos, and code based on user input, a key variable in driving efficiency transformation and innovation. The "Generative Artificial Intelligence Application Development Report (2025)" shows that as of June 2025, the number of users of generative AI products in China reached 515 million, with a penetration rate of 36.5%, with young and middle-aged, highly educated users forming the core group. The “New Generation Artificial Intelligence Development Plan” explicitly states the need to seize the major strategic opportunities in AI development and build a first-mover advantage for China's AI development. However, problems behind the technological dividends are gradually emerging. Some students, lacking clear ethical boundaries, directly appropriate AI-generated content, cite data without verification, and even risk leaking private information. Although China has introduced regulations such as the “Interim Measures for the Management of Generative Artificial Intelligence Services,” the laws and regulations concerning university students' use of artificial intelligence are relatively lagging. Particularly, digital ethics education for students in applied universities is virtually non-existent, creating a dilemma of “technology application first, ethical norms lagging behind.” Students' understanding of digital ethics remains unclear, and relevant institutional guidance is also weak. Therefore, exploring the cognitive, behavioral, and institutional causes of digital ethics among students in Beijing applied universities from the perspective of AIGC-empowered education, and proposing targeted optimization paths, holds significant theoretical value and practical urgency.

2. Overview of Digital Ethics

2.1. Definition of the Concept of Digital Ethics

Digital ethics refer to the value concepts and behavioral norms that individuals and institutions should follow in the development, dissemination, and application of digital technologies and products (Wang & Li, 2023). Drawing on existing literature, the concept is commonly understood to encompass several dimensions: data privacy and security, concerning the protection of personal information; algorithmic fairness and bias, addressing whether technological decisions are just and neutral; responsibility and transparency, emphasizing traceability and accountability; and human autonomy and dignity, ensuring that technology serves human development rather than replacing human thought. Collectively, these dimensions underscore the need to consider ethical issues throughout the entire lifecycle of digital technology.

In terms of its connotation system, digital ethics is a composite concept that integrates key domain issues such as algorithm ethics, data ethics, and artificial intelligence ethics (Zhao & Li, 2026). The internal aspect of ethics guides people to pursue benevolent ideas and spiritual forces, shaping people's values and moral outlook, and driving them to make choices that align with standards of goodness (Yang & Xu, 2026). However, when facing certain challenges currently, the integrity values of contemporary college students present a contradiction between high recognition and low practice levels (Jia, 2025), leading to a dilemma where knowledge and action

are inconsistent. In many situations, AIGC is often regarded by learners as a mere auxiliary tool attached to traditional education and teaching, thus falling into the trap of machine logic, subtly causing learners to develop habitual dependence (Zhang, 2026). To address these challenges, for instance in the art field, when facing AIGC technology, students should avoid over-reliance on inherent professional knowledge and learning content like traditional design tools, discard inertial and habitual thinking, actively understand and learn new technologies, and consciously enhance their autonomous learning ability and continuous learning ability (Jing, 2025). Meanwhile, AI literacy education needs to transcend the technical level, delving into the shaping of values and ethical concepts, and guiding social participation (Cai et al., 2024). This can promote university students' understanding of ethical and moral responsibilities and norms, guide them to make correct data practice decisions based on data ethics, and help prevent and correct data misconduct (Zhang, 2024). This also illustrates that talent cultivation and quality enhancement, as two inseparable dimensions, complement and promote each other, jointly driving the continuous development and progress of education (Wen, 2025). Such contextualized ethical conflict exercises aim to guide students to actively confront the social responsibilities behind technology, thereby elevating their ethical cognition from passive norm adherence to proactive responsibility consciousness.

This indicates that digital ethics are not only external normative constraints in the technological era but also a manifestation of values internalized in people's hearts. It requires us, against the backdrop of rapid digital technology development, to guide individuals, especially the younger generation, to overcome the disconnect between knowledge and action and habitual dependence through the deep integration of education and practice, transforming ethical concepts into conscious action guidelines. Only then can we ensure that digital technology truly serves the comprehensive development of humanity and promotes society's steady progress on the track towards goodness.

2.2. Distinction of Concepts Related to Digital Ethics

Many concepts are related to digital ethics, including technology ethics, algorithm ethics, data ethics, digital technology ethics, and digital society ethics, which have been extensively discussed in academia. However, in the development process of digital technology, a series of social and technical ethical issues have arisen, all falling under the concept of “digital ethics.” Therefore, distinctions are made among related concepts (Figure 1).

(1) Digital Ethics and Technology Ethics. Technology ethics are the value concepts and behavioral norms to be followed in scientific and technological activities, covering numerous technological fields such as life sciences, medicine, and artificial intelligence. Digital ethics are a specific extension of technology ethics in the digital age, primarily applied in daily details such as product design, interactive interfaces, user agreements, and algorithmic recommendations.

(2) Digital Ethics and Data Ethics. Data ethics also fall within the scope of technology ethics, mainly studying the social issues and behavioral norms triggered by big data technology, involving topics like personal privacy, data rights, and algorithmic discrimination. Simultaneously, the ethical value of big data technology originates from the purpose and motivation of its users.

(3) Digital Ethics and Digital Technology Ethics, Digital Society Ethics. Digital technology ethics focuses on examining ethical issues from the perspective of technology research, development, and engineering implementation, emphasizing the embedding of ethical principles into the technological architecture. Digital society ethics focuses on examining the ethical consequences of digitalization from the perspective of social structure and institutional change.

(4) Digital Ethics and Digital Literacy. Digital literacy is a core term in the field of information management, referring to an individual's comprehensive ability to efficiently discover, access, evaluate, integrate, and communicate information using technology in a digital environment, encompassing dimensions such as digital tool operation, data thinking construction, and digital ethical cognition. As a key competency for adapting to a digital society, its connotation emphasizes the integration of technological application, critical thinking, and social collaboration.

In summary, digital ethics is not merely the sum of the above branches of technology ethics; rather, it treats ethical issues across the entire process—from technology development to application—as an integrated whole. In the context of AIGC-empowered education, students at applied universities in Beijing frequently use AIGC to complete course papers, coding assignments, design projects, and even graduation work, encountering various ethical challenges. A pressing question thus emerges: how can they use digital technology appropriately, clearly defining the boundaries of AI?

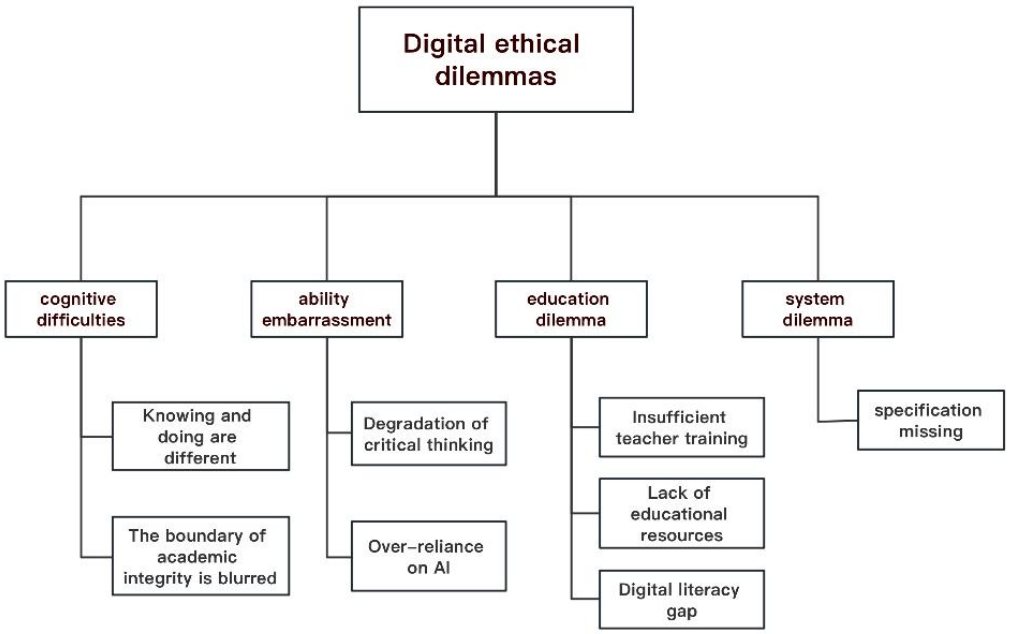

Figure 1. Frame diagram of digital ethical dilemma

3. Current Status of AIGC Application among Students in Beijing Applied Universities

As a unique type of higher education institution, applied universities originated in Europe, with the English name “Universities of Applied Sciences.” According to the definition in the Langenscheidt German-Chinese Dictionary, the core characteristic distinguishing this type of university from traditional comprehensive universities is its emphasis on students' practical

training, committed to cultivating high-level, high-quality applied talents oriented towards the workplace. Specifically, these are talents with strong practical and innovative abilities, capable of engaging in production, management, service, and construction, possessing a certain theoretical foundation, research capabilities, and technical skills (He & Qian, 2020). Therefore, in terms of educational characteristics, programs are closely linked with industry needs, curriculum design combines theory and practice, integrating industry standards, job skills, and professional ethics into the entire teaching process, aiming to equip students with comprehensive qualities for specific positions upon graduation.

It is precisely because of this workplace-oriented training model that applied university students, when encountering the new technological wave represented by AIGC, exhibit some distinct characteristics in their application scenarios. They are not only learners of AIGC tools but may also become its frontline developers and industry practitioners. In daily learning scenarios, they use AIGC to assist in completing tasks such as project design, code writing, and copywriting, significantly improving learning efficiency and output. In internships and practical work, they may also directly participate in specific tasks such as the development of AIGC-based educational products, user data analysis, and operations. While widespread application can enhance professional competence, it also brings digital ethics dilemmas from relatively abstract academic integrity issues to very specific and urgent workplace scenario choices. For example, how to ensure information accuracy and clear copyright while using AIGC to improve content production efficiency? How to balance technical efficiency and personal privacy protection when operating user data? How to avoid bias and discrimination in the application of algorithmic models? These dilemmas not only concern personal professional integrity but also directly touch the compliance bottom line of technology socialization. Therefore, the ethical cognition and practical level of applied university students will profoundly affect the health and safety of future technology application in education and related industries. In-depth research on their application status and ethical dilemmas in the context of AIGC-empowered education has irreplaceable practical value for building an operable technology ethics education system.

4. Empirical Analysis of Digital Ethics among Beijing Applied University Students from the Perspective of AIGC-Empowered Education

In order to further understand the current situation of digital ethics of applied college students in Beijing from the perspective of AIGC empowerment education, three research methods of big data crawler analysis, questionnaire survey and in-depth interview are adopted to carry out systematic data collection and current situation analysis.

In terms of web crawlers, the study selected the official websites of eleven application-oriented universities in Beijing (including North China University of Technology, Beijing Institute of Petrochemical Technology, Beijing City University, etc.) as data sources, and the scope of crawling covers the news, notices, academic trends, teaching resources and other public content published on the official websites of each school. Content capture and frequency statistics are carried out around eight core keywords such as digital ethics, artificial intelligence ethics, AIGC,

big data and information technology social responsibility. After data collection, deduplication, denoising and manual review are performed to ensure the accuracy of keyword matching and the reliability of analysis results.

In the questionnaire survey part, the research object is the students in the application-oriented universities in Beijing. Sampling was conducted by random sampling method according to the type of school, and finally 500 valid questionnaires were collected. The questionnaire design is based on the literature and previous interview results, covering multiple dimensions such as basic information, AIGC usage habits, ethical cognition, dilemma experience and educational needs. It shows the behavior pattern and cognitive level of the application-oriented college students in Beijing through quantitative methods.

In terms of in-depth interviews, the study selected a total of 6 front-line teachers and school leaders from different universities as interviewees, covering the background of science and engineering, humanities, art and other disciplines, to ensure that the interviewees have relevant experience in AIGC teaching application and digital ethics management. The interview was conducted in a semi-structured form, focusing on the application status of AIGC in teaching, student behavior recognition, institutional dilemma and educational support. Each interview lasted about 15 minutes, and was recorded and transcribed verbatim with the consent of the interviewee. The interview data were coded and summarized by thematic analysis to improve the reliability of the analysis.

4.1. Web Crawling Analysis

This study derives around the core keywords, selects eight keywords, and conducts keyword capture and frequency statistics on the official websites of eleven Beijing application-oriented universities, covering the news, notices, academic trends, teaching resources and other public content published on the official websites of each university, so as to ensure the pertinence of data sources and the reliability of the analysis process. The above figure is a 3D surface map drawn by programming software through the crawler results (Figure 2). The research heat of each university on the topics related to technical ethics shows a clear pattern of differentiation. Among them, ' information technology social responsibility ' is the most concerned topic at present, especially in Beijing Institute of Materials Science and Technology, showing a very high peak and a far-reaching heat, showing the school 's key layout in this direction. At the same time, ' artificial intelligence ethics ' and ' big data ' also showed strong attention, forming a small peak in many universities such as North China University of Technology and Beijing Institute of Petrochemical Technology, reflecting the frontier exploration of these traditional engineering colleges in the interdisciplinary field of technology and ethics. In contrast, the heat of emerging issues such as ' AIGC ' and ' digital ethics ' is obviously low, and it is still in its infancy in most colleges and universities, only appearing in individual colleges and universities such as China Institute of Labor Relations. It shows that the current exploration of various universities in this field still needs to be strengthened.

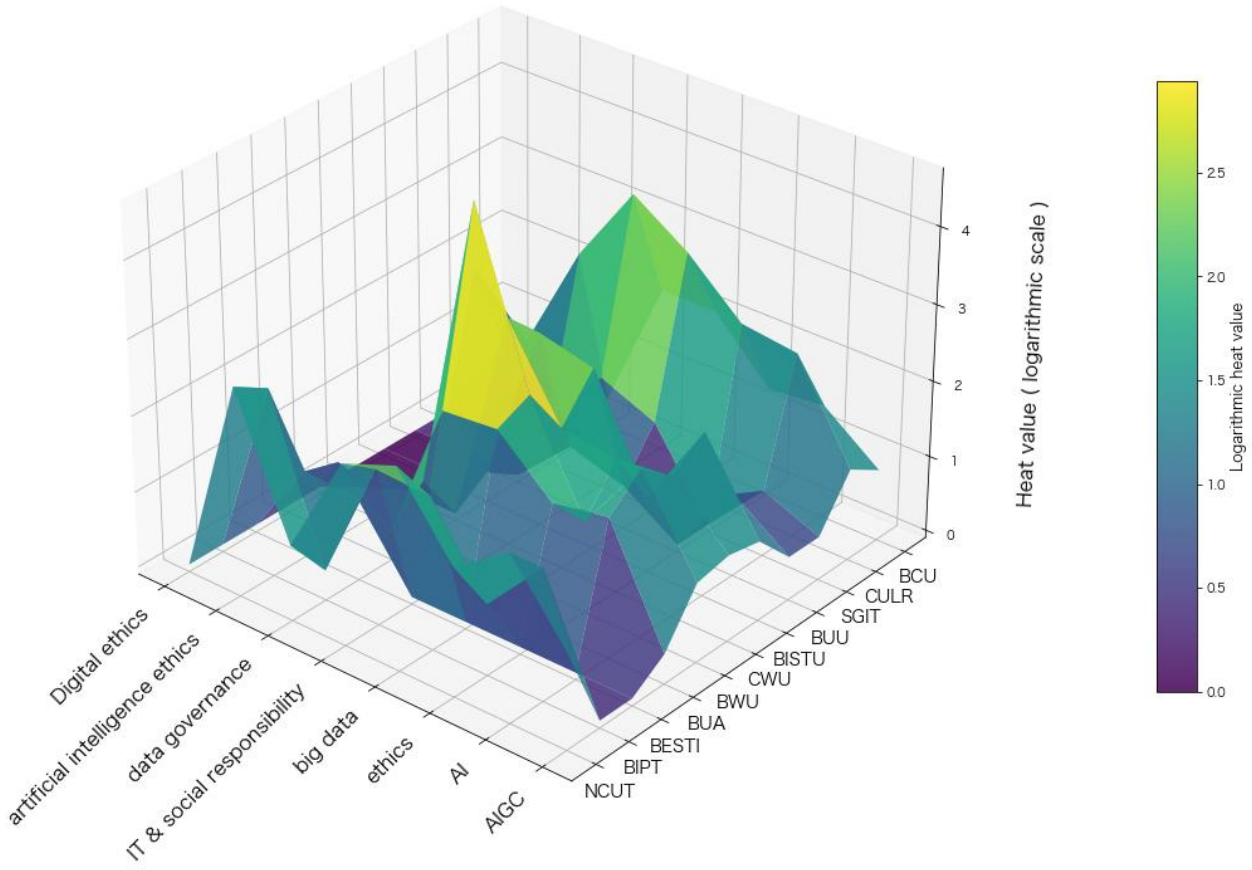

Figure 2. Web crawler analyzes 3D surface graph

4.2. Questionnaire survey and interview survey analysis

Based on 500 valid student questionnaires and in-depth interviews with a number of front-line teachers and managers, this study aims to comprehensively analyze the digital ethical dilemmas faced by Beijing application-oriented college students in the use of AIGC. The report will be carried out from the following five dimensions :

(1) Blurred boundary of academic integrity

The results of the questionnaire survey show that AIGC tools have been deeply embedded in students academic scenes. Up to 74.6 % of students use AIGC mainly for homework assistance and 56.8 % for thesis writing. This high-frequency academic application is in stark contrast to students vague cognition of behavioral boundaries, which constitutes the primary ethical dilemma. Although 77 % of the students tend to ' modify and use it after optimization, 34 % of the students still admit that they will ' directly copy the generated content, and 21.8 % of the students think that directly submit the complete work generated by AI is acceptable. These findings suggest that a considerable number of students struggle to distinguish AI-generated content from their own original work, indicating a weak awareness of academic integrity boundaries. Furthermore, this ambiguity creates confusion. The data show that 47.8% of students report experiencing “integrity confusion” in academic settings, while 26.4% are most concerned about being accused of

academic misconduct. Together, these figures reveal a contradiction between students' behavior and their concerns, pointing to a lack of clarity about the nature of the misconduct itself.

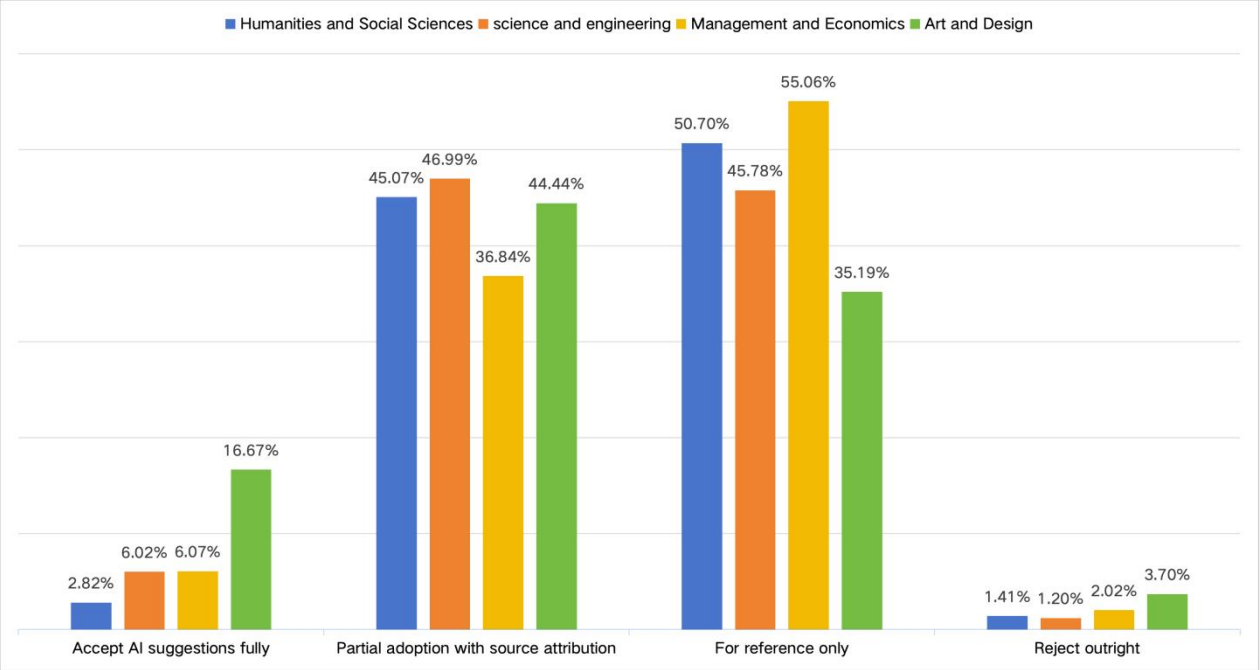

Figure 3. Cross-analysis of Cognitive Conflict Between Students from Different Majors on Generated Content

As shown in Figure 3, there are significant differences in how students from different majors handle "conflict between AI-generated content and their own cognition." Students in art and design have the highest proportion of "completely adopting AI suggestions" and also the highest proportion of "completely rejecting AI suggestions," showing a polarized attitude. This suggests inherent differences within art-related disciplines: some are more creative and require a personal style, so they may not adopt AI suggestions, while others may use AI to assist in copying artworks, potentially leading to adoption. In contrast, students in science, engineering, humanities, and social sciences tend to "partially adopt and cite the source" or "use only as a reference," showing more cautious and standardized usage habits. This disciplinary difference indicates that the blurring of academic integrity boundaries is not uniformly distributed and may be related to the thinking training and research paradigms of each discipline. Meanwhile, teachers' interviews, from an educator's perspective, clearly outline this fuzzy boundary. Teacher Wang clearly delineated the limits: acceptable uses are "using AI to assist in finding information, organizing thoughts, and polishing language," while "completely generated by AI and submitted as personal work" is unacceptable. Teacher Chen emphasized, "Core academic tasks must be completed by the students themselves." Teachers can quickly identify AI-generated assignments precisely because the content is often "too logically structured," "beyond the student's cognitive level," or "content is relatively hollow." These characteristics contradict the originality, personal thought, and deep understanding required for academic integrity. Students frequently use AIGC for academic purposes, yet their understanding of behavioral boundaries is deviated, creating a gap with teachers' clear academic standards. This ultimately leads to widespread student confusion and challenges for teachers in assessment and guidance.

(2) Information Quality and Cognitive Risk Issues

This issue concerns the reliability of AIGC output and its potential negative impact on users' cognitive processes. A primary risk lies in content authenticity and accuracy: 68.6% of students reported difficulty judging whether generated content was true, making this the most frequently encountered ethical dilemma. Similarly, 40% expressed concerns about content accuracy when completing academic tasks. Teacher Zhao highlighted a related technical limitation, noting that AIGC can produce "hallucinations," or entirely fabricated information.A second risk involves algorithmic bias. More than half of the students surveyed had encountered biased or discriminatory content. Teacher Liu explained that "AI models themselves may carry biases from the training data. We need to educate students to possess critical thinking, to verify and judge." This underscores that technology is not value-neutral; its outputs can reflect and even amplify existing biases.These risks together challenge students' critical thinking abilities. When AI-generated content conflicted with their own understanding, 49.4% of students chose to "use it only as a reference," demonstrating some caution; however, 7.2% opted to "completely adopt AI suggestions." Teacher Wang noted that a key issue is students "using AI without critical evaluation." Teacher Liu echoed this concern, warning that uncritical acceptance could lead students to internalize biased perspectives.

(3) Technology Dependence and Developmental Competency Issues

Regarding independent thinking, over half of the students surveyed (57%) expressed concern—ranging from "somewhat" to "very worried"—that excessive reliance on AIGC could negatively affect their personal development. When asked to rank potential risks, "academic ability degradation" received the highest composite score (3.61), making it the most widely feared consequence among students. At the same time, 46.6% of students believed that AI and thinking ability could develop in balance. Teachers, however, held a different perspective. Teacher Wang argued that improper AIGC use leads to "a lack of learning initiative and responsibility," while Teacher Li noted that it could render task training meaningless, reducing teacher-student interaction to "meaningless false interaction." These concerns prompt a critical reflection: whether AI can truly support balanced cognitive development remains an urgent question.

As shown in Figure 4, there are significant differences in the frequency of AIGC usage among students of different grades. Sophomores have the highest proportion of "daily use" of AIGC, reaching 47.92%, while postgraduate students have the highest proportion of "multiple times per week" usage, at 47.83%, with no one reporting "never used." This high-frequency, in-depth usage habit, while potentially improving efficiency, also hides a stronger risk of dependence. In contrast, freshmen have relatively higher proportions of "rarely use" (16.92%) and "never used" (15.63%), likely because they are new to the university and are still in the exploratory stage of understanding and applying technological tools. Some teachers have also proposed corresponding guidance strategies, attempting to steer students towards a "balanced development" path. Teacher Chen encourages students to use AI as a tool to "inspire ideas, construct ideas, and refine ideas," rather than a simple answer generator. Teacher Li also believes that the reasonable value of AI lies in helping students "expand knowledge boundaries, optimize cognitive levels, and enhance logical abilities." However, he simultaneously emphasizes a crucial prerequisite: "without

weakening their independent thinking ability." Thus, concerns that technological dependence may lead to the degradation of independent thinking ability, learning initiative, and responsibility have become a shared anxiety. How to guide students from "substituting thinking" to "augmenting thinking" is a timely challenge for educators.

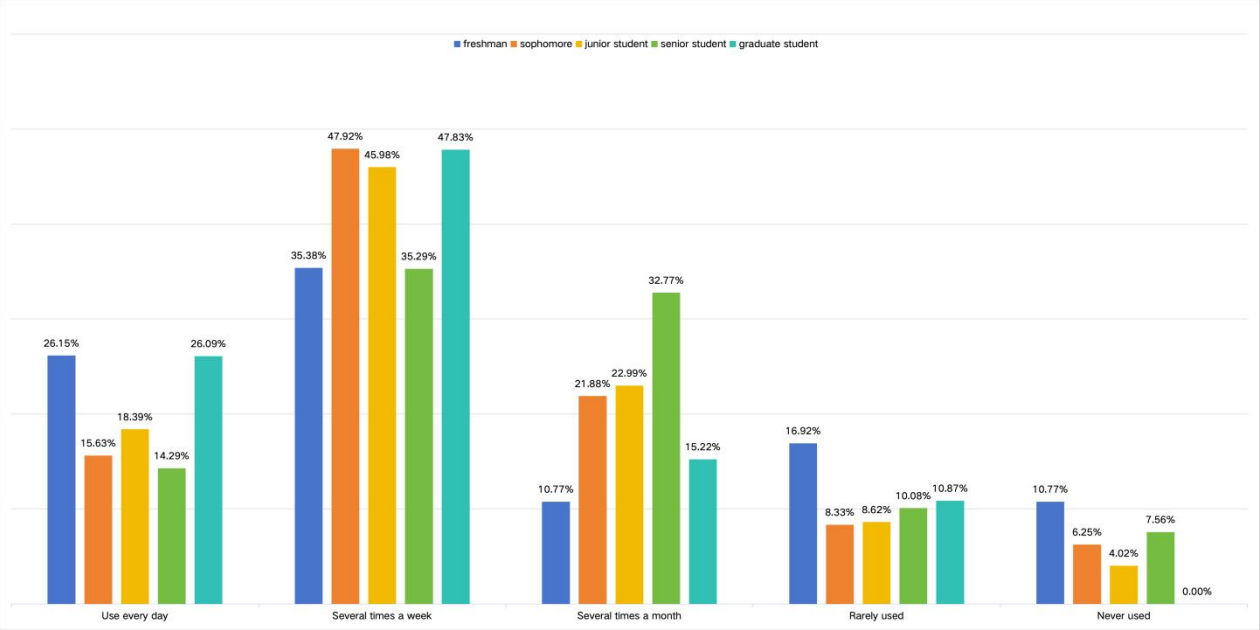

Figure 4. Cross-analysis of AIGC usage frequency among students of different grades

(4) Lack of Accountability and Norms Issues

While 83.6% of students agreed that AIGC-generated content “must” or “should” include source attribution, there is no unified guidance on the extent or format of such citation. Awareness of institutional regulations is also low: 45.8% of students indicated they had “heard of but were unclear about” or were “completely unaware of” relevant school policies. This cognitive gap leads to inconsistent behavior and makes it difficult for teachers to evaluate academic work.

In interviews, Teacher Wang noted that while schools are aware of digital ethics issues, their response is limited to reminders during exams and paper submissions, with no systematic training for faculty. Teacher Zhou pointed to the lack of a “precedent to follow” as a major institutional challenge, testing administrators’ capacity for innovation. Teacher Liu highlighted the “widespread anxiety among teachers” and the difficulty of balancing cross-disciplinary differences in AIGC usage norms.

As shown in Figure 5, as many as 47% of students indicated that their schools only "occasionally mention" related education, while the combined proportion of "not at all" and "unclear" reaches 13.8%. Only 14.2% of students believe their schools provide "systematic courses." This starkly contrasts with the strong demand from students, highlighting a severe lag in educational supply. Facing this dilemma, the leadership proposed pragmatic policy paths. Teacher Liu revealed that the school plans to first issue a university-wide guiding framework, then "fully authorize each college/department to formulate AIGC usage implementation rules that align with their professional characteristics" under this framework, balancing principled unity with

professional particularity. Teacher Zhou also suggested first establishing a set of universal normative rules, then, based on the differences of each major, "introducing more targeted related normative rules." Currently, from student behavior to teachers' judgment basis, to school rules and regulations, there is a widespread problem of normative gaps, unclear guidance, and insufficient support. Constructing a systematic, hierarchical, and dynamic governance system is urgent.

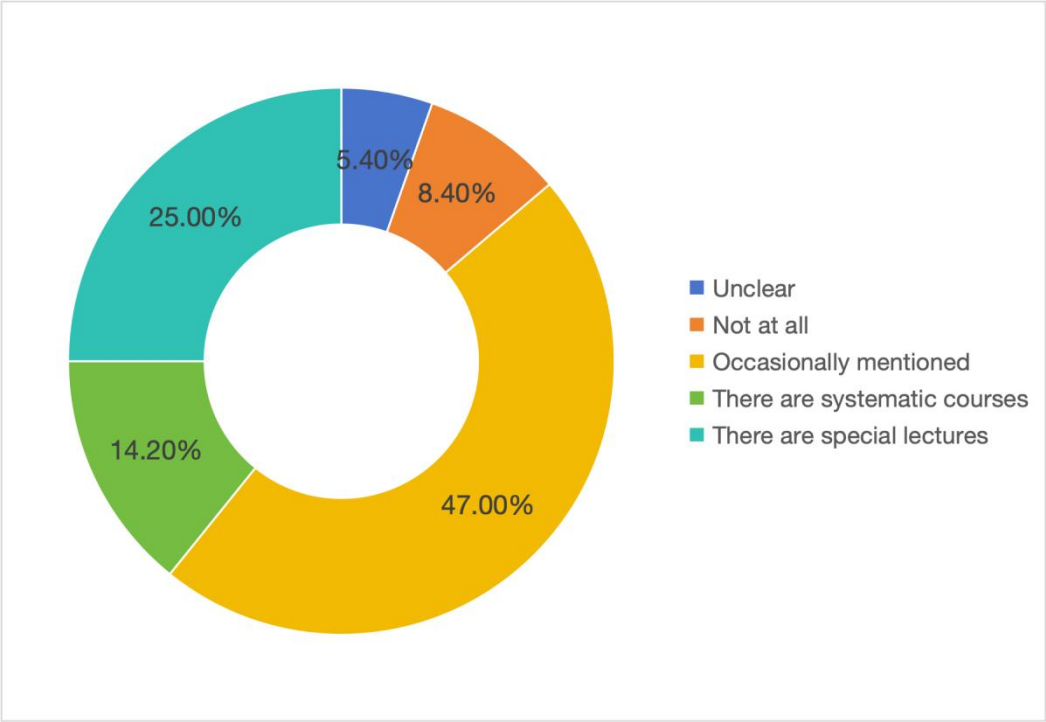

Figure 5. The provision of education related to AIGC or digital ethics by the school

(5) Privacy and Data Security Issues

In the students' ranking of AIGC usage risks, "privacy data leakage" ranked second (3.11 points), becoming one of the core risks of high concern to students. Moreover, 72.4% of students believe that "respecting user privacy" is the most important ethical principle in AIGC educational applications, fully reflecting students' strong awareness and value demand for personal information protection. However, a huge gap exists between students' concerns and actual risks. Despite strong awareness, students generally lack clear understanding and effective coping strategies for how to protect their data, what responsibilities platforms should bear, and what guarantees schools should provide. In interviews, Teacher Wang clearly listed "data privacy leakage" as one of the most prominent digital ethics issues when students use AIGC. This view highly aligns with the student questionnaire data, confirming the universality and urgency of the issue. In current educational discussions and school norm formulation, compared to hot topics like academic integrity and assessment method reform, privacy and data security issues still receive relatively less attention and discussion. When using various free AIGC tools, students often pay with their personal data, and they may not fully estimate the long-term consequences of this behavior. How to integrate data privacy protection education into the digital ethics curriculum, how to establish strict "technology access" review mechanisms when introducing technological

platforms, and how to clarify students' self-protection responsibilities when using public tools will become key issues that applied universities must directly face and strive to solve in the future.

5. Digital Ethics Dilemmas of Students in Beijing's Applied Universities from the Perspective of AIGC-Empowered Education

5.1. Causes of Digital Ethics Dilemmas

Through empirical findings from the above five dimensions, the “Blurring of Academic Integrity Boundaries” and “Lack of Accountability and Norms” reflect the lag at the institutional level, together creating the “Institutional Dilemma.” The “Information Quality and Cognitive Risk Issues” and “Technology Dependence and Developmental Competency Issues” focus on the deficiencies at the student literacy level, together constituting the “Competency Dilemma.” The “Privacy and Data Security Issues” run through both the cognitive and educational levels, highlighting the existence of the “Educational Dilemma.” It is the interplay of these five specific issues that ultimately forms a systematic dilemma at the cognitive, competency, institutional, and educational levels.

5.2. Specific Dilemmas

(1) Cognitive Dilemma. Survey data show that the basic cognitive state of the student population regarding the concept of “digital ethics” is reflected to a certain extent as being widespread. The level of understanding stays at a shallow level limited to “having heard of it.” Only 8.4% of students expressed that they “know it very well.” This cognitive characteristic, possessing breadth but lacking depth, is revealed in this specific context. The practical consequences of this superficial understanding amplify ethical issues. For example, in the question setting of “whether accepting directly submitting assignments generated by generative AI is acceptable,” 21.8% of students still chose to accept, a choice result that to some extent shows the vague state of some students' concept of academic integrity boundaries. Simultaneously, in the questioning framework of “whether worried about personal information being collected when using generative AI”; although 72.4% of students expressed it as the most important ethical principle, in actual usage, reliance on unofficial, unverified platforms is still common, and deficiencies in action related to data privacy protection are also evident. This “knowledge-action gap” highlights the serious deficiency in the transformation of digital ethics education from conceptual understanding to behavioral internalization.

(2) Competency Dilemma. The popularity of AIGC tools, while improving learning efficiency, also brings the risk of degrading students' critical thinking and independent problem-solving abilities. The questionnaire survey shows that “academic ability degradation” is viewed by students as the most worrying risk of AIGC use. Cross-analysis further reveals that 24.23% of students still believe that “AI will seriously weaken independent thinking ability.” In interviews, Teacher Li pointed out that some assignments submitted by students are “fluent in language but logically hollow,” lacking depth in problem analysis and independent construction. Teacher Wang also worried that excessive use of AI leads to a “lack of learning initiative and responsibility.” Additionally, crawling data shows that in the process of promoting AIGC technology

implementation, universities generally have a tendency of “emphasizing tool application, neglecting thinking cultivation.” In the long run, students may degenerate from “technology users” to “technology dependents,” facing the risk of losing core competitiveness in the future workplace, which runs counter to the goal of applied universities to cultivate practical and innovative talents.

(3) Institutional Dilemma. Currently, applied universities in the Beijing area show obvious lag in the institutional construction for AIGC application. According to big data crawling results, among the selected sample of 11 universities, only a few institutions occasionally mention “digital ethics,” and systematic institutional texts have not yet been formed. Questionnaire survey data show that 45.8% of students either "have heard of but are unclear about" or are “completely unaware of” the relevant school regulations, indicating a significant information asymmetry in the institutional communication process. In interviews, Teacher Wang pointed out that “clear academic normative guidance” is still lacking within the school, and teachers have no unified basis to follow when facing AIGC-related issues; Teacher Chen also admitted that “academic norms have not yet been formed,” and management practices face practical difficulties. Due to the variety of disciplines and majors within the university, institutional design fails to fully consider the characteristics of each discipline. For example, art and design majors and economics and management majors have differences in AIGC usage scenarios and originality judgment standards, but current norms do not provide classified guidance, resulting in uneven implementation effects. Thus, the dilemma of “technology application precedes, ethical norms lag” emerges.

(4) Educational Dilemma. Interviews revealed an issue that questionnaires cannot directly present: the key factor behind the lag in digital ethics education at the practical level is the lack of teacher support. Interviews found that teachers generally stated they had not received systematic training. Teacher Li mentioned, “The school has no training; mainly rely on peer communication.” Teacher Wang called for the school to provide “systematic teacher training, clear academic normative guidance, teaching resource libraries, technical support, and assessment tools.” Teacher Liu also pointed out the “widespread anxiety among teachers” from a leadership perspective. Crawling data also corroborate this: although various universities frequently hold AI technology lectures, there are few thematic activities involving ethics education or teaching integration. This unbalanced distribution of educational resources further exacerbates the structural gap in digital literacy between teachers and students, making the digital ethics dilemma for both increasingly prominent.

6. Optimization Paths for Digital Ethics from the Perspective of AIGC-Empowered Education

(1) Construct a multi-level digital ethics education system to resolve the cognitive dilemma of the “knowledge-action gap.”

To address the problems of “sufficient breadth but insufficient depth” and the “knowledge-action gap” at the cognitive level among students, universities need to consider constructing a digital ethics education system that runs through the entire talent cultivation process. First, incorporate digital ethics courses into general education or talent cultivation programs, offering

core courses such as “AIGC Technology Principles and Ethical Norms.” Systematically explain core issues like algorithmic bias, data privacy, and academic integrity to fill the structural gaps in students' cognition. Second, promote the integration of curriculum ideology and politics with professional education, infusing elements of digital ethics into the courses of various majors. For example, emphasize AI-assisted citation norms in related classes, and discuss copyright issues of AI-generated content in design classes, developing characteristic teaching modules based on the features of each discipline. Third, regularly organize thematic lectures, workshops, or debates, inviting technical experts, legal scholars, and corporate representatives to share cases, transforming abstract ethical principles into vivid practical understanding, thereby narrowing the gap between conceptual identification and behavioral norms.

(2) Construct a thinking cultivation system to prevent technological dependency, addressing the competency dilemma of “core literacy degradation.”

To effectively address the degradation of students' critical thinking and independent problem-solving abilities caused by the misuse of AIGC, they need to start from teaching design and evaluation reform, establishing a firewall to protect thinking abilities. On one hand, clearly delineate the red lines and guidance zones for the use of AIGC in teaching activities, issue guiding opinions requiring teachers to specify in the course syllabus academic tasks prohibited from being completed directly using AIGC, while also establishing parts where AIGC use is allowed under guidance, requiring students to submit detailed records of their thinking process, revision history, or usage logs. On the other hand, promote innovation in teaching methods, encouraging teachers to design more open-ended, non-standard-answer practical projects, reducing students' reliance on AIGC at the source. Third, reform the single-outcome evaluation model, establishing a multi-dimensional assessment system that includes classroom discussions, project practice, innovation proposals, and process records. By documenting the problem awareness, analytical depth, and originality of solutions students demonstrate throughout the learning cycle, the foundation for students' independent thinking and autonomous innovation abilities is strengthened.

(3) Improve hierarchical and classified management system construction to resolve the institutional dilemma of “unclear accountability.”

To address the chaos caused by the absence of systems and insufficient system implementation, universities should start from top-level design, scientifically constructing a hierarchical, classified, and clear-accountability AIGC management system covering the “university level - college/department level - classroom level.” At the university level, regulations like “AIGC Educational Application Management Measures” should be issued as soon as possible, specifying technology usage requirements, data security and privacy requirements, and procedures for identifying and handling technology usage violations, providing a bottom line and principles for people to follow. At the college/department level, actively encourage system construction based on the characteristics of each major, requiring detailed rules to be formulated under the guidance of university-level principles, balancing university-level baselines with departmental characteristics. At the classroom level, encourage teachers to include AIGC usage policy provisions in the course syllabus, such as whether usage is allowed, scope of use, citation

requirements, and quantitative evaluation standards. Relevant units of the university can also launch AIGC usage reporting or spot-check platforms, conducting checks on AI content in graduation theses and important academic achievements, preventing academic misconduct from the source.

(4) Strengthen the systematic construction of the teaching faculty to overcome the educational dilemma of "insufficient guidance."

Teachers are the intermediaries of AIGC education; their own digital literacy and digital ethics guidance ability directly determine the effectiveness of AIGC education. Universities should include the cultivation of teachers' digital literacy in the faculty development plan, establishing special training programs. Training content includes: the use and evaluation of AIGC tools, identification and handling of digital ethics issues, how to integrate AI into teaching activities, and how to detect and identify AI-generated content. Some teachers in interviews expressed a strong demand for "training" and "teaching resource library" support. Universities can collaborate with enterprises or other universities, jointly building shared resources such as AI teaching cases, suggestions for handling digital ethics issues, and collections of excellent AIGC teaching design cases. Simultaneously, encourage the establishment of digital ethics teaching and research groups or work groups within certain disciplines, organizing AI teaching observation activities and experience-sharing exchanges between schools, jointly building a "AI + Ethics" teaching and research force.

7. Conclusion

AIGC technology is profoundly reshaping the educational ecology of applied universities, bringing infinite opportunities for talent cultivation while also triggering a series of profound digital ethics challenges concerning academic integrity, cognitive development, data security, etc. Through empirical investigation of applied universities in the Beijing area, this study reveals the four major dilemmas students face in AIGC application: cognition with breadth but no depth, risks in competency development, lag in institutional norms, and insufficient educational guidance. These phenomena are interconnected, proving that in the context of rapid technological advancement, how to establish student guidance mechanisms and standardize usage in schools is a significant challenge currently facing the education system.

Facing such challenges, universities need to undertake construction in various aspects such as teaching, education, management, and faculty. Only by guiding students to consciously recognize and abide by behavioral norms in the digital age, treating AIGC as a learning partner for thinking and inspiring creativity, can technology truly serve education and cultivate contemporary talents with both professional competence and digital literacy. This is both a current task for applied universities and an inherent requirement for the long-term development of higher education.

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The Differentiating Effect of Family Socioeconomic Status on College Students' Healthy Lifestyles: The Mediating Role of Health Literacy

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Abstract

To investigate the influence pathway of family socioeconomic status (SES) on college students' healthy lifestyles and to examine the mediating mechanism of health literacy in this relationship. A convenience sampling method was used to recruit 1,050 college students from 9 universities in central and western China as research subjects; A cross-sectional survey was conducted using standardized scales, including the Family Socioeconomic Status Scale, the Health Literacy Rapid Assessment Questionnaire (HLRAQ), and the Health-Promoting Lifestyle Scale II (HPLP-II); Stratified stepwise regression analysis was used, and based on Hayes' (2017) Process macro Model 4, the bias-corrected Bootstrap method (repeated sampling 5,000 times) was performed in SPSS22.0 to test the mediating effect and confidence intervals of health literacy. Pearson correlation analysis revealed varying associations between dimensions of family SES, healthy lifestyle, and health literacy, with differences in both direction and magnitude: Family economic status was significantly positively correlated with both healthy lifestyle ($r = 0.091$, $p < 0.05$) and health literacy ($r = 0.088$, $p < 0.05$); Family social status was significantly negatively correlated with healthy lifestyle ($r = -0.113$, $p < 0.05$) and health literacy ($r = -0.065$, $p < 0.05$). Health literacy was strongly positively correlated with a healthy lifestyle ($r = 0.259$, $p < 0.001$). The mediating effect test further indicated that health literacy played a partial mediating role between family economic status and healthy lifestyle, with an indirect effect $\beta=0.022$ (SE=0.0028,95% CI [0.006, 0.041]), accounting for 24.18% of the total effect; It also played a partial mediating role between family social status and healthy lifestyle, with an indirect effect $\beta= -0.016$ (SE=0.0082,95% CI [-0.0330, -0.0005]), accounting for 14.58% of the total effect. The family SES is not a single construct, and its economic dimension and social dimension have independent effects on the healthy lifestyle of college students in opposite directions and with different intensities; Health literacy is a key psychological mediating variable that links family

background to individual health behavior. This study systematically reveals for the first time the differentiated pathways of SES multi-dimensionality in the formation of health behaviors, providing high-quality empirical evidence and theoretical support for universities to implement stratified, classified, targeted and precise health literacy improvement and health behavior intervention.

Keywords: Healthy Lifestyle; Family Socioeconomic Status; Health Literacy; College Students; Mediation

1. Introduction

A healthy lifestyle encompasses a constellation of health-promoting behaviors—including balanced nutrition, regular physical activity, sufficient and restorative sleep, stress management, and avoidance of harmful substances—that individuals adopt to maintain and enhance their physical, mental, and social well-being (Walker et al., 1987). As emphasized by the World Health Organization (WHO), approximately 60% of the global burden of non-communicable diseases (NCDs) is attributable to modifiable behavioral and lifestyle factors. Sustained engagement in such behaviors has been consistently associated with reduced risk of chronic conditions (e.g., cardiovascular disease, type 2 diabetes, and certain cancers), increased life expectancy, and improved health-related quality of life. The college years represent a critical developmental window: a transitional phase from adolescence to emerging adulthood characterized by growing autonomy and heightened neuroplasticity—making it a pivotal period for the acquisition, reinforcement, and long-term consolidation of health behaviors. Yet, this formative stage is frequently accompanied by competing psychosocial demands—including academic workload, identity exploration, peer relationship dynamics, and vocational uncertainty—which may undermine consistent adherence to healthy practices. Consequently, evidence-informed interventions that foster scientifically grounded, sustainable lifestyle habits among college students constitute an essential strategic priority for advancing the Healthy China Initiative and strengthening population-level health resilience.

The family, as a primary microsystem shaping adolescent development, constitutes a critical social determinant of health disparities among college students across socioeconomic strata (David et al., 2018). Families with higher socioeconomic status (SES) typically prioritize health promotion and possess greater material and cultural capital—enabling access to preventive services (e.g., routine health screenings), nutrient-dense diets, structured physical activity opportunities, restorative leisure, and consistent health-related modeling. Consequently, they are better positioned to provide instrumental support, normative reinforcement, and cognitive scaffolding that foster the internalization of sustainable health behaviors in their children (Conner et al., 2013). In contrast, families with lower SES often contend with structural constraints—including financial insecurity, time poverty, and limited access to health information and quality care—that impede their capacity to deliver comprehensive health education or model health-protective practices. Empirical evidence further indicates that such contextual limitations correlate with elevated prevalence of health-risk behaviors within low-SES households (Roshchina, 2016).

Despite its theoretical and practical significance, the mediating pathways through which familial SES influences college students' healthy lifestyle adoption remain underexplored—particularly the interplay among material conditions, psychological cognition (e.g., health literacy), and behavioral enactment. To address this gap, the present study adopts a tripartite conceptual framework—grounded in the socioecological model—to examine how family SES shapes college students' healthy lifestyles indirectly, via individual-level health literacy. By elucidating this mechanism, the research aims to generate actionable, evidence-based insights for designing targeted health promotion curricula and campus-wide wellness initiatives in higher education institutions.

2. Theory and Hypotheses Development

(1) Family socioeconomic status and healthy lifestyle

Family socioeconomic status (SES) is defined as the position a family holds within society, which is determined by the social resources that the family possesses or can exercise control over. As a comprehensive measure of family resources, it is usually composed mainly of family income, parents' educational attainment and parents' occupation (Bradley & Corwyn, 2002). Studies have shown that families with higher SES levels usually have more resources, knowledge and social capital, and can provide a healthier living environment and behavioral pattern for their children. Using large-scale cohort data analysis, Zhang et al. (2021), through an analysis of large-scale cohort data, found that individuals with lower socioeconomic status (SES) exhibit a higher risk of all-cause mortality relative to those with higher SES, and that a healthy lifestyle serves as a significant mediator in this association. Similar conclusions were also verified in the group of college students, with studies indicating that young people with low SES faced more problems such as resource scarcity, environmental stress, and insufficient social support during their growth, and were more likely to develop irregular schedules and unhealthy eating habits (Pampel et al., 2010). Based on this, the study puts forward Hypothesis 1:

H1: Family socioeconomic status has a significant predictive effect on the healthy lifestyle of college students.

(2) Mediating health literacy

In the research on the influencing factors of a healthy lifestyle, health literacy is an important variable proposed by the research community in the 21st century. Health literacy refers to an individual's ability to acquire, understand, evaluate and apply health information in order to make beneficial health decisions (Sørensen et al., 2012). Health literacy is not only an important prerequisite for a healthy lifestyle, but is also considered a key mediating mechanism for explaining the transmission of social inequality in the health domain (Nutbeam, 2008).

On the one hand, family socioeconomic status has a significant impact on health literacy. Studies have shown that families with high SES typically have more abundant health information resources, higher levels of parental health awareness, and better educational investment, which can effectively enhance children's health knowledge reserves and information processing

capabilities (Stormacq et al., 2019). Empirical research shows that household income is positively correlated with health literacy and is one of the main factors influencing individual health literacy (Hu et al., 2019; Liu et al., 2019; Zeng et al., 2019); In terms of parental education, some studies suggest that the educational attainment of fathers is one of the main factors influencing health literacy (Hu et al., 2019; Li et al., 2017), while others suggest that the educational attainment of mothers is the main factor influencing children's health literacy (Li et al., 2017). However, whether it is the father or the mother, their educational attainment has a significant positive impact on an individual's health literacy. As this study puts forward Hypothesis 2:

H2: Family socioeconomic status has a significant predictive effect on health literacy among college students

On the other hand, health literacy is an important determinant of a healthy lifestyle. Individuals with higher health literacy are better able to understand the necessity of a healthy lifestyle, acquire scientific health knowledge, and take the initiative to adopt a healthy lifestyle in their daily lives (Suka et al., 2015). A large number of empirical studies have confirmed that health literacy is significantly positively correlated with healthy lifestyles and significantly negatively correlated with health-risk behaviors such as suicide and self-harm (Wang et al., 2020). Residents with health literacy scored significantly higher on health-promoting lifestyles than those without (Chen et al., 2020), while lack of health literacy or moderate to low levels of health literacy were risk factors for health-risk behaviors among adolescents (Li et al., 2019), and the detection rate of picky eating or selective eating was also the highest (Han Xiaosheng, 2018). Therefore, this study presents research hypothesis 3:

H3: Health literacy of college students has a significant predictive effect on their healthy lifestyle.

Based on the above analysis, health literacy may become the key mediating variable of family SES influencing college students' healthy lifestyles. Although studies have explored the relationship between family SES and health literacy, and between health literacy and healthy lifestyle, there are still limited studies that test all three in the same mediating model. Therefore, Hypothesis 4 is proposed in this study:

H4: Health literacy plays a mediating role between family socioeconomic status and healthy lifestyles of college students.

3. Methods

3.1. Participants

The subjects were college students from nine universities in the central and western parts of Mainland China. Using a convenience sampling method, electronic questionnaires were distributed to students in their classes by counselors and instructors. Participation was voluntary and based on informed consent. A total of 1,300 questionnaires were retrieved, and 1,050 were valid, with a valid questionnaire rate of 80.8%. Among the samples, 579 were male, accounting for 55.1%; 471 women, 44.9%; 564 freshmen, 53.7%; 195 sophomores, 18.6%; 213 juniors,

20.3%; 80 seniors and above, 7.6; 127 in liberal arts, 12.1%; 175 in science, 16.7; 489 in engineering, 46.6%; 158 in medicine, 15.0%; Others 101, 9.6%. The sample demonstrated a reasonable demographic distribution, providing a reliable basis for research inference.

3.2. Measures

3.2.1. Family Socioeconomic Status Scale

Family socioeconomic status is mainly assessed by collecting information on parents' education, occupation, and income. The scoring method refers to the Kuppuswamy evaluation method and Li Qiang (2002) multi-division assignment standard, dividing education, income and occupation into seven levels: 21 is the top level, 18-20 is the upper level, 15-17 is the upper-middle level, 12-14 is the middle-middle level, 9-11 is the lower-middle level, 6-8 is the lower level, and 3-5 is the lowest level. Among them, the income assignment criteria are based on the 2020 Blue Book China Class Income Classification (Li et al., 2020), with the income level of middle-class families as the median and divided into seven grades. The assignment criteria are shown in Table 1.

Table 1. Assignment of Family Socioeconomic Status

Education	Household income (ten thousand yuan)	Occupation	Score
Illiterate or literate very little	3 Below	Temporary worker, unemployed	1
Primary school graduate	3 ~ 8	Manual workers	2
Junior high school graduation	8 to 15	Skilled workers	3
High school graduate	15 ~ 30	General office workers	4
Graduated from a secondary technical school or vocational school	30 ~ 100	General managers and general professional and technical personnel	5
College or university degree	100 ~ 500	Middle managers and general professionals	6
Master's degree and above	More than 500	Senior executives and senior professionals	7

3.2.2. Health Literacy Questionnaire

Health literacy tool selection: The Rapid Assessment Questionnaire of Urban Public Health Literacy by Zhuang (2014). The questionnaire is currently the shortest health literacy assessment tool in China. It consists of 20 questions, including 8 questions on health knowledge, 8 questions on healthy lifestyle and behavior, and 4 questions on health skills. Each question is worth 5 points, and each correct answer is worth 5 points, out of 100 points. The criteria for defining health

literacy use 60% and 75% as cut-off values to divide health literacy levels into three grades: below 60 is low health literacy, above 75 is high health literacy, and 60 to 74 is marginal cost health literacy. The Cronbach's α coefficients for each dimension of the scale were 0.87, 0.78, and 0.90 respectively.

3.2.3. Health-promoting Lifestyle Scale

The Healthy Lifestyle Scale is based on the second edition of the Healthy Lifestyle Scale developed by Walker et al. (1996) and revised by Wu Mingcang (2014). It consists of 29 questions and is based on the preliminary research through item analysis and exploratory factor analysis. Two items, "I practice relaxation and meditation every day," and "I resolve disputes with others through discussion and inclusion," were removed, and 27 items, six dimensions, were retained: interpersonal relationship (4), health responsibility (6), stress management (4), nutritional behavior (3), physical activity (4), and mental growth (6). Using the Likert five-point scoring system, "strongly disagree" for 1 point, "disagree" for 2 points, "uncertain" for 3 points, "agree" for 4 points, "strongly agree" for 5 points, with a total score of 27 to 135 points, the higher the score, the better the healthy lifestyle. The Cronbach's α coefficient of the scale is 0.965, and the Cronbach's α coefficient of each dimension is between 0.737 and 0.891.

3.3. Data Analysis

Descriptive statistics, consistency reliability analysis and correlation analysis of the study data were performed using SPSS 22.0 software, and mediating effect analysis was conducted using the Process 3.3 plugin.

Common method bias test: This study collected data using the self-reporting method, and there may be common method bias. To control this bias, the study took preventive measures such as voluntary participation, anonymous surveys, and random distribution of three variable items, and tested the data using the Harman univariate test. The results showed that a total of 15 factors were extracted, and the variance variation explained by the first factor was 33.3%, below the critical value of 40%, indicating that there was no serious common method bias problem in this study.

4. Results

In analyzing the study results, it was found that family socioeconomic status (SES) exhibited a non-significant negative correlation. During the testing process, no positive correlation was observed between parents' educational attainment, occupation, and income—this contradicts the a priori assumption of the scale, which posits that educational attainment, occupation, and income are positively correlated. Specifically, people with a high level of education do not necessarily have a high economic income, and people with a high occupational assignment do not necessarily have a high income. According to regression analysis, economic income better represents the socioeconomic status of a family, and this result is more in line with the current development situation in central and western China (Zhou, 2018). Therefore, in the results analysis, this study divided family socioeconomic status into two dimensions: family social status and family economic status.

4.1. Correlations Between Socioeconomic Status of College Students' Families, Health Literacy, and Health-Promoting Lifestyles

Pearson product-difference correlation analysis was adopted, and the results are shown in Table 2. Family economic status is significantly positively correlated with a healthy lifestyle ($r = 0.091$, $p < 0.05$), and significantly positively correlated with health literacy ($r = 0.088$, $p < 0.05$). Family social status was significantly negatively correlated with both healthy lifestyle ($r = -0.113$, $p < 0.05$) and health literacy ($r = -0.065$, $p < 0.05$); Health literacy was significantly positively correlated with a healthy lifestyle ($r = 0.259$, $p < 0.05$), if 1, 2, 3 were verified.

Table 2. Correlation coefficients of Family socioeconomic status, health literacy and healthy lifestyle

Variables	Family economic status	Family social status	Health literacy	Healthy lifestyle
Family Economic status	1			
Family social position	0.903**	1		
Health literacy	0.088*	-0.065*	1	
Healthy lifestyle	0.091*	-0.113*	0.259*	1

Note: * p <.05

4.2. A mediating Test of Health Literacy

(1) The mediating effect of health literacy between family economic status and healthy lifestyle

To examine the mediating role of health literacy in the relationship between family economic status and healthy lifestyle of college students, stepwise regression analysis was used in this study, and the results are shown in Table 3.

In the first step of the regression model, family economic status was the independent variable and healthy lifestyle was the dependent variable. The results showed that family economic status had a significant positive predictive effect on the healthy lifestyle of college students ($\beta = 0.091$, $t = 2.973$, $p < 0.05$), with model explanatory power of 0.8% ($R^2 = 0.008$, $F = 8.842$, $p < 0.05$), indicating that the higher the family economic status, the level of healthy lifestyle among college students was higher.

In the second-step regression model, family economic status was designated as the independent variable and health literacy as the dependent variable. Results demonstrated that family economic status exerted a significant positive predictive effect on health literacy ($\beta = 0.088$, $t = 2.846$, $p < 0.05$). The model accounted for 0.8% of the variance ($R^2 = 0.008$, $F = 8.099$, $p < 0.05$), indicating that students from families with higher economic status exhibit a higher level of health literacy.

In the third-step regression model, both family economic status and health literacy were included as independent variables, with a healthy lifestyle as the dependent variable. The results

showed that health literacy had a significant positive predictive effect on healthy lifestyle (β = 0.252, t = 8.447, p < 0.05), while the direct predictive effect of family economic status on healthy lifestyle was weakened. It still reached a significant level (β = 0.069, t = 2.320, p < 0.05). The explanatory power of the model increased significantly to 7.2% (R^2 = 0.072, ΔR^2 = 0.070, F = 40.392, p < 0.05). The results suggest that health literacy plays a partial mediating role between family economic status and the healthy lifestyle of college students.

Table 3. shows the results of the sequential examination of the mediating effect of health literacy between family economic status and healthy lifestyle

Independent variables	Dependent variable	Standardized β	*t*	R^2	$\triangle R^2$	*F*
Step 1 Family economic status	Healthy lifestyle	0.091	2.973*	0.008	0.007	8.842*
Step 2 Family economic status	Health literacy	0.088	2.846*	0.008	0.007	8.099*
Step 3 Family economic status	Healthy lifestyle	0.069	2.320*	0.072	0.070	40.392*
Health literacy		0.252	8.447*			

Note: * $p < .05$*

To further verify the significance of the mediating effect, the Process macro (Model 4) developed by Hayes (2017) was used for the mediating effect test. The Bootstrap method was used for repeated sampling 5,000 times to calculate the 95% deviation corrected confidence interval. The results showed that the direct effect of family economic status on healthy lifestyle was β=0.069 (p < 0.05), the indirect effect through health literacy was β=0.022 (SE = 0.0028, 95% CI [0.006, 0.041]), and the confidence interval did not include 0. The mediating effect of health literacy was significant. The mediating effect accounted for 24.18% of the total effect. The mediating effect model is shown in Figure 1.

Figure 1. Diagram of the mediating effect of health literacy between family economic status and healthy lifestyle

(2) The mediating effect of health literacy between family social status and healthy lifestyle

Stepwise regression analysis was used to examine the mediating effect of health literacy between family social status and healthy lifestyle of college students, and the results are shown in Table 4.

The first step was to conduct a regression analysis with healthy lifestyle as the dependent variable and family social status as the independent variable. The results showed that the regression coefficient of family social status on healthy lifestyle was significant ($c = -0.113$, $t = -3.672$, $p < 0.05$), indicating that family social status had a significant negative predictive effect on healthy lifestyle among college students, and family social status could explain 1.3% of the variation in healthy lifestyle.

In the second step, a regression analysis was performed with health literacy as the dependent variable and family social status as the independent variable. Results revealed that the regression coefficient of family social status on health literacy was statistically significant ($a = -0.065$, $t = -2.123$, $p < 0.05$), indicating that family social status exerted a significant negative predictive effect on health literacy and accounted for 0.4% of the variance in health literacy.

In the third step, both family social status and health literacy were included as independent variables, and a healthy lifestyle was used as the dependent variable for regression analysis. The results showed that the regression coefficient of health literacy on healthy lifestyle was significant ($b = 0.252$, $t = 8.474$, $p < 0.05$), while the direct effect of family social status on healthy lifestyle remained significant ($c' = -0.096$, $t = -3.231$, $p < 0.05$).

Table 4. shows the results of the sequential examination of the mediating effect of health literacy between family social status and healthy lifestyle

Independent variables	Dependent variable	Standardized β	*t*	R^2	$\triangle R^2$	*F*
Step 1 Family social status	Healthy lifestyle	-0.113	-3.672*	0.013	0.012	13.484*
Step 2 Family social status	Health literacy	-0.065	-2.123*	0.004	0.003	4.509*
Step 3 Family social status	Healthy lifestyle	-0.096	-3.231*	0.076	0.074	43.102*
Health literacy		0.252	8.474*			

Note: * $p < .05$*

The mediating effect test was conducted using the Process macro (Model 4) developed by Hayes (2017), and the Bootstrap method was used for repeated sampling 5,000 times to calculate the 95% deviation corrected confidence interval. The results showed that the direct effect of family social status on healthy lifestyle was $\beta = -0.096$ ($p < 0.05$), the indirect effect through health

literacy was β=0.016 (SE = 0.0082, 95% CI [-0.0330, -0.0005]), and the confidence interval did not include 0. The mediating effect of health literacy was significant. The mediating effect accounted for 14.58% of the total effect. The mediating effect model is shown in Figure 2. To sum up, Hypothesis 4 is validated.

Figure 2. Map of the mediating effect of health literacy between family social status and healthy lifestyle

5. Discussion

5.1. The Relationship Between Family Socioeconomic Status, Health Literacy and Healthy Lifestyle

(1) The relationship between family socioeconomic status and health literacy

This study found that family economic status was significantly positively correlated with health literacy among college students, whereas family social status was significantly negatively correlated with health literacy. This finding reveals the heterogeneity in the effects of different dimensions of family socioeconomic status on health literacy.

The economic status of a family reflects the material resources at its disposal. Families with higher incomes are more likely to invest in quality educational resources, access to health information, and a health-promoting environment for their children, thereby providing favorable conditions for their health literacy development (Zhang et al., 2022). This result is in line with the family investment theory that family economic capital, through resource transformation, directly affects the accumulation of children's human capital (including health literacy). However, the seemingly contradictory result of a negative correlation between family social status and health literacy is worthy of further exploration. Families where parents have a higher professional status or a better educational attainment tend to be accompanied by a more intense work pace, higher work pressure and longer working hours. In the context of social transformation in contemporary China, such families may focus their limited time and energy highly on their children's academic achievements, objectively squeezing the space for the cultivation of health literacy. In addition, the notion of a "health-academic trade-off" that may exist within high social status families may also weaken the emphasis on the transmission of health knowledge and the formation of healthy habits. This result suggests that in health interventions, high social status should not be simply equated with high health literacy. Attention should be paid to the different paths of impact of

different family resource dimensions on health literacy.

In terms of effect size, the correlation coefficients between each dimension of family socioeconomic status and health literacy are at a relatively weak level. This finding is consistent with previous studies that after entering college, an individual's health literacy is more shaped by proximal factors such as peer influence, campus environment, and media exposure (Nutbeam & Lloyd, 2021). Family, as a remote factor, has relatively limited direct influence.

(2) The relationship between family socioeconomic status and healthy lifestyle

The findings show a significant positive correlation between family economic status and healthy lifestyle among college students, while a significant negative correlation between family social status and healthy lifestyle. This result is highly consistent with the previous discovery pattern of health literacy, further confirming the differentiated effects of different dimensions of family resources on health-related behaviors.

Families with higher economic income are able to provide their children with better health resources (such as quality food, exercise facilities, medical services), thereby promoting the formation of healthy lifestyles (Pampel et al., 2010). This resource-oriented approach reflects the direct shaping effect of family economic capital on healthy behavior.

It is notable that family social status is negatively correlated with a healthy lifestyle. This result may reflect a particular phenomenon in current Chinese society that families where parents have high professional status and good education are often in high-intensity, highly competitive professional environments. This "high status - high pressure" state of existence may be passed on to children through two mechanisms. First, parents are too busy with work pressure to demonstrate and supervise health, weakening the role of families as role models in the formation of healthy lifestyles. The second is that parents define success as academic and career achievements, which imperceptibly leads to children's neglect of healthy lifestyles. Theoretically, this can be seen as a "status inconsistency" or "resource-stress paradox," suggesting the need to distinguish different dimensions of family status in the study of healthy lifestyles and avoid simplifying it to a single class indicator.

(3) The relationship between health literacy and a healthy lifestyle

There was a significant positive correlation between health literacy and healthy lifestyle among college students ($r=0.259$, $p<0.05$), but the correlation coefficient was small and it was a weak correlation. This result is consistent with previous studies (Suka et al., 2015), indicating that health literacy is a necessary but not sufficient condition for a healthy lifestyle.

From the perspective of the knowledge-belieft-action theory, health literacy mainly addresses the issue of health cognition, while the formation of a healthy lifestyle requires crossing the knowledge-action gap and is influenced by multiple mediating and moderating variables such as behavioral intention, self-efficacy, social support, and environmental factors (Bandura, 2004). Therefore, promoting a healthy lifestyle merely by enhancing health literacy may have limited effect. Future interventions should combine health literacy improvement with behavioral skills training and environmental support to form a multi-level promotion strategy.

5.2. Mediating Role of Health Literacy

Mediating effect analysis shows that health literacy plays a partial mediating role between family socioeconomic status and healthy lifestyle. In terms of dimensions, family economic status indirectly promotes healthy lifestyles by enhancing health literacy; family social status, on the other hand, has an indirect negative impact on healthy lifestyles by weakening health literacy.

This result reveals the dual-path mechanism by which family socioeconomic status affects healthy lifestyles. On the one hand, there are direct effects, such as family resources directly providing health conditions and family atmosphere directly influencing healthy habits; on the other hand, there is an indirect effect through the proximal individual factor of health literacy. Health literacy, as an intervenable individual factor, is an important intermediate link in the impact of family socioeconomic status on a healthy lifestyle, in line with the theoretical framework that distant factors act on health through proximal factors (Braveman & Gottlieb, 2014).

Notably, the direct effect remained significant after controlling for health literacy, indicating that the influence of family socioeconomic status on healthy lifestyles is not entirely transmitted through health literacy, and there are other mediating pathways that have not been included. Future studies could further explore multiple mediating mechanisms to more fully reveal the transmission chain between family background and healthy lifestyle.

Furthermore, the negative indirect effect of family social status on healthy lifestyles through health literacy is a finding worthy of continued attention. It suggests that improving the healthy lifestyle of children from high social status families cannot rely solely on traditional health literacy education. Attention should also be paid to their family stress environment and value adjustment to help them establish a more balanced cognitive framework between academic competition and healthy living.

6. Limitations and Future Research Directions

The main limitations of this study are as follows:

First, this study utilizes cross-sectional data. While the mediation model was constructed based on theoretical deduction, it cannot fully rule out the potential for reverse causality or the influence of third-variable confounders. Future research could employ longitudinal designs or natural experimental approaches to further validate the directionality of the mediating pathway.

Second, the counterintuitive finding that family social status is negatively correlated with health literacy and healthy lifestyle is worthy of further study. Further research could explore the psychological and social mechanisms behind it from perspectives such as family time allocation, parental stress transmission, and intergenerational cultural capital, providing a theoretical basis for targeted intervention.

Third, although the influence on some paths is significant, the overall explanatory power (R2) of the model is relatively low. This result suggests that the healthy lifestyle of college students is

still affected by a large number of factors not included in the model. Future research should expand the theoretical framework to include variables such as campus health environment, peer influence, media exposure, and personal health motivation, in order to enhance the explanatory power and intervention guidance value of the model.

Author Contributions:

Conceptualization, C. X & P. L.; methodology, C. X & P. L.; investigation, C. X & P. L.; resources, C. X & P. L.; data curation, C. X & P. L.; writing—original draft preparation, C. X & P. L.; writing—review and editing, C. X & P. L.; visualization, C. X & P. L.; supervision, C. X & P. L. All authors have read and agreed to the published version of the manuscript.

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From Shell Preservation to Value Reconstruction: Based Analysis of Bankruptcy Reorganization in Delisted Private Firms

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Abstract

With the rapid development of China's capital market, a large number of private enterprises have achieved listing and promoted national economic growth. However, under the background of economic transformation and industrial structure adjustment, many listed companies have fallen into operational difficulties due to internal governance problems and market changes, and eventually face delisting. In order to protect investors' rights and rescue valuable delisted enterprises, China promulgated the Enterprise Bankruptcy Law of the People's Republic of China in 2007, introducing the bankruptcy reorganization system. At present, only three enterprises have successfully re-listed after delisting and reorganization, indicating that the bankruptcy reorganization system of delisted companies is still imperfect, with low application frequency and insufficient academic research. As a large private listed enterprise engaged in cable materials, Jiangsu Dewei New Materials Co., Ltd. has large-scale assets, numerous creditors and stakeholders, and has typical research value. This paper takes Dewei New Materials as a case, adopts literature analysis, case analysis and a combination of qualitative and quantitative methods, systematically combs the bankruptcy background, reorganization motivation, model selection, implementation process and effect of the company, and reveals how high-quality enterprises can achieve rebirth through the bankruptcy reorganization system. The study finds that Dewei New Materials has got out of the financial crisis and achieved legal rebirth by introducing social capital as strategic investors, implementing share consolidation, debt restructuring and other measures. This case provides important reference for the bankruptcy reorganization practice of China's delisted private enterprises.

Keywords: Healthy Lifestyle; Family Socioeconomic Status; Health Literacy; College Students; Mediation

1. Introduction

Against the backdrop of China's continuous economic development and industrial restructuring, many listed companies have been unable to adapt to the rapidly changing market environment, fallen into serious financial crisis, and eventually been forced to delist. Among them, traditional material listed enterprises are facing greater operational pressure. On the one hand, the market saturation of building materials and power industries has led to the continuous decline in the revenue of traditional metal and rubber material enterprises; on the other hand, the rise of emerging semiconductor material enterprises has further squeezed the survival space of traditional material enterprises. Most traditional material enterprises choose to restructure or transform. Dewei New Materials, as a representative of traditional material enterprises, fell into a capital chain break and serious financial difficulties due to the blind expansion and improper governance of the former actual controller, and was eventually forced to delist.

Before the promulgation of the *Enterprise Bankruptcy Law of the People's Republic of China* in 2007, Chinese enterprises facing bankruptcy risks only had two ways: liquidation and reconciliation. Once an enterprise went bankrupt and liquidated, it would bring irreparable losses to investors and even have a negative impact on the regional economy. The implementation of the new bankruptcy law introduced bankruptcy reorganization, a third institutional tool, which can minimize losses and rescue high-quality delisted enterprises with operational value as much as possible. However, in practice, the application of the bankruptcy reorganization system in delisted private enterprises is facing many obstacles, such as imperfect legal rules, difficult implementation, ambiguous judicial compulsory confirmation boundaries, etc., resulting in a low success rate of reorganization and few successful cases. At the same time, domestic academic research on the bankruptcy reorganization of delisted private enterprises is relatively insufficient, lacking in-depth mechanism analysis and typical case verification.

This paper takes Dewei New Materials as the research object, and focuses on solving three core issues: first, what internal and external factors lead to the bankruptcy and delisting of private enterprises, and what is the realistic motivation for initiating reorganization; second, what mechanisms are included in the design and implementation of the reorganization plan of delisted private enterprises, and how to balance the interests of creditors, shareholders, investors and other subjects; third, what effects have been achieved after reorganization, what problems still exist, and what theoretical and practical implications can be brought. Through the systematic analysis of this case, this paper aims to enrich the theoretical research of bankruptcy reorganization, provide practical experience for the reorganization of other delisted private enterprises, and provide a reference for the improvement of relevant systems.

2. Literature Review

2.1. Stakeholder Motivation and Interest Balance in Bankruptcy Reorganization

The existing literature has fully discussed the motivation of different subjects in the reorganization of listed companies and the importance of interest balance. He (2020) took Chongqing Iron & Steel as an example and found that the motivations of stakeholders in

reorganization are significantly different: industrial investors participate in reorganization to obtain low-cost control and achieve industrial expansion; creditors actively promote reorganization to avoid low repayment rate in liquidation; original controlling shareholders and small and medium-sized shareholders participate in reorganization to retain the residual value of equity; local governments promote reorganization for the purposes of maintaining stability, ensuring employment and promoting regional economy. The study points out that effectively balancing the interests of all parties is the foundation for the success of reorganization.

Lü (2023) believes that the fundamental reason for the poor effect of listed company reorganization lies in the impure and short-sighted motivation. Many enterprises take "shell preservation" as the core goal, rather than fundamentally solving operational difficulties and realizing long-term development. This kind of short-sighted behavior leads to the lack of prudence in the selection of reorganization investors, the introduction of single financial investors lacking industrial synergy, and the neglect of the improvement of operational capacity and corporate governance. The study warns that "pseudo-reorganization" centered on shell preservation is difficult to sustain and may even fall into a vicious circle.

2.2. Reorganization Model and Debt Restructuring Innovation

With the deepening of research, scholars have gradually shifted their focus from legal procedures to the design of reorganization models. Li (2025) took Kangmei Pharmaceutical as an example and found that the innovative model of "trust scheme + debt-for-equity swap" can effectively deal with huge debt disputes, balance the interests of small and medium-sized investors, creditors and new investors, and promote the smooth passage and implementation of the reorganization plan. This kind of innovative model breaks through the limitations of traditional cash repayment and simple debt-for-equity swap, and provides a new idea for solving complex debt problems.

Existing studies have shown that there is no unified model for enterprise reorganization. For enterprises in different industries and with different crisis causes, it is necessary to design differentiated debt repayment schemes and investor introduction mechanisms according to their actual conditions. The selection of reorganization investors is particularly critical. Introducing strategic investors with industrial background and resource endowment is more conducive to the long-term development of enterprises than single financial investors.

2.3. Institutional Defects and Judicial Enforcement Dilemma

Scholars have found that China's bankruptcy reorganization system still has obvious defects in the application of delisted enterprises. Zou (2013) pointed out that the uncertainty of the court's compulsory approval of the reorganization plan stems from the lack of rules and the absence of interest balance mechanism. Xu (2026) also emphasized that improving the approval and implementation rules of the reorganization plan is the key to rescuing high-quality difficult enterprises.

Specifically, the institutional dilemmas mainly include: first, legal defects, such as not distinguishing the causes of reorganization and liquidation, lacking clear rules for investor equity adjustment, and unclear priority of reorganization financing; second, implementation difficulties,

such as complex creditor-debt relationships, difficult recovery of illegal assets of original controllers, and serious interest conflicts among small and medium-sized shareholders; third, the boundary of judicial compulsory confirmation is blurred, and the discretion space of the court is too large. These problems jointly lead to the low success rate of reorganization of delisted companies and great resistance in the process.

3. Relevant Concepts

3.1. Concept of Bankruptcy Reorganization

In 1986, China promulgated the *Enterprise Bankruptcy Law of the People's Republic of China (for Trial Implementation)*, which only stipulated two ways for enterprise bankruptcy: liquidation and reconciliation. The concept of "bankruptcy reorganization" was first formally established in the *Enterprise Bankruptcy Law of the People's Republic of China* promulgated in 2007. Chapter 8 of the law stipulates the application scope, period, formulation of reorganization plan and other contents, but does not directly define it.

Academic circles have continuously enriched the definition of bankruptcy reorganization. Wang (1996) believed that bankruptcy reorganization is a system that protects the continued operation of difficult enterprises through legal procedures, realizes debt restructuring and enterprise relief, and balances private rights and social interests. Fan and Wang (2009) regarded reorganization as a bankruptcy prevention mechanism, which aims at debtors with reorganization reasons and ability, sorts out creditor-debt relationships under the supervision of the court, adjusts the operation mode, and helps enterprises get out of difficulties. Jia (2011) pointed out that the bankruptcy reorganization system is a special legal procedure for enterprises with bankruptcy risks but revival prospects to carry out operational restructuring and creditor-debt relationship adjustment under the supervision of the court.

Although the bankruptcy reorganization system has been established, it still has obvious limitations in the application of delisted private enterprises, including legal defects, implementation difficulties and ambiguous judicial compulsory confirmation boundaries, which restrict the rescue effect of valuable delisted enterprises.

4. Background and Implementation of Bankruptcy Reorganization of Dewei New Materials

4.1. Basic Situation of the Company

Jiangsu Dewei New Materials Co., Ltd. (Stock Code: 300325) was established in December 1995 and listed on the Shenzhen Stock Exchange ChiNext in June 2012. It is a leading enterprise in the field of cable polymer materials in China. During the 2015 bull market, the company's stock price once reached about 43.8 yuan, with a market value of more than 4 billion yuan.

However, the former actual controller Zhou Jianming blindly promoted the hydrogen energy transformation, provided a large number of illegal guarantees and misappropriated funds, leading to the break of the company's capital chain, continuous losses and negative net assets. In June

2022, the company was officially delisted from the Shenzhen Stock Exchange, becoming a typical case of delisting caused by poor corporate governance and blind expansion.

4.2. Operational Status Before Reorganization

Before reorganization, the company's operating conditions deteriorated sharply. The asset-liability ratio exceeded 100%, it was insolvent, the current ratio was far below the safety level, the gross profit margin continued to decline, the main business lost the ability to make profits and generate cash flow, and the company was on the verge of bankruptcy.

Table 1. Profitability, Operational and Solvency Indicators of Dewei New Materials (2021–2022)

Financial Indicator	2021-6-30	2021-9-30	2021-12-31	2022-3-31	2022-6-30
Operating Revenue (RMB 10,000)	26805.73	29846.14	30568.06	27892.59	26908.38
Net Profit (RMB 10,000)	-2616.45	-4405.49	-41084.66	-2845.48	-6965.65
Asset-Liability Ratio (%)	94.92	96.47	112.47	113.18	—
Net Asset Value Per Share (RMB)	-0.03	-0.08	-0.49	-0.52	—
Current Ratio	0.65	0.64	0.57	0.59	—
Gross Profit Margin (%)	19.2	13.77	7.64	8.79	3.75

Source: Compiled by the author

4.3. Causes of Bankruptcy and Reorganization Process

The direct causes of Dewei New Materials' crisis are blind expansion, illegal guarantees and fund misappropriation. In 2016, the former actual controller blindly entered the hydrogen fuel cell project unrelated to the main business, consuming a lot of capital; at the same time, a large number of illegal guarantees and fund misappropriation seriously damaged the company's assets. The main business revenue declined, unable to repay the due debts, resulting in a comprehensive capital chain break.

In June 2023, the Taicang People's Court ruled to accept the company's reorganization application; in August 2023, the first creditors' meeting was held; in November 2023, the shareholders' meeting voted against the equity adjustment plan for the first time; in February 2024, the second vote was passed; in November 2024, the court formally approved the reorganization plan. By the end of 2024 and the beginning of 2025, the reorganization plan was fully implemented, and the company was out of the reorganization procedure.

4.4. Reorganization Plan and Implementation

4.4.1. Share Consolidation and Capital Reserve Conversion

The reorganization plan implemented a drastic share consolidation: 100 shares were merged into 25 shares, and the reduced part was included in the capital reserve. The capital reserve was used for capital increase, debt-for-equity swap and transfer to strategic investors. Existing

shareholders were greatly diluted and basically lost control. This is an extreme but necessary adjustment under the condition of unclear institutional rules.

4.4.2. Debt Settlement Scheme

The debt settlement adopted the principle of "protecting small creditors and taking care of large creditors": claims below 100,000 yuan were fully repaid in cash; claims above 100,000 yuan were repaid by "cash + shares" in installments. This arrangement alleviated the company's short-term capital pressure and realized debt reduction.

The share consolidation plan was strongly opposed by small and medium-sized shareholders. With the court's mediation and compulsory approval expectation, the plan was finally passed. This reflects the bottom-line role of the judicial compulsory confirmation system, but also exposes the lack of institutionalization and standardization.

5. Effect Analysis of Bankruptcy Reorganization of Dewei New Materials

5.1. Financial Capability Analysis

After reorganization, the company's asset-liability ratio dropped sharply from 333.95% to 38.08%, and the short-term solvency was greatly improved. The net profit turned positive, benefiting from debt restructuring gains. However, the net profit after deducting non-recurring gains and losses was still negative, the operating income shrank, and the main business profitability had not been fundamentally repaired.

Table 2. Cash Flow Structure Changes of Dewei New Materials (2023–2025)

Cash Flow Item	2023-12-31	2024-12-31	2025-6-30
Net Cash Flow From Operating Activities (RMB 10,000)	4963.14	-3266.36	-871.83
Net Cash Flow From Investing Activities (RMB 10,000)	12361.36	-382.12	4503.33
Net Cash Flow From Financing Activities (RMB 10,000)	-27376.11	3390.13	-3783.96
Net Increase in Cash and Cash Equivalents (RMB 10,000)	-10223.02	-246.45	-152.46

Source: Compiled by the author

Table 3. Profitability and Solvency Indicators After Reorganization

Item	2025-06-30	2024-12-31	2024-06-30
Net Profit (RMB)	3170260	17488018	-15092200
Debt-to-equity ratio (%)	38.08	58.44	333.95
Current ratio	1.45	0.87	0.17
Net asset value per share (RMB)	0.34	0.3	-1.87

Source: Compiled by the author

5.2. Experience and Enlightenment of Reorganization

First, financial investors transformed into strategic investors, providing real gold and silver capital injection and industrial resources, which is the prerequisite for the success of reorganization. Second, the drastic share consolidation created space for debt settlement and investor entry. Third, the coordination and compulsory confirmation of the court broke the deadlock of shareholder voting. Fourth, technical cooperation with the Chinese Academy of Sciences laid a foundation for sustainable development.

6. Research Conclusions and Theoretical Contributions

6.1. Research Conclusions

The reorganization practice of Dewei New Materials confirms that the bankruptcy reorganization system can effectively rescue delisted private enterprises with main business value. Through the equity adjustment mechanism of "share consolidation + capital reserve conversion" and the debt restructuring model of "introducing strategic investors + debt-for-equity swap", the company has realized the balance of interests of all parties, resolved the insolvency crisis, and achieved financial rebirth.

However, the case also reveals a structural contradiction: the current profit mainly depends on non-recurring gains such as debt restructuring, the main business profitability is still weak, and it has not completed the transformation from "financial recovery" to "operational revival". This shows that bankruptcy reorganization is only the beginning of enterprise relief, and long-term development still needs to rely on the improvement of main business capacity and corporate governance.

6.2. Theoretical Contributions

Based on **stakeholder theory** and **institutional theory**, this paper makes three theoretical contributions:

(1) Expanding the research scope of bankruptcy reorganization from listed companies to delisted private enterprises, enriching the theoretical framework of bankruptcy reorganization.

(2) Revealing the mechanism of judicial coordination breaking the reorganization deadlock, and supplementing the research on the enforcement of bankruptcy reorganization system.

(3) Distinguishing between "shell preservation" and "value reconstruction", emphasizing that the core of enterprise relief is to restore operational capacity rather than simple financial adjustment.

6.3. Research Outlook

Future research can further focus on the long-term governance mechanism and main business recovery path of delisted enterprises after reorganization, explore the optimization strategy of strategic investor selection, and carry out quantitative analysis on the long-term effect of different

reorganization models, so as to provide more sufficient theoretical support and policy suggestions for the improvement of China's delisted enterprise reorganization system.

Author Contributions:

Conceptualization,Y. Q.; methodology, Y. Q.; investigation, Y. Q.; resources, Y. Q.; data curation, Y. Q.; writing—original draft preparation, Y. Q.; writing—review and editing, Y. Q.; visualization, Y. Q.; supervision, Y. Q. All authors have read and agreed to the published version of the manuscript.

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A Preliminary Study on the Cultural Value and Protection of Ancient Town Architecture in Fencheng, Shanxi

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Abstract

This paper examines Fencheng Ancient Town, an ancient architectural complex located in Shanxi Province, China, through an analysis of its architectural characteristics, cultural significance, and conservation strategies. The town is distinguished by its long history, favorable natural environment, and rich cultural traditions. Its spatial layout is organized around the Drum Tower as the central core, forming a well-structured urban pattern.The principal architectural forms exhibit distinctive features, including the decorated front wall and the stage of the City God Temple, the screen wall and lattice doors of the Confucian Temple, as well as structures such as examination halls and pre-school towers, all of which embody profound cultural meanings. Both the overall layout and the individual architectural elements reflect the integration of local agrarian traditions and Confucian culture.In response to current challenges, such as the decline of traditional customs and inadequate building conservation, this study proposes a series of targeted strategies aimed at promoting the sustainable preservation and development of Fencheng Ancient Town.

Keywords: Fencheng Ancient Town; Architectural Form; Cultural Value; Conservation Recommendations

1. Introduction

With the designation of numerous of ancient building complexes as heritage sites, increasing attention has been given to their role in strengthening cultural identity, preserving architectural heritage, and promoting traditional art. The report of the 19th National Congress of the Communist Party of China emphasized the need to promote the creative transformation and innovative development of excellent traditional Chinese culture. Before transformation and development, we must do relevant preparatory work, namely, understanding the development

history of a certain culture and clarifying its development background, which will help promote the completion of the historical task of "dual innovation". Faced with this situation, the current qualitative description of ancient building complexes mainly focuses on well-known building complexes such as the Forbidden City and its central axis in Beijing (Que, 2022), and the Confucius Temple in Qufu (Wu & Wu, 2019). Research on building complexes in Shanxi Province is also more focused on various courtyards related to Shanxi merchants (Hu & Xie, 2020) and the changes in the Huangcheng Xiangfu and its surrounding environment (Huang, 2021), which have profound historical value at a specific historical moment. The main content of the research is the analysis of the characteristics of the buildings themselves and the development and protection of the buildings (Shi, 2024; Collection of Chinese Local Chronicles, 2006). This paper analyzes the cultural background of the existing buildings in Fencheng Ancient Town and the cultural customs of the area from the perspective of architecture, explaining the relationship between these contents and the geographical environment.

2. Overview of the Ancient City

2.1. Historical Evolution

Fencheng Ancient Town is located in Fencheng Town, Xiangfen County, Shanxi Province today, on the eastern foot of Gushe Mountain in the Lüliang Mountains. According to the Guangxu edition of Taiping County Annals, its original site was located in Jincheng Village, at the southern end of Xiangfen County and the border of Xinjiang County, Yuncheng City (Xue, 2014). Fencheng's history can be traced back to the Tang and Yu periods. The Yongzheng edition of the "Taiping County Annals" records: "Taiping was the capital of the ancient Emperor Yao. Since the Yu, Xia, Shang and Zhou dynasties, it has belonged to Jizhou. During the Spring and Autumn period..., it belonged to Wei. From the Qin and Han dynasties onwards, through the Wei and Jin dynasties, the Later Wei dynasty, the Sui dynasty, the Tang dynasty, the Song dynasty and the Yuan dynasty, for several decades and hundreds of years, it belonged to Hedong, Jiangjun, or Pingyang, and its affiliation changed many times (Bao & Feng, 2011)." Until January 1914, during the comprehensive adjustment of the administrative divisions and place names in Shanxi Province, since there were already three county towns in the country named "Taiping", the ancient place name "Fencheng" was reused. Thus, the ancient Taiping County became today's "Fencheng Town". Fencheng Ancient Town was formerly known as "Taiping County". In 633, the 7th year of the Zhenguan era of the Tang dynasty, the county seat of Taiping County was moved here. After that, Fencheng Ancient Town was able to develop and has a long history, lasting for 1321 years. The construction time of the buildings that can be seen now is mainly concentrated in the Ming and Qing dynasties.

2.2. Natural Environment

Fencheng Town is located in the southwest of present-day Xiangfen County, 18 kilometers from the county seat. It borders Xiangning County to the west, Xijia Township of Xiangfen County to the east, Jingmao Township of Xiangfen County to the north, and Xinjiang County and Zhaokang Town of Xiangfen County to the south. The town covers a total area of 127 square

kilometers. The town proper, also known as Taiping Ancient Town, is located at 110°16.315′E, 35°48.883′N, measuring 332 meters wide from east to west and 655 meters long from north to south, covering an area of 22 hectares.

The Fencheng County Gazetteer states: "Gushe Mountain stands to the west, Chongshan Mountain forms a screen to the east, and the Fen River flows through the middle, making the terrain rugged and secure." Specifically, this refers to the area west of Fencheng Town being the Gushe Mountain range, the main ridge of the Lüliang Mountains, and to the east being the Chongshan Mountain range, a branch of the Taiyue Mountains. The Fen River flows through this region, its banks being flat and forming part of the Linfen Basin. Huoshan Mountain is adjacent to the north, and the Hui River to the south forms a protective barrier around Fencheng Town. Such town layout is in line with the traditional Chinese architecture of relying on mountains and water, and its site selection is completely in line with the typical Chinese architectural tradition.

Fencheng Ancient Town is located in a climate zone that belongs to the semi-arid and semi-humid monsoon climate zone and the temperate continental climate zone. Its typical characteristics are that spring is sunny and warm, summer is hot and rainy, and winter is cold and dry. The four seasons are distinct, spring and autumn are relatively short, and rain and heat occur at the same time. There are many sunny days and few rainy days throughout the year, and the sunshine time is sufficient. The lowest temperature is usually in January, which is the time of the lowest temperature of the year; the temperature is highest in July and August, and the frost period is relatively long.

The annual and seasonal variations in precipitation are very large. There are many rainstorms in July, August and September every year, and floods are likely to occur. The northwest wind is strong in spring and winter, and the southeast wind is relatively mild in summer and autumn. Many features of Fencheng Ancient Town's architecture are fully adapted to the above-mentioned climate characteristics.

2.3. Human Environment

2.3.1. Running Drum Cart

Shanxi is one of the birthplaces of Chinese drum art, and it is also one of the regions in China with a wide variety of drum music and a high level of artistic development (Li, 2012). In Xiangfen, where Fencheng is located, a very important folk activity is called "Running the Drum Cart." Legend has it that it originated in the Spring and Autumn Period. To escape attacks from political enemies, the Marquis of E of Jin built a fortified village (formerly known as "Egongbao") in what is now Weicun, where he stationed his troops for rest and recuperation. Therefore, the "drum" and "cart" in "Running the Drum Cart" refer to the war drum and war chariot of that time. Later, during the Tang Dynasty, Yuchi Gong was enfeoffed there, where he trained soldiers and cultivated land, adopting a policy of combining military and agricultural labor, which further developed "Running the Drum Cart." Today, Running the Drum Cart no longer has a war-related attribute and has gradually been passed down through generations as a folk custom. The "Running the Drum Cart" in Weicun has been preserved to this day, continuously developing and evolving. However, the basic structure of the drum cart has not changed significantly, basically maintaining

its original appearance from thousands of years ago. But due to the loss of its war-related attributes and the increasing emphasis on daily entertainment, the rules surrounding Running the Drum Cart have become increasingly refined and strict. For example, “There are five drum carts in Weicun, located in five different directions within the village. People from different directions can only pull the drum cart belonging to their assigned direction and cannot pull the same cart in different directions (Kang & Zhang, 2020).” Each drum cart has a different pattern, and during the competition, villagers pulling drum carts from different directions wear different colored clothing.

The “drum cart running” tradition itself has a long history and profound meaning. It has been inherited and developed over thousands of years and will continue to be passed down through generations. On the one hand, this custom has been successfully declared a national intangible cultural heritage and is protected by policy. More importantly, it needs to be continuously developed and passed down by the people who play the drums. Local activities include the “Drum Cart Culture Festival.” Furthermore, it is imperative to deepen the understanding and appreciation of this activity among local young people.

2.3.2. Xiangfen Taige (a type of traditional folk performance)

Since the mid-Qing Dynasty, the term "Taige" has been used in various regions including Jiangsu, Zhejiang, Anhui, Jiangxi, Beijing, Shanghai, Fujian, Hunan, Hubei, Yunnan, Guizhou, Sichuan, as well as parts of Hebei, Shanxi, and Henan (Lu, 2012). Because the specific causes and performance styles differ from place to place, each has its own unique characteristics. The Taige performance in Xizhonghuang Village, Fencheng Town, is particularly distinctive.

Taige is less a performance and more a complete ritual, integrating martial arts, acrobatics, drama, and dance, possessing a unique and surprising performance style. Furthermore, the music, costumes, and props used in the performance are subject to strict formal constraints.

There are different accounts of the origin of the Taige performance in Xizhonghuang Village. Among the widely circulated accounts, the main origin times and events include the "Hundred Families Opera" of the Han Dynasty and the "Peacock God" sacrifice of the Ming Dynasty. Regardless of its origin, what we know now is that the current Fencheng Taige performance already had its prototype in the Han and Tang dynasties, and its function changed from welcoming gods and ancestors to the current entertainment activities (Cui & Zhao, 2024). From the perspective of welcoming gods and ancestors, Taige performance shows the Chinese nation's awe of nature and its national imprint of not forgetting its roots.

Nowadays, as an entertainment activity, it has gradually shown a departure from its original sacred and inviolable function, and has truly entered the bloodline of every local person's life in a more vivid form. As a result, the educational and social normative significance derived from Taige activities has become more significant.

A typical problem at present is that Taige, as a national intangible cultural heritage activity, cannot always organize a complete team for performance. Large-scale performances can only be held during the "Thirty-Sixth Day of the Lunar New Year" and the New Year. This problem is enough to show that the inheritance of Taige performance faces a rather arduous challenge. "No

successors" is a predicament faced by the inheritance of many traditional activities in my country.

3. Architectural Features of the Site

According to historical records, the old town site of Fencheng Ancient Town was 655 meters long from north to south and 332 meters wide from east to west, covering an area of 22 hectares. The overall structure was centered on the Drum Tower, with buildings radiating outwards in four directions. To the west were the Confucian Temple, the Imperial Academy, the Examination Hall, and the School Pagoda; to the northwest were the City God Temple, the Wei Hou Temple, the Nuwa Temple, the Guanyin Hall, and granaries; to the east were the county government office, various government offices, the Guan Yu Temple, and the prison. In total, there were as many as 17 streets and alleys (see Figure 1).

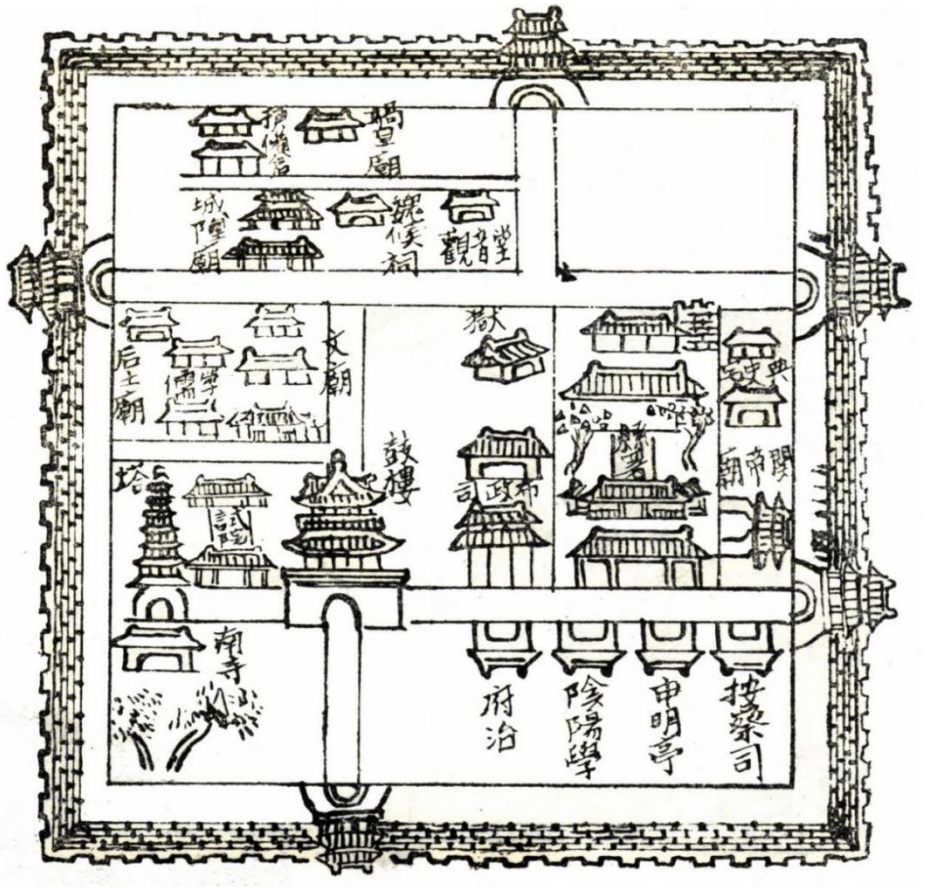

Figure 1. Layout map of the ancient city of Taiping County (from the Qing Dynasty Guangxu edition of the Taiping County Gazetteer)

Fencheng Town has a long history, with more than ten temples built during the Yuan, Ming, and Qing dynasties. The distribution of residences and temples is interwoven, and the town's layout has been well preserved to this day. The specific street layout and building distribution mainly retain the pattern from the late Ming dynasty. It shows traces of the ancient Chinese urban ward system and the layout of shops along the streets after the Song dynasty, truly a unique example of surviving county-level architecture in my country. Because Fencheng Town is located

in the Fen River Valley, its wide and flat terrain has resulted in a well-organized and orderly layout. The basic components of an ancient Chinese city include city walls for defense, temples for education, government offices for administration, shops for commerce, and residences. Fencheng Town encompasses all these elements and is further divided into several unevenly spaced small blocks by Gulou Street, making its land use extremely compact.

4. Main architectural forms and characteristics of the site

Now, when you go to Fencheng Ancient Town, you can see that the two largest groups of buildings preserved in the town are the Confucian Temple and the City God Temple. These two groups of buildings are located on the north and south sides of an alley. The author will mainly introduce these two groups of buildings, as well as some local buildings such as the Xueqian Pagoda and the Examination Hall, and explain their historical background and cultural value.The spatial layout of Fencheng Ancient Town is not a random accumulation of buildings, but a structured system shaped by social hierarchy, ritual practices, and everyday life. Centered on the Drum Tower, the overall spatial organization reflects a form of central-place structure that integrates administrative, religious, and residential functions. This spatial pattern demonstrates how traditional settlements in northern China were organized to balance governance, ritual activities, and local livelihood.

Unlike highly formalized imperial architectural complexes, the layout of Fencheng Ancient Town exhibits a certain degree of flexibility. However, the prominence of key structures, such as the City God Temple and the Confucian Temple, indicates their dominant role in organizing social and cultural space. These buildings function not only as physical landmarks but also as symbolic centers that structure collective memory and social order.

4.1. City God Temple

On the east and west sides of the alley, there is a wooden archway, which is inscribed with "Jiancha Archway (see Figure 2)" and "Yizhen Archway" respectively. Such decorative signs as archways often have the function of strengthening and defining the entrance space (Zhang, 2020). In addition, the meaning of the two archways is closely related to the City God Temple. The City God has always occupied an important position in the folk culture of my country. He is regarded as the spiritual core of a city and maintains the safety of the city and the stability of the residents' lives (Fang et al., 2008). As a strategic location fought over by military strategists since ancient times, the city god in the town could serve as a "protector" during wartime and as a "supervisory god" in peacetime, and was worshipped by the people of the town. In the second year of Hongwu (1369), Emperor Zhu Yuanzhang bestowed titles upon the city god (Li & Wang, 2018) and ordered officials at all levels to take an oath at the city god temple in their place of office after taking office, and to make a pledge to ensure that they were honest and upright and loved the people like their own children.

Figure 2. Jiancha Fang

4.1.1. The Painted Screen

In front of the gate In front of the main gate of the City God Temple, there is a painted screen (see Figure 3). In the middle of the screen is a round Qilin. The "Qilin screen" or "Greedy screen" was built in the early Ming Dynasty during the Hongwu period. The screen is located in front of the City God Temple, which once again highlights the simple legal system of the City God Temple (Hu, 2012). On both sides are inscribed a couplet with the philosophical meaning of life and death: "Man transforms into things and things transform into man, the changes are endless. He is born and dies, and he is born and dies without end." A pair of stone flagpoles are erected on both sides of the screen, on which are inscribed "On behalf of Heaven, we proclaim the transformation of the country and protect the people. The Emperor inherits the power to show good and punish evil." Before even stepping into the temple gate, one is deeply impressed by the solemnity of the gate.

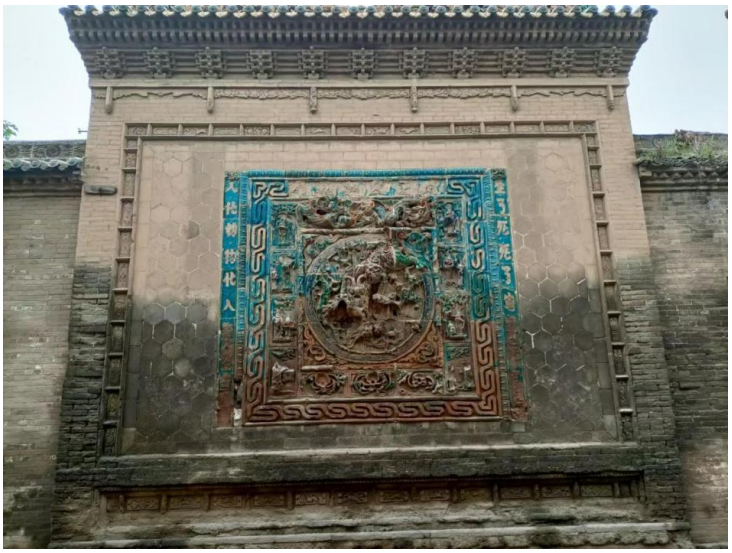

Figure 3. Screen wall at the main gate of the City God Temple

4.1.2. Passing-Through Stage

Inside the gate of the City God Temple, about one meter away, there is a "passing-through stage" facing north (see Figure 4). The foundation of the stage is made of stone. The wooden structure supports the main framework. Because it is a "passing-through stage", it is only set up when a theatrical performance is needed. Otherwise, it serves as a passageway. According to existing data, this type of stage construction began to appear in the mid-to-late Ming Dynasty. By continuously moving the relative position of the stage southward, it eventually formed a close connection with the building, making the temple more secular (Zhang & Liu, 2001).

4.1.3. Offering Hall

From the passageway inwards, one is greeted by a square, cross-shaped, hipped-roof building with a depth of one bay—the Offering Hall of this City God Temple. The Offering Hall was where sacrifices were offered to the City God, and its glazed tile roof, ridge, eaves, and gable ridges are all well-preserved.

4.1.4. Main Hall

Adjoining the Offering Hall and being the highest building in the temple grounds is the south-facing Main Hall. The Main Hall is a seven-bay, corridor-less hall, five bays wide, with a glazed tile roof that has been preserved to this day, showcasing the superb glazing techniques of ancient craftsmen. The bell and drum towers of the City God Temple are located on the east and west sides of the Main Hall. The bell is rung at sunrise, and the drum is sounded at sunset. The double-eaved hipped roofs of the bell and drum towers are beautifully designed and are treasures of northern Chinese wooden architecture.

Figure 4. Pass-through stage

4.2. Confucian Temple

Separated by an alley from the City God Temple and located southeast of it, lies another well-preserved and grand building—the Confucian Temple. Its first courtyard is shaded by towering cypress trees, hence the local name "Cypress Courtyard." Legend has it that this complex was first built in the Tang Dynasty. The Confucian Temple complex perfectly embodies the symmetrical distribution along a central axis. Facing south, the complex consists of a screen wall, the Lingxing Gate, the Pan Pool, the Ji Gate, and the Dacheng Hall, arranged from south to north.

4.2.1. Screen Wall

Directly opposite the main gate of the Confucian Temple stands a straight screen wall made of blue bricks. A couplet is inlaid on both sides of the screen wall: the first line reads, "The Way is uniquely illustrious, its virtues are universally appreciated," and the second line reads, "There is no second place to honor, the poems of the sage are revered throughout history." Following the typical structure of a complete screen wall, the screen wall in front of the Confucian Temple is composed of three parts: the base, the body, and the top. The base is a meticulously crafted "Sumeru pedestal," highlighting the temple's importance in the area. The body is empty, but other screen walls in the ancient town of Fencheng often feature auspicious motifs like the Qilin (a mythical creature), suggesting that this screen wall originally had some designs, which were likely destroyed later. The top is a double-sloped roof with tiled ridges and animal figures.

4.2.2. Lingxing Gate

The Lingxing Gate (see Figure 5) of the Confucian Temple, according to records, was built during the Zhengde period of the Ming Dynasty.

Figure 5. Lingxing Gate

Figure 6. Dismounting Stele

It is a three-bay, four-pillar, three-story stone archway with a hipped roof imitating a wooden structure. Both the inner and outer sides of the gate are supported by four stone pillars, each with a reclining lion encircling its base. The inner side of the Lingxing Gate is inscribed with "Golden Sound and Jade Vibration". The first documented record of it is in Mencius, which interprets it as "sage" (Li, 2010), which is also to praise the contributions of the sage Confucius. There is a stone tablet in front of the Lingxing Gate, which is inscribed with "Civil and military officials, soldiers and civilians, etc., dismount here" (see Figure 6). This also reflects the respect for Confucius and the symbolic role of etiquette. In addition, it can also serve the practical value of tethering horses.

4.2.3. Pan Pond

The Pan Pond (see Figure 7) can be regarded as a representative of local official schools. It originated in the State of Lu during the pre-Qin period (Deng, 2017). During the Northern Song Dynasty, a large number of Pan Ponds were built. At that time, the shape of the Pan Pond was mostly square. Although most of them were located in front of the Minglun Hall, there was no written rule on the location of the Pan Pond. Even in the Yuan Dynasty, the regulations were not unified and the rectangular shape was still the main one. Until the middle and late Ming Dynasty, there were clear regulations on the location of the Pan Pond, namely, the Pan Pond was built inside and outside the Lingxing Gate. In addition, the shape of the Pan Pond was changed from the original rectangular shape to a semi-circle or a near semi-circle shape.

The Pan Pond in the Confucian Temple in Fencheng Ancient Town is located inside the Lingxing Gate. When people of all kinds enter the Lingxing Gate and see the Pan Pond, they will

feel infinite respect and admiration in their hearts, thus laying a solemn and dignified spiritual foundation for entering the Dacheng Gate for worship (Xiao & Cao, 2012). Its shape is semi-circular, and the crescent shape also represents the idea that learning has no end (Li & Wang, 2024). The main building material is brick, and the banks are surrounded by stone railings. There are ten balusters on each side of the railings, and stone lions are carved on the top of the balusters, each with its own shape. On the railings, there are plant patterns with auspicious meanings such as peonies and lotuses. In addition, there is a "Pan Bridge" above the Pan Pond, also known as the "Zhuangyuan Bridge".

Figure 7. Pan Pond and Zhuangyuan Bridge

4.2.4. Dacheng Gate

Passing through the Lingxing Gate and the Zhuangyuan Bridge over the Pan Pond, the Dacheng Gate comes into view (see Figure 8). Dacheng Gate is also called "Ji Gate," meaning a gate with halberds erected. In ancient times, emperors would use halberds as gates when they traveled. Unlike military halberds, gate halberds were a type of ceremonial weapon, and their number was directly proportional to the official rank (Cui, 2014). The Dacheng Gate of Fencheng Ancient Town was first built in the Ming Dynasty. It is a gable-roofed building with glazed tiles on the top, three bays wide and four rafters deep. There is a side gate on each side of the Ji Gate, for pedestrians to use outside of special times. The main gate is only opened during occasions such as grand ceremonies and sacrifices.

On the east and west sides of Dacheng Gate, there are two shrines: the Shrine of Famous Officials and the Shrine of Local Worthies. The Shrine of Famous Officials is used to enshrine honest and upright officials who served in Taiping County, while the Shrine of Local Worthies enshrines people from Taiping who served elsewhere and local gentry.

Figure 8. Dachengmen

4.2.5. Dacheng Hall

After entering Dacheng Gate, you can see the main building of the Confucian Temple - Dacheng Hall (see Figure 9). At the same time, this hall is also the most magnificent building in the entire Fencheng Ancient Town architectural complex. It is said that it was first built in the Tang Dynasty, and the existing buildings are from the Ming Dynasty. The hall is five bays wide, and the top is a double-eaved hip roof covered with glazed barrel tiles. The ridge is also decorated with glazed tiles and carved with strange flowers and beasts. There is a platform in front of Dacheng Hall, and a porch on the platform. The porch is a double-eaved hip roof. According to records, there were originally statues of Confucius and his four sages in the hall. After the "Supreme Sage Teacher" was honored during the Jiajing period of the Ming Dynasty, the statues were changed to memorial tablets (Li, 2010). There are nine rooms on each side of Dacheng Hall, which are also places to worship the sages and scholars.

Figure 9. Dacheng Hall

4.3. Examination Hall and Xueqian Tower

Walking forward from the Lingxing Gate of the Confucian Temple, you will see the Examination Hall of Taiping County, the place where scholars of all dynasties took the imperial examinations. Built in August of the seventeenth year of the Daoguang Emperor's reign, it had a main hall at the rear and a platform at the front, with 15 examination rooms. Bricks were used as tables and benches in the rooms, accommodating a total of 900 examinees. After the examination hall was built, a wall was constructed, enclosing the original Wenfeng Tower, thus transforming it into the Xueqian Tower. This tall building, visible from the Lingxing Gate of the Confucian Temple (see Figure 10), was located within the examination hall's wall and in front of the Confucian Temple, hence the name "Xueqian Tower" (meaning "Pagoda Before the Scholars").

The Wenfeng Pagoda itself is a byproduct of my country's imperial examination system. When Buddhism and Confucianism met in East Asia, Chinese culture embraced and integrated all reasonable foreign elements. As a pagoda, the Wenfeng Pagoda was originally a product of Buddhism. In Shandong, the birthplace of Confucianism, it was compatible with Confucianism. Combined with the most traditional Chinese feng shui, it eventually formed the Wenfeng Pagoda with Confucian connotations (Zhu & Yang, 2026).

The Wenfeng Pagoda in Fencheng Ancient Town is a nine-story pagoda, 23 meters high, standing majestically on the south side of the Confucian Temple. The pagoda is a hollow structure, with the entire space from the first to the ninth floor being interconnected, without any stairs for climbing.

Figure 10. Xueqian Tower

5. Status, Characteristics and Value of the Site

5.1. Cultural Significance of Fencheng Ancient Town

Fencheng Ancient Town is actually a collection of buildings from the Jin, Yuan, Ming and Qing dynasties. The history of the town can even be traced back to the Warring States period. Its long history and well-preserved state are unparalleled.

5.1.1. Agricultural Culture/Central Plains Culture

Fencheng Ancient Town is located in the lower reaches of the Fen River, the second largest tributary of the Yellow River. It shares the same land with the ancient Dingcun Site. As an important site of human distribution in ancient my country, the Dingcun Site is where China's agricultural civilization originated. The earliest wisdom of the Chinese people, the earliest agricultural development, the earliest record of time, and even the observation of the nascent Twenty-Four Solar Terms (Kanjumba, 2026) are all here. The solar terms still play a guiding role in agricultural production in this land. Generation after generation has lived and thrived here. Although the time of the existing buildings can only be traced back to the Yuan and Qing Dynasties, in the uninterrupted bloodline inheritance, time has become a simple symbol, and customs are the memories that we can see with our own eyes.

5.1.2. Confucian Culture

The Confucian Temple buildings in the two major building complexes of Fencheng Ancient Town embody the profound influence of Confucian culture on the Chinese land in every brick and tile.

Confucianism, as the creator of the ideology that maintained social stability in traditional Chinese society (Ge & Li, 2026), embodies loyalty, filial piety, benevolence, and righteousness as the backbone of every Chinese soul. This has been the source of the Chinese nation's enduring strength throughout history, even under foreign rule. This influence manifests itself in behavioral habits, written symbols, and, of course, architecture.

There are over two thousand Confucian temples of varying sizes throughout China and even the world. While the thoughts of Confucius endure, the widespread promotion of Confucian temples is not only due to the immense influence of Confucian thought itself, but also largely attributable to the "respect for Confucius and Confucianism" by successive Chinese emperors. Furthermore, the consistency in the scale and architectural style of these scattered temples demonstrates that the cultivation of moral character, such as propriety, righteousness, integrity, and a sense of shame, was not merely empty rhetoric in traditional Chinese feudal society.

5.2. Architectural Significance of Fencheng Ancient Town

5.2.1. Overall Architectural Layout Perspective

Fencheng Ancient Town itself is not a complex of buildings that served a specific social function. The existing buildings within it are simply those necessary for the daily lives and production of the local residents, including some residences. During the author's research, these residences were not open to the public; only general observations were made from the outside. It is evident that these residences were built around the same time as the Confucian Temple and City God Temple, which were highlighted earlier. This demonstrates that the architectural complex was closely aligned with the actual lives of the local people.

Therefore, the overall structure and layout of the complex are not as strict and orderly as those of the Confucian Temple. However, it is clear that the buildings related to the guardian deities and Confucius are the largest in the entire complex. Through the study and analysis of the overall architectural layout, we can understand the daily life and festive atmosphere of ordinary Chinese people hundreds of years ago.

5.2.2. Detailed Architectural Design

Architecture is inherently designed to meet people's daily needs, so the most important design principle must be prioritizing human needs. For example, in Fencheng Ancient Town, located in a typical monsoon climate, flat roofs are not typically built. Furthermore, Xiangfen, "backed by mountains to the east and bordered by Gushe to the west," enjoys a guaranteed timber supply due to its climate and topography. This ensures that wood remains the primary building material in Fencheng Ancient Town. While overall rainfall is not insignificant, it is concentrated, preventing even wooden buildings from succumbing to excessive moisture and allowing them to retain their former glory and splendor even centuries later.

6. Conclusion and Recommendations

Based on the life cycle theory of tourist destinations, Fencheng Ancient Town is currently in the exploratory stage and, overall, has not yet been commercialized. One major reason is that the location of Fencheng Ancient Town is closely intertwined with the lives of the local people; it is not an independent place completely detached from their daily lives. Therefore, further commercial development of the ancient town is needed. However, precisely because it has not been commercially developed, Fencheng Ancient Town is well-preserved, with no obvious signs of human damage. Some buildings, however, did not survive artillery fire. So, overall, the problem with Fencheng Ancient Town lies in the fact that the damage to some buildings was not repaired in a short period, making subsequent restoration more difficult. Overall, the preservation of the ancient buildings is relatively complete.

Beyond the architecture itself, the charm of Fencheng Ancient Town lies in its unbroken customs and traditions passed down through history. However, with economic development and social progress, these customs and traditions face enormous challenges. People's aesthetic demands for literature and art are increasing, but old traditions cannot keep pace with the times. The issue of their inheritance is urgent. While updating performance styles and engaging the younger generation are possible, their implementation faces many difficulties. Besides local artisans taking responsibility for our cultural heritage, the local government needs effective policies and measures to leverage the power of the public and society to revitalize and ensure the enduring transmission of traditional culture. I will offer some suggestions on the protection and tourism development of certain buildings:

6.1. Research Findings

This study has systematically examined the architectural characteristics and cultural significance of Fencheng Ancient Town through the analytical lenses of spatial organization, ritual function, and cultural symbolism.

The results demonstrate that the spatial structure of the ancient town is organized around the Drum Tower, forming a central-place pattern that integrates administrative authority, religious activities, and residential life. This spatial configuration reflects a localized governance model in which political, cultural, and everyday functions are closely intertwined.

At the level of individual architectural complexes, the Confucian Temple represents a highly structured ritual space defined by axial alignment and hierarchical progression. The sequential arrangement of architectural elements—such as the Lingxing Gate, Pan Pond, Dacheng Gate, and Dacheng Hall—constructs a ceremonial pathway that regulates both physical movement and symbolic meaning. This spatial logic embodies Confucian principles of order, hierarchy, and moral cultivation, demonstrating how architecture serves as a medium for ideological expression.

In contrast, the City God Temple illustrates a more flexible spatial system characterized by the integration of sacred and secular functions. The coexistence of ritual space and performance space within the same complex reflects the dual role of the temple as both a site of religious belief and a center of communal interaction. This highlights the importance of architecture in mediating between collective belief systems and everyday social practices.

Furthermore, the Examination Hall and Xueqian Tower embody the institutional and symbolic significance of the imperial examination system. Their spatial presence reflects not only functional requirements but also the cultural value placed on education, meritocracy, and social mobility. The incorporation of elements such as the Wenfeng Pagoda also indicates the interaction between Confucian ideology, folk beliefs, and geomantic principles, revealing the hybrid nature of the cultural landscape.

Overall, the study reveals that Fencheng Ancient Town constitutes an integrated cultural landscape in which architectural space operates simultaneously as a physical environment, a ritual framework, and a carrier of cultural meaning. The relationship between spatial form and social structure is therefore central to understanding the historical and cultural value of the site.

6.2. Policy Recommendations

Based on the above findings, this study proposes the following recommendations for the conservation and sustainable development of Fencheng Ancient Town.

First, conservation strategies should prioritize the integrity of spatial organization rather than focusing solely on individual buildings. As demonstrated in this study, the cultural significance of the site lies in the relational structure between architectural elements, particularly the axial system and ritual sequences of the Confucian Temple. Therefore, preservation efforts should aim to maintain the overall spatial logic and not merely restore isolated structures.

Second, heritage conservation should emphasize the preservation of ritual function and cultural symbolism. Architectural elements such as gates, stages, and ceremonial spaces derive their significance from their use within cultural practices. Without the continuation of these practices, the meaning of the architecture risks being reduced to purely visual or aesthetic value.

Third, the City God Temple should be managed as a dynamic cultural space that balances preservation and social vitality. Given its role in integrating religious belief with community activities, moderate cultural activation—such as the revival of traditional performances and temple fairs—can enhance its relevance while maintaining its historical authenticity.

Fourth, heritage management should integrate both tangible and intangible cultural resources. The findings indicate that the value of Fencheng Ancient Town extends beyond its physical structures to include local customs, festivals, and performance traditions. Effective conservation therefore requires coordinated efforts involving local communities, cultural practitioners, and policy institutions.

Fifth, tourism development, if pursued, should be carefully aligned with the spatial structure and cultural logic identified in this study. Rather than introducing externally driven commercial models, development strategies should reinforce the existing cultural identity of the site. Excessive commercialization or spatial alteration may disrupt the historical continuity and undermine the authenticity of the cultural landscape.

Finally, environmental management should be incorporated into conservation planning. As observed during field investigation, external environmental pressures, such as traffic-related pollution, pose potential threats to the long-term preservation of the site. Coordinated planning

measures are therefore necessary to ensure both cultural and ecological sustainability.

6.3. Limitations and Future Research

This study is primarily based on qualitative analysis, including field investigation and architectural interpretation. While this approach provides in-depth insights into spatial and cultural relationships, it may benefit from further methodological expansion. Future research could incorporate quantitative spatial analysis, GIS-based modeling, or comparative studies with other traditional settlements to deepen the understanding of regional architectural patterns and cultural landscapes.

In addition, further interdisciplinary research integrating architectural history, cultural geography, and heritage studies would contribute to a more comprehensive framework for analyzing and preserving similar historical settlements.

Author Contributions:

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Dietary Cholesterol and Cardiovascular Disease: The Triangular Relationship Between Evidence-Based Medicine, Public Health Policy, and the Food Industry as Seen Through the Evolution of Dietary Guidelines

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Abstract

The relationship between dietary cholesterol and cardiovascular disease is one of the most controversial topics in the history of nutritional science. This paper systematically reviews the historical evolution of dietary cholesterol recommendations in dietary guidelines since the mid-20th century, revealing the complex interplay among evidence-based medicine, public health policy, and the food industry that underlies this evolution. The study finds that the evolution of dietary cholesterol recommendations is not a simple narrative of scientific progress, but rather a tortuous process involving "hypothesis establishment—policy entrenchment—scientific revision—and interest-based bargaining." From the 1950s to the 1970s, Ancel Keys' "lipid hypothesis" was established as the dominant paradigm within a specific historical context, and strategic interventions by the sugar industry further reinforced the singular attribution of health risks to "fat and cholesterol." The first edition of the U.S. Dietary Guidelines in 1980 established a daily upper limit of 300 mg for dietary cholesterol, a standard adopted by many countries over the following four decades. However, the 2015 U.S. Dietary Guidelines' decision to remove the cholesterol limit marked a fundamental shift in scientific understanding—from a focus on individual nutrients to a holistic dietary pattern. The issue of industry influence exposed in the 2025 edition of the U.S. Dietary Guidelines reveals the tension between scientific consensus and policy-making. The "ultra-processed foods" classification system in the Brazilian Dietary Guidelines represents a new path away from the reductionist paradigm. This article argues that the essence of the dietary cholesterol controversy lies in the conflict between "reductionist" and "holistic" scientific paradigms. Public health decision-making requires the establishment of more robust mechanisms to prevent conflicts of interest, while future nutritional science should transcend debates over individual nutrients and return to the fundamentals of whole foods and dietary patterns.

Keywords: Dietary Cholesterol; Cardiovascular Disease; Dietary Guidelines; Evidence-Based Medicine; Food Industry; Commercial Determinants of Health

1. Introduction

Since the mid-20th century, cardiovascular disease has been a leading cause of death worldwide. In the quest to understand its causes, the relationship between dietary cholesterol and serum cholesterol, as well as the relationship between serum cholesterol and cardiovascular disease, has been a central focus of nutritional epidemiology (The Rockefeller University, 1994; Kepczyk & Moore, 2026). However, dietary cholesterol recommendations have undergone a dramatic shift over the past seven decades—from advocating for restriction in the 1960s, to the removal of the 300-milligram daily limit in the 2015 U.S. Dietary Guidelines, and finally to the implicitly contradictory stance in the 2025 guidelines.

This evolution is by no means a simple story of "scientific progress." It is interwoven with the accumulation and interpretation of scientific evidence, path dependence in public health policy, the interests of the food industry, and conflicts between different scientific paradigms. As historians have pointed out, the production of scientific knowledge never occurs in a vacuum but is deeply embedded within specific social, economic, and political contexts.

This paper aims to systematically trace the historical evolution of dietary guidelines regarding dietary cholesterol, analyze the multiple driving factors behind them, and explore the implications of this case for contemporary public health policy-making. The paper will proceed in four parts: first, a review of the evolution of scientific understanding regarding the relationship between dietary cholesterol and cardiovascular disease; second, an analysis of the historical evolution of cholesterol recommendations in dietary guidelines and their key turning points; third, an examination of the role of the food industry in scientific controversies and policy-making; and finally, a discussion of the profound implications of this case for evidence-based medicine and public health policy.

2. The Evolution of Scientific Understanding: From the "Lipid Hypothesis" to "Paradigm Shifts"

2.1. The Development and Establishment of the Lipid Hypothesis

Research into the link between dietary cholesterol and cardiovascular disease began in the early 20th century. In 1913, Russian pathologist Nikolai Anichkov, through feeding experiments on rabbits, first demonstrated that cholesterol can induce atherosclerotic lesions, providing early experimental evidence for cholesterol-related theories. However, this study had significant limitations: rabbits are herbivores, and their dietary cholesterol metabolism differs fundamentally from that of humans—a flaw that was not fully recognized at the time.

In the 1950s, the incidence of cardiovascular disease rose rapidly in Western countries, and myocardial infarction became the leading cause of death in the United States, prompting the

scientific community to accelerate its search for the underlying causes of the disease. Against this backdrop, Ancel Keys, a physiologist at the University of Minnesota, formally proposed the lipid-heart hypothesis, whose central tenet was that dietary saturated fat and cholesterol raise serum cholesterol levels, thereby triggering atherosclerosis and coronary heart disease.

Launched in 1958, the Seven Countries Study provided key support for the lipid hypothesis. The study compared dietary patterns and coronary heart disease mortality rates across seven countries, including Japan, Greece, and the United States, and concluded that there was a positive correlation between saturated fat intake and coronary heart disease mortality. Subsequent studies have pointed out significant methodological flaws in this research: Kees initially collected data from 22 countries but selected only the seven that supported his hypothesis for publication; countries such as France, which had high saturated fat intake but low rates of coronary heart disease, were deliberately excluded; and the study contained statistical biases such as selective reporting.

Despite scientific controversy, the Seven Countries Study had a significant impact on policy. In 1955, when U.S. President Eisenhower suffered a sudden heart attack, his attending physician publicly emphasized the health risks of saturated fat and cholesterol, bringing the lipid hypothesis into the spotlight of political attention. For decades thereafter, the fat-cholesterol paradigm became the dominant theoretical framework in the field of cardiovascular disease prevention.

2.2. The Accumulation and Revision of Scientific Evidence

In the second half of the 20th century, as research methodologies improved, the limitations of the lipid hypothesis gradually became apparent. First, numerous epidemiological studies confirmed that the association between dietary cholesterol and serum cholesterol was weaker than theoretically predicted. Research by Edward Arens at Rockefeller University demonstrated that there are significant individual differences in the metabolism of dietary cholesterol in humans; in some populations, high cholesterol intake did not lead to a significant increase in serum cholesterol, suggesting that a one-size-fits-all restriction on dietary cholesterol lacks a physiological basis (Liu & Zhao, 2017; Dean et al.,2024). Second, clinical trials of statins have prompted new academic reflection. While statins can significantly lower LDL cholesterol and reduce cardiovascular events, a large number of cardiovascular events remain unpreventable even when LDL cholesterol is reduced to extremely low levels. This suggests that interventions focused solely on cholesterol overlook other risk factors that have not been taken into account.

Since the beginning of the 21st century, several large-scale meta-analyses have re-evaluated the relationship between dietary cholesterol and cardiovascular disease. The results of meta-analyses incorporating dozens of prospective studies indicate that dietary cholesterol intake is not significantly and independently associated with the risk of coronary heart disease. At the same time, a growing body of evidence suggests that industrial trans fats, refined carbohydrates, and excessive added sugars pose a greater risk to the cardiovascular system than saturated fats and cholesterol found in natural foods.

During this period, significant breakthroughs were made in research on biomarkers of cardiovascular disease risk: Apolipoprotein B and non-HDL cholesterol are superior to LDL

cholesterol in predicting the total burden of atherogenic lipoprotein particles; the triglyceride-to-HDL cholesterol ratio effectively assesses insulin resistance and metabolic dysfunction; and lipoproteins, as independent genetic risk factors, can explain part of the mechanism underlying cardiovascular events. These findings confirm that the assessment of cardiovascular disease risk must move beyond the simplified paradigm centered on low-density lipoprotein cholesterol.

2.3. The Current Scientific Consensus: From the Cholesterol-Centric Model to the Multifactorial Model

Currently, the international nutrition community has reached a nuanced consensus regarding dietary cholesterol and cardiovascular disease: First, the effect of dietary cholesterol on serum cholesterol varies significantly among individuals; the population can be divided into high-responders and low-responders, with the majority exhibiting low sensitivity to dietary cholesterol; Second, dietary cholesterol intake is highly correlated with saturated fat intake, making it difficult to precisely distinguish their independent effects; third, the food matrix effect plays a critical role, as cholesterol from different sources—such as eggs and red meat—exhibits differences in metabolic effects.

More importantly, modern nutritional science has shifted from a reductionist paradigm focused on individual nutrients to an ecological perspective centered on holistic dietary patterns. The 2025–2030 Dietary Guidelines for Americans reflects this shift, with the core focus moving from restricting the intake of a single nutrient—such as cholesterol—to establishing healthy dietary patterns. It emphasizes the holistic combination of vegetables, fruits, whole grains, and high-quality protein, rather than evaluating individual nutrients in isolation. This paradigm shift reflects a deepening of scientific understanding: human diets are based on whole foods as the unit of intake, and the health effects of a diet are determined by the interactions between foods, processing methods, and sociocultural contexts.

3. The Evolution of Dietary Guidelines: From Restrictions to Liberalization and Beyond

3.1. 1980 First Edition Guidelines: Establishing Upper Limits for Cholesterol

In 1980, the U.S. Department of Agriculture and the Department of Health and Human Services jointly released the first edition of the *Dietary Guidelines for Americans*, which became a landmark document in modern nutrition policy. The guidelines explicitly recommended reducing the intake of total fat, saturated fat, and dietary cholesterol, based primarily on the finding that a high-fat, high-cholesterol diet increases the risk of heart disease.

The development of this edition of the guidelines was influenced by academic biases and conflicts of interest. Mark Hegerst, a core member of the drafting team and a nutritionist at Harvard University, had previously received funding from the Sugar Research Foundation to participate in the publication of a research review that attributed the causes of heart disease to fat rather than sugar; Frederick Starr, the founder of Harvard University's Department of Nutrition, had financial ties to the sugar industry. This background suggests that when the first edition of the guidelines established cholesterol restriction standards, sugar industry interest groups used

funding for targeted research to shift public and policy attention away from sugar and toward fat and cholesterol.

The guidelines established a core recommendation limiting daily cholesterol intake to no more than 300 milligrams, which became a long-standing standard for global nutrition education. Guided by this policy, the U.S. food industry launched a low-fat revolution, introducing a flood of low-fat, low-cholesterol processed foods onto the market. To compensate for the loss of flavor, the use of added sugars in processed foods generally increased.

3.2. A Turning Point in 2015: The Removal of Cholesterol Upper Limits

In 2015, the U.S. Dietary Guidelines Advisory Committee released a scientific report recommending the removal of the daily upper limit for dietary cholesterol intake. This recommendation was incorporated into the 2015–2020 Dietary Guidelines for Americans, marking the end of the era of cholesterol restrictions.

This policy adjustment is based on clear scientific evidence: current evidence does not support a dose-response relationship between dietary cholesterol and cardiovascular disease; the effect of dietary cholesterol on serum cholesterol varies among individuals; and the core of a healthy dietary pattern lies in the overall combination of foods, rather than the control of individual nutrients. This decision has also sparked controversy. Critics argue that removing the upper limit could be misinterpreted by the public as implying that cholesterol is harmless, while foods high in cholesterol are typically high in saturated fat and still require moderate consumption.

Another significant change in the 2015 Guidelines was the first-ever establishment of a limit on added sugar intake: added sugars should provide no more than 10% of total daily calories. This recommendation indirectly acknowledges the health risks associated with the previous dietary focus on low-fat, high-sugar diets (Nascimento et al., 2026; Physicians Committee for Responsible Medicine, 2026). From a historical perspective, the 2015 revision corrects the policy deviations of the past four decades, shifting the focus of research and policy from fat and cholesterol to other dietary risk factors, such as sugar.

3.3. 2025 Guidelines: Contradictions and Controversies

The Dietary Guidelines for Americans 2025–2030, released in January 2026, sparked widespread academic controversy. On the surface, the guidelines retained the restriction that saturated fat should account for no more than 10% of total energy intake, emphasized the consumption of vegetables, fruits, and whole grains, and, for the first time, called for the complete elimination of added sugars, reflecting a deepening understanding of the harms of sugar.

The guidelines contain fundamental flaws that have drawn criticism from both the academic community and the public health sector. A core contradiction lies in the fact that while the guidelines restrict saturated fat intake, they simultaneously prioritize animal protein and full-fat dairy products as recommended protein sources—both of which are major dietary sources of saturated fat. This coexistence of restrictions and recommendations has created confusion among the public.

Issues of scientific integrity are even more pronounced: of the nine experts providing the scientific basis for the guidelines, at least eight had conflicts of interest with the food industry. In

January 2026, the Physicians Committee for Responsible Medicine submitted a petition to the Office of the Inspector General of the U.S. Department of Health and Human Services and the Department of Agriculture, demanding the withdrawal and redrafting of the guidelines on the grounds of suspected unlawful industry influence, exposing the failure of conflict-of-interest prevention mechanisms in public health policymaking.

Furthermore, the guidelines represent a step backward in visual presentation; the new Food Guide Pyramid reverts to reductionist, abstract symbols that fail to reflect the complexity of modern food systems. In contrast, Brazil's dietary guidelines adopt the NOVA food classification system, which categorizes foods based on their degree of processing and explicitly recommends avoiding ultra-processed foods—representing a paradigm shift from a focus on nutrients to food itself, and from individual choice to the broader food environment.

3.4. International Comparison: Paradigm Innovation in the Brazilian Guidelines

Within the global dietary guidelines framework, Brazil has forged a distinctive research and policy path. The Brazilian Dietary Guidelines, published in 2014, moved away from the traditional nutrient-based perspective and instead built its framework around the degree of food processing. Using the NOVA classification system, it categorizes foods into four groups: fresh and minimally processed foods, cooking ingredients, processed foods, and ultra-processed foods.

The revolutionary value of this classification system lies in breaking free from the reductionist framework of "good" versus "bad" nutrients, demonstrating that industrial processing alters the food matrix and produces independent health effects. Ultra-processed foods are not only high in sugar, fat, and salt, but their physical structure and chemical composition have been profoundly altered, potentially disrupting satiety signals, gut microbiota, and metabolic responses. The Brazilian guidelines explicitly recommend basing diets on fresh and minimally processed foods while completely avoiding ultra-processed foods, a stance that aligns closely with mainstream epidemiological evidence.

The methodological innovation of the Brazilian guidelines is equally significant: the development process strictly excluded industry interference, was led by an independent academic team, and explicitly rejected industry funding; the content framework integrates public values such as social equity, environmental sustainability, and food sovereignty, embodying the core principle that nutrition policy serves the overall well-being of society rather than the interests of specific industries.

The Brazilian guidelines have had a profound impact on global nutrition policy. Many Latin American countries have adopted similar frameworks and implemented accompanying regulatory measures, such as warning labels and taxes on ultra-processed foods, thereby providing an alternative model for global public health governance and challenging the industry-friendly policy paradigm exemplified by U.S. guidelines.

4. The Role of the Food Industry: The Clash of Interests and the Shaping of Scientific Discourse

4.1. The Sugar Industry Lobby's Historical Strategies

Perhaps the most cautionary tale in the evolution of dietary cholesterol guidelines is the sugar industry's interference in scientific research and policymaking. In 2016, a historical analysis published in the *Journal of the American Medical Association: Internal Medicine* revealed a startling discovery: in 1967, the Sugar Research Foundation provided approximately $6,500 in funding to three Harvard scientists, commissioning them to publish a review attributing coronary heart disease to fat rather than sugar.

The three recipients included Frederick Stal, founder of the Department of Nutrition at the Harvard School of Public Health, and Mark Hegerst, who later drafted the first edition of the U.S. Dietary Guidelines. In 1967, they published a review in the *New England Journal of Medicine* concluding that "the only dietary change necessary to prevent coronary heart disease is a reduction in saturated fat and cholesterol intake," while making no mention of the link between sugar and heart disease. After its publication, this review became a highly cited paper in the field and had a profound impact on subsequent policy-making.

The success of the sugar industry's strategy lay in its exploitation of the complexity of scientific research. By funding specific studies, influencing academic publications, and suppressing dissenting voices, the sugar industry successfully shifted the scientific focus from sugar to fat. Ironically, when British nutritionist John Yudkin published Pure, White, and Deadly in 1972, systematically detailing the link between sugar and cardiovascular disease, he faced academic suppression orchestrated by Case and others and was stigmatized as a fringe figure "lacking scientific rigor." Yudkin's research career was thus derailed, while Keys, hailed as the "father of the Mediterranean diet," achieved fame and lived to be 100 years old.

4.2. The Food Industry's Ongoing Influence on Dietary Guidelines

The history of the sugar industry is just the tip of the iceberg. The controversy surrounding the 2025 edition of the U.S. Dietary Guidelines shows that the food industry's influence on nutrition policy has not ended but continues in more covert ways.

The core issue exposed during the development of the new guidelines is "conflicts of interest among experts." The vast majority of experts responsible for drafting the scientific reports had financial ties to the beef and dairy industries. This phenomenon highlights the "revolving door" problem: the boundaries between academic experts and industry are becoming increasingly blurred, and mechanisms to prevent conflicts of interest are virtually non-existent.

The consequences of this industry influence are evident in the specific content of the guidelines. While the new guidelines retain restrictions on saturated fat, they place animal protein and full-fat dairy products at the center of protein source recommendations. This contradictory strategy of "retaining restrictions while strengthening encouragement" essentially provides policy cover for the dairy and meat industries. When public health policies reframe systemic food environment issues as a moral narrative of "personal choice," industry responsibility is successfully sidestepped.

4.3. The Theoretical Framework of "Commercial Determinants of Health"

In recent years, the public health community has proposed the conceptual framework of "Commercial Determinants of Health" to analyze the role of corporate activities in shaping population health. This framework posits that commercial behavior influences health through multiple channels: direct effects, indirect effects, and structural effects.

The food industry's influence on dietary guidelines is a prime example of "commercial determinants of health." By funding research, participating in guideline development, and lobbying government agencies, the industry has successfully kept the policy focus on a track that benefits the sales of its products. U.S. dietary guidelines have long emphasized "individual choice" and "nutrient balance" while avoiding discussion of structural factors such as food processing, product formulation, and marketing strategies; this path dependence aligns closely with the industry's interests.

An analysis of international literature indicates that dietary guidelines in many countries do not faithfully reflect scientific evidence but rather reflect the combined influence of agricultural subsidy structures, trade agreements, and industry lobbying. Animal-based foods occupy a central position in most guidelines not because their health benefits surpass those of plant-based foods, but due to the weight and political influence of the livestock industry within the agricultural economy. This explanation helps clarify the fundamental divergence between the U.S. and Brazilian guidelines: the former is constrained by a powerful agribusiness complex, while the latter has chosen a path independent of industry interests.

5. Theoretical Reflection: The Paradigm Clash Between Reductionism and Holism

5.1. The Epistemological Dilemma in Nutritional Science

Behind the controversy over dietary cholesterol lies a deeper epistemological dilemma in nutritional science: how to strike a balance between "reductionism" and "holism"? The reductionist approach breaks down food into nutrients and uses randomized controlled trials and epidemiological studies to explore the relationship between individual nutrients and health outcomes. This approach has achieved significant historical milestones—the discovery of vitamins, the elucidation of the roles of essential fatty acids, and the establishment of nutrient targets in dietary guidelines.

However, the fundamental flaw of the reductionist approach lies in the fact that humans consume food, not individual nutrients; broader factors such as food matrix, processing methods, and dietary patterns are overlooked. The dietary cholesterol case clearly illustrates the limitations of reductionism—when scientific focus is overly concentrated on a single nutrient, it may neglect more important dietary determinants. The 2015 decision to remove the cholesterol intake limit was precisely a correction of this reductive oversimplification.

The holistic approach, in contrast, views the diet as a complex system, focusing on food combinations, processing methods, dietary patterns, and sociocultural contexts. The NOVA classification system in Brazil's dietary guidelines represents the application of this holistic

approach at the policy level: rather than telling the public how much cholesterol to limit, it recommends which foods should form the foundation of daily diets and which should be avoided. This framework acknowledges that the health effects of food cannot be reduced to the sum of its nutritional components.

5.2. Path Dependence in Public Health Decision-Making

The evolution of dietary guidelines also reveals the "path dependence" inherent in public health decision-making. Once a particular theoretical paradigm is established as the basis for policy, it becomes difficult to adjust the policy direction even when subsequent evidence calls it into question. The "cholesterol ceiling" established in 1980 became a fundamental tenet of global nutrition education over the following four decades; even as scientific evidence gradually accumulated to demonstrate its limitations, policy adjustments did not occur until as late as 2015.

The formation of path dependence involves multiple mechanisms: institutional lock-in, the solidification of professional consensus, and the stability of vested interests. These factors interact to create a massive inertia that must be overcome for policy shifts to occur.

The issue of industry influence exposed in the 2025 U.S. Dietary Guidelines demonstrates that path dependence is not merely a matter of scientific understanding, but also a matter of political economy. When specific industries gain institutionalized influence in policy-making, policy direction becomes systematically locked into a trajectory that favors industry interests. The inherent contradiction in the U.S. guidelines between "encouraging animal protein" and "restricting saturated fat" is a concrete manifestation of this locking effect.

5.3. Scientific Autonomy and the Prevention of Conflicts of Interest

The key lesson for contemporary public health policy drawn from the dietary cholesterol case is the need to establish more robust mechanisms to protect scientific autonomy and prevent conflicts of interest from eroding scientific integrity.

The controversy surrounding the 2025 U.S. guidelines has exposed the failure of existing mechanisms to prevent conflicts of interest. The fact that eight out of nine authors of the scientific report had industry ties demonstrates that the transparency and fairness of the expert selection process require fundamental improvement. Even more concerning is that these conflicts of interest were exposed by external oversight organizations after the guidelines were published, rather than being proactively disclosed by official bodies.

The experience with the Brazilian guidelines offers an alternative model worth emulating. Its development process explicitly rejected industry participation; all experts declared no conflicts of interest, and the final document genuinely reflected scientific evidence rather than industry demands. This model demonstrates that it is possible to develop dietary guidelines free from commercial influence; the key lies in political will and institutional design.

The international public health community has put forward several reform proposals: establishing an independent expert selection mechanism, mandating the disclosure of conflicts of interest, prohibiting experts with industry ties from participating in guideline development, and separating guideline review from industry lobbying. These proposals aim to place the control of "commercial determinants of health" at the core of public health governance.

6. Discussion

Looking ahead, nutritional science and public health policy must undergo a threefold shift: at the conceptual level, moving from "reductionism" to "holism," focusing on food systems and dietary patterns rather than individual nutrients; at the methodological level, establishing stricter mechanisms to prevent conflicts of interest to ensure the independence and integrity of scientific evidence; and at the governance level, incorporating "commercial determinants of health" into policy frameworks to address the food industry's impact on public health through structural interventions.

The story of dietary cholesterol is far from over. As nutritional science advances and food systems evolve, new scientific evidence will continue to emerge, and policies will continue to be adjusted. But the deeper lesson of this case goes beyond cholesterol itself—it reminds us that public health decision-making requires not only scientific evidence, but also critical awareness of the social context in which evidence is produced, as well as systematic safeguards against commercial interests. Only then can dietary guidelines truly serve public health, rather than the interests of specific industries.

7. Conclusions

The debate over the relationship between dietary cholesterol and cardiovascular disease appears to be a scientific issue, but in reality, it is a complex narrative intertwined with the triple logic of science, policy, and business. From Ancel Keys' "Seven Countries Study" to the industry controversy surrounding the 2025 U.S. Dietary Guidelines, seven decades of history reveal a clear trajectory: the establishment of scientific hypotheses is often constrained by specific historical conditions and social contexts; once policies are formed, they generate path dependence; and commercial interests continually seek to shape scientific discourse to maintain their own standing.

The core findings of this paper can be summarized in four points: First, the relationship between dietary cholesterol and cardiovascular disease is far more complex than early hypotheses suggested, with individual metabolic differences, food matrix effects, and overall dietary patterns all playing significant roles; Second, the evolution of dietary guidelines has undergone four stages: "hypothesis establishment—policy solidification—scientific revision—interest-based bargaining," and the removal of the cholesterol upper limit in 2015 marked a fundamental shift in scientific understanding; Third, strategic interventions by the sugar industry lobby in the 1960s and 1970s profoundly influenced the direction of early guidelines, and the issues of industry influence exposed in the 2025 guidelines indicate that this pattern persists; fourth, the Nova classification system and independent development model of Brazil's dietary guidelines offer a viable alternative pathway for breaking free from the reductionist paradigm and industry influence.

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Conceptualization,F. W.; methodology, F. W.; investigation, F. W.; resources, F. W.; data curation, F. W.; writing—original draft preparation, F. W.; writing—review and editing, F. W.; visualization, F. W.; supervision, F. W. All authors have read and agreed to the published version of the manuscript.

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"Integrated Medical and Nursing Care" Service Practice: The Adaptive Roles of Social Workers in Elderly Care Institutions and Implications for Age-Friendly Modifications

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Abstract

This study examines elderly care institutions to investigate how the scope and quality of age-friendly environmental modifications continuously shape the effectiveness of integrated medical and nursing care services, and analyzes the adaptive responses and practices of social workers within this process. Based on qualitative research, the findings reveal that inadequacies in the built environment directly trigger service disruptions and potential risks, forming a "hidden bottleneck" that restricts service quality. Social workers exhibit significant agency by proactively adopting assessment, advocacy, and coordination strategies. Nevertheless, their effectiveness is constrained by structural factors including resource shortages and institutional limitations. This study advocates for a synergistic "Environment–Service–Person" framework and highlights age-friendly environmental modification as a core determinant of service quality. Such a perspective is critical to promoting the operationalization of integrated medical and nursing care and improving overall service quality.

Keywords: Age-Friendly Modifications; Integrated Medical and Nursing Care; Social Worker; Adaptive Role

1. Introduction

Population aging is one major social challenge for modern China. Older adults need medical care and daily living support. China has promoted the "Integrated Medical and Nursing Care" strategy since 2015. The strategy aims to combine health care resources with elderly care services. Macro-level conditions have improved step by step. Service work inside care institutions still runs

poorly and inefficiently. Most existing research focuses on structural factors. It pays little attention to the physical environment. The physical environment limits service delivery in specific ways. Research does not fully explore how social workers deal with these limits.

This study uses elderly care institutions as research sites. It adopts participatory observation and semi-structured interviews. It answers two core questions. The first question is how age-friendly changes limit service effects. The second question is how social workers carry out adaptive practices. Results show that small problems in the physical environment form a hidden bottleneck. The bottleneck lowers service efficiency. Social workers act as assessors, advocates and coordinators at the same time. These roles are limited by many structural factors. These factors include lack of professional knowledge, insufficient institutional support and no feedback mechanism. The study suggests using the "Environment–Service–Person" combined view. The physical environment provides structural support for service quality. Social workers' adaptive actions connect environment and services in a dynamic way. Their work helps improve the quality of care.

2. Literature Review

2.1. Integrated Medical and Nursing Care Service Practice

The National Health Commission (2025) gives a clear definition. Integrated medical and nursing care combines medical and health services with elderly care services. It provides older adults with continuous services. These services cover prevention, treatment, rehabilitation, long-term care and hospice care. Huang, Nie and Li (2025) point out one fact. This model is a key strategy for China to deal with population aging. It aims to break barriers between medical and care services. It achieves deep integration. Care includes medical support. Medical services include care components. Policies have experienced a clear development path. Early integrated care focuses on building basic services. Practices keep moving forward. People pay more attention to resource integration and service quality improvement.

Many research results show one common situation. Local implementation of integrated care still faces many difficulties. Policies, funds and workforce conditions keep getting better. Daily operation of integrated care services still gets affected by small environmental details. People need to study two key variables. They are age-friendly modifications and adaptive roles of social workers. These studies help people understand micro mechanisms of service implementation.

2.2. Age-Friendly Modifications: A Key Factor Influencing Service Difficulties

The idea of age-friendly modifications comes from a classic theory. Lawton and Nahemow (1973) put forward the Person-Environment Fit Theory. The core idea of this theory is easy to understand. Environment matches personal ability. The individual keeps the best function and positive emotion. Environment exceeds personal coping ability. The individual shows bad behaviors. He or she feels emotional pain. He or she may even lose some functions. Environment gives too little pressure. Personal functions may weaken gradually. This theory offers a basic tool. It helps people explain how environment affects the well-being of older adults.

Recent empirical studies show more details. They explain how physical environment influences service processes. Wang et al. (2025) study the built environment carefully. They check its effects on social interactions of older adults in care homes. Results show clear patterns. Environmental elements include recreational spaces, functional equipment and accessibility. These elements influence many things. They affect how often older adults talk with each other. They affect participation in activities. They affect relationship quality with caregivers. These findings prove one point. Environmental design has strong effects on service processes and social interactions.

Social work research includes physical environment into professional practice. Cashwell (2024) puts forward a clear idea. People should add physical environment into the "person-in-environment" framework. This becomes an important task in modern social work practice. Social workers need certain abilities. They need to find risks and resources in the built environment. They need to use professional methods to intervene. Interventions happen at micro, mezzo and macro levels. Research on age-friendly modifications also changes its focus. It no longer only centers on barrier removal. It aims to build supportive environments. Zhou (2018) gives a clear opinion. Age-friendly modifications should do more than remove obstacles. Good environmental design supports older adults actively. It helps them keep personal functions and life quality.

These studies all show one close relationship. Environment, service and person affect each other dynamically. This study focuses on this interactive relationship. It tries to explore this topic in depth.

2.3. Research on the Adaptive Roles of Social Workers

The role of social workers helps people understand the "Environment–Service" interaction. Traditional views define institutional social workers clearly. They mainly provide non-medical services. These services include psychological support and recreational activities. They often stay at the edge of institutional work. Integrated care keeps developing. Scholars begin to notice the key role of social workers in service integration.

NASW Standards for Social Work Services in Long-Term Care Facilities (2003) gives clear rules. Core social work services in long-term care settings include assessment, treatment, rehabilitation and supportive care. The basic goal is clear. It helps older adults keep and improve physical, psychological and social functions. This standard shows a clear trend. Professional roles of social workers expand. They change from activity organizers to service integrators and environmental assessors. Greene et al. (2023) study resilience of social workers in nursing homes. They find one important function. Social workers reduce risks and strengthen protective factors. They help older adults keep social functions and personal identity in complex institutional environment.

Chen and Lin (2024) study coping strategies of social workers. These strategies are used in integrated care facilities. They focus on spatial constraints. They use the "Relationship–Space–Function" analysis tool. Research shows clear behaviors. Social workers use interpersonal advantages. They bridge service gaps across different spaces. They show practical wisdom when facing physical environment limits.

These studies show potential functions of social workers. Social workers do not only provide services. They also act as mediators. They help build good relationships between older adults and their living environment.

2.4. Summary

Many factors lead to implementation challenges of integrated medical and nursing care. Challenges come from dynamic interactions among “Environment–Service–Person”. Age-friendly modifications belong to physical environment. They directly affect service continuity and safety. Adaptive roles of social workers act as a dynamic link. They connect environment and services. They find problems. They push for improvements. They coordinate available resources. The three parts influence each other closely. Physical environment lays structural foundation for service quality. Adaptive practices of social workers connect environment and services dynamically. Service delivery shows final results of these interactions.

3. Research Methods

3.1. Research Framework

Based on the analysis of the interactive relationship among environment, service and human beings in the literature review, this study constructs the research framework shown in Figure 1. Integrating the Person-Environment Fit Theory (Lawton & Nahemow, 1973) and relevant literature on the adaptive roles of social workers, this framework aims to provide clear conceptual guidance for subsequent empirical analysis.

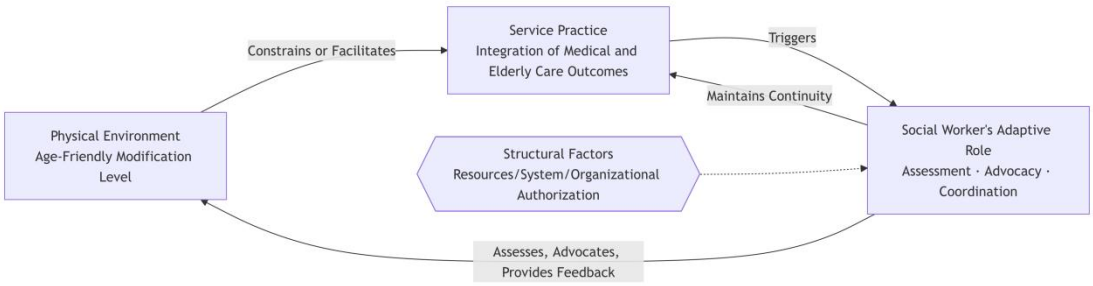

Figure 1. "Environment–Service–Person" Collaborative Interaction Model

Within the framework, the physical environment (level of age-friendly renovation) directly restricts or facilitates service practice (effectiveness of integrated medical and elderly care services). Problems emerging in service practice trigger the intervention of social workers in adaptive roles (assessment, advocacy and coordination). Social workers exert counteractive effects on the physical environment through assessment, advocacy and feedback, while compensating for environmental deficiencies by maintaining service continuity. External structural factors (resources, systems and organizational authorization) moderate the scope of effectiveness of social workers’ adaptation. The direction of the arrows reflects the bidirectional and dynamic interactive relationship between the three elements.

3.2. Participatory Observation

Participatory observation belongs to qualitative research. The observer takes a specific role in the research field. The setting keeps natural and real. The observer collects first-hand data on purpose. He uses senses and auxiliary tools to finish the work.

This study uses participatory observation. It checks age-friendly environment and integrated care services in institutions. It aims to understand specific situations. It sees how small environmental details limit service effects. It records interactions of social workers. It documents their responses when facing environment limits. This method offers real and concrete data. It helps analyze "Environment–Service" conflicts. It helps study adaptive strategies of social workers.

3.3. Semi-Structured Interviews

Semi-structured interviews serve as the main research method. It keeps information comparable across different interviewees. It allows flexible in-depth exploration. It finds out how environmental details limit service processes. It records how social workers adjust and respond. Researchers use this method to select key informants. These informants offer key information for research questions.

This study uses purposive sampling for sample selection. Purposive sampling follows a clear logic. Researchers choose participants actively based on research goals. They pick people with rich and relevant information. These people help answer research questions better. Critical case sampling is used on this basis. Researchers select influential people in the institution. These people have access to core information. They represent different role perspectives.

Researchers choose administrators and social workers as interview subjects. They do not select random employees from other positions. Two groups of people offer different views. These views can check and support each other. They show interactive dynamics of "Environment–Service–Person". This method ensures data diversity. It makes data more complete and credible.

A total of 12 participants were interviewed in this study, including 6 institutional managers (coded A–F) and 6 social workers (coded G–L). The basic information of the respondents is presented in Table 1 and Table 2. Each participant received one semi-structured interview, with the duration ranging from 45 to 90 minutes and an average length of 60 minutes. All interviews were conducted in independent meeting rooms or quiet office areas within the institutions, with full audio recording and verbatim transcription. The interview outline covered multiple dimensions, including physical environmental constraints encountered in daily services, specific coping strategies adopted by social workers, experiences in cross-departmental collaboration, and feedback channels for environmental improvement suggestions.

Data collection was conducted in an iterative manner. Preliminary coding and thematic summarization were performed after every two to three interviews. After the tenth interview, new information began to overlap and no new themes emerged. The interviews with the eleventh and twelfth respondents further verified the saturation of existing themes. Accordingly, theoretical saturation was achieved, and participant recruitment was terminated.

The transcribed interview data were analyzed through thematic analysis. First, each transcript was read repeatedly to familiarize with the materials and extract information relevant to the research questions. Relevant contents were then compared and categorized to generate initial codes, and similar codes were further aggregated into preliminary themes. Finally, core themes were refined by cross-checking original materials and comparing narratives from different respondents. The entire analytical process adhered to the principle of identifying research problems from raw data, refining themes from practical problems, and verifying themes with original evidence, so as to ensure that analytical findings are strictly grounded in empirical materials.

Table 1. Basic Information of Interviewed Administrative Personnel

Code	Gender	Age	Education	Professional Background	Years of Experience	Position/ Title	Main Responsibilities
A	Female	32	Bachelor's	Gerontology	5	General Manager	Overall Manager institutional operations, resource coordination, external partnerships
B	Female	51	Associate Degree	Nursing	11	Head of Nursing Department	Nursing team management, coordination of integrated care services
C	Female	36	Bachelor's	Nursing	6	Nursing Supervisor	Staff scheduling, care quality supervision, nursing training
D	Female	41	Bachelor's	Administrative Management	8	Operations Manager	Daily operations environmental maintenance, logistical support
E	Male	39	Bachelor's	Administrative Management	4	Director of General Office	Facility maintenance, safety management
F	Female	53	Bachelor's	Gerontology	8	Care Assessment Supervisor	Admission assessment, care planning, interdepartmental service coordination

Table 2. Basic Information of Interviewed Social Workers

Code	Gender	Age	Education	Professional Background	Years of Experience	Position/ Title	Main Responsibilities
G	Female	28	Associate Degree	Gerontology	5	Junior Social Worker	Activity organization, environmental safety inspections
H	Male	25	Bachelor's	Social Work	2	Junior Social Worker	Psychosocial support, interprofessional coordination
I	Female	39	Bachelor's	Social Work	11	Intermediate Social Worker	Service integration, interdepartmental communication
J	Female	24	Bachelor's	Social Work	1	Junior Social Worker	Case follow-up,activity assistance,needs assessment
K	Female	42	Associate Degree	Psychology	8	Intermediate Social Worker	Elderly care, environmental assessment
L	Male	38	Master's	Social Work	6	Intermediate Social Worker	Service project management,work supervision

4. Environmental Constraints: The Level of Age-Friendly Modifications and Service Difficulties

4.1. Dilemma of Environmental Pressure in Rehabilitation Training

Researchers carry out in-depth interviews. They talk with institutional administrators, frontline social workers and nursing staff. The research finds clear manifestations. Environmental constraints appear in typical service scenes. These scenes include rehabilitation training, daily care and support for residents with cognitive impairments.

Rehabilitation training is a core part of integrated care services. It has clear goals. It does not only finish prescribed exercises in the therapy room. It transfers training effects into daily life functions. Current institutional environment design has an obvious gap. Training effects cannot connect well with daily life.

C: The medical rehabilitation area stays far away from living quarters.

I: The rehabilitation room keeps a long distance from residents' rooms. The connecting corridor has thresholds. These thresholds block wheelchairs.

K: Many older adults use walkers or wheelchairs. The path from rooms to rehabilitation room has a necessary section. It includes two consecutive steps with uneven height. It has no ramp. One older man finished knee surgery recently. He came to the steps with his walker. He hesitated for a long time. He turned back at last. He said it was too dangerous. He refused to take rehabilitation training. Environmental barriers reduce motivation of older adults directly. This harm is bigger than lack of basic facilities.

This separation typically embodies the environmental pressure dimension in the Person-Environment Fit Theory. The value of rehabilitation training lies in the transfer of capabilities acquired in the training room to the real living environment. When the distance between the training area and living area is artificially extended, and obstacles such as thresholds exist on the access path, the physical strength of the elderly is partially consumed before reaching the training room, and rehabilitation effects can hardly be consolidated in natural daily situations. Wang et al. (2025) also verified that environmental obstacles can significantly reduce the activity participation willingness of the elderly, with its influencing paths including both movement limitations and psychological withdrawal. From "Environment–Service–Person" Collaborative Interaction Model, this represents a direct restriction of the environment on services. The fragmentation of physical space breaks the continuity of rehabilitation services and forms an implicit bottleneck.

4.2. Environmental Defects in Daily Care

Daily care is the most basic and frequent service in institutions. It includes help with toileting, bathing, moving and eating. These tasks have high requirements for physical environment. Environmental problems turn into care difficulties directly. They increase safety risks.

D: The most serious environmental problem is high bed density. Some rooms put four beds closely together. The aisle only allows a person to pass sideways. Care workers find it hard to turn residents over or change bed sheets. Back injuries happen often among nursing staff.

This reveals the transformation path from physical environmental defects to human resource costs and occupational health risks. From the perspective of the "Environment–Service–Person" Collaborative Interaction Model, it reflects the restriction of the environment on services at the human resource level. When environmental design fails to meet the basic requirements for operational space, institutions tend to compensate for environmental deficiencies through human input, which inevitably increases the work intensity of caregivers and raises the risk of occupational injuries. As indicated in the systematic review by Chaudhury et al. (2017), environmental quality is significantly positively correlated with care quality in long-term care facilities. Spatial congestion directly impairs the safety and comfort of daily care operations. This also constitutes an implicit bottleneck. Although bed density is rarely reflected in service quality evaluation reports, it continuously undermines service delivery on a daily basis through caregiver lumbar injuries and the physical discomfort of the elderly.

A: Family members complained before. They pointed out insufficient anti-slip measures in bathrooms. Staff always stay with residents in toileting and bathing. The institution added anti-slip mats on the floor later. It installed an extra handrail.

This case shows a common pattern. Environmental problems lead to complaints from families. Complaints push institutions to make improvements. Administrators point out one fact. Staff always accompany residents in toileting and bathing. The institution relies on extra manpower to make up for environment limits. This compensation method brings extra costs. It increases workload of nursing staff. It reduces sense of autonomy and personal dignity of older adults. Cashwell (2024) also pointed out that when practitioners are accustomed to compensating for environmental deficiencies through human resources, they tend to overlook the value of the environment itself as an intervention resource. From the perspective of the Environment–Service–Person Collaborative Interaction Model, this case also indicates the necessity of social workers' role adaptation. Without feedback from family members, environmental defects may be long concealed by human resource substitution, while professional assessment conducted by social workers is essential to break such concealment.

L: I work with a newly admitted resident. He is not familiar with the environment. Small design flaws make him feel upset easily. He complains most about light switches and call buttons. These devices are placed in unreasonable positions. Older adults feel very difficult to use them. Small design flaws bring big obstacles for older adults.

This interview reveals the causal relationship between micro environmental design flaws and daily service barriers. The concept of "supportive environment" proposed by Zhou (2018) emphasizes that age-friendly renovation should not be limited to the crude standard of mere facility availability. Instead, it needs to delve into operational details including layout arrangement, usability intensity and feedback mechanisms. Even a minor positional deviation may render certain facilities virtually ineffective. Small design problems bring big troubles to older adults. Environmental assessment should not stay at macro level. It should look into small details of daily use.

4.3. Allocation Barriers to Dementia Support

Environment design offers insufficient support for special groups. It hinders targeted services clearly.

G: Residents with cognitive impairments are very sensitive to environment. Special dementia care unit has no obvious difference from standard units. Corridors are too long. Signage is not clear. Residents enter wrong rooms frequently. They cannot find the restroom easily.

In the absence of differentiated corridor signs and visual landmarks, elderly individuals with cognitive disorders cannot receive effective support for spatial orientation, which further exacerbates behavioral and psychological symptoms such as wandering, anxiety and incontinence. This issue also brings two results. Residents may lose control of bowels and bladder. They lose personal dignity deeply. Nursing staff have to deal with behavioral problems caused by environment confusion. Their workload increases clearly. Respondent G once attempted to assist the elderly with wayfinding training, yet achieved limited effects. This fully demonstrates that

when the physical environment itself acts as an obstacle, mere behavioral intervention proves ineffective. A dual approach integrating environmental optimization and behavioral support is therefore indispensable.

F: The most serious environmental flaw is lack of clear functional zoning. Residents with dementia live with independent older adults. Interpersonal conflicts happen easily.

This observation also reveals the embodiment of environmental constraints on services at the spatial zoning level. Ambiguous functional zoning directly triggers frequent service conflicts and gives rise to implicit bottlenecks: Older adults have different physical and cognitive conditions. They need different environment supports. Mixed living arrangements reduce sense of security of residents. They bring extra pressure to care workers. Age-friendly modification should adopt a differentiated design approach. Customized environmental support should be provided for elderly residents with varying care needs, instead of simply applying a uniform standard for all seniors.

5. Social Work Intervention: Three Adaptive Roles

Faced with the aforementioned conflicts between environment and services, social workers within institutions do not accept such predicaments passively, but develop a series of proactive adaptive practices. From the perspective of the Environment–Service–Person Collaborative Interaction Model, the problems emerging in service practices activate the proactive role adaptation of social workers. When coping with environmental dilemmas, social workers exert three core roles. As evaluators, they identify environmental defects and translate practical problems into systematic evidence. As advocates, they deliver relevant evidence to the management and promote environmental optimization. As coordinators, they connect available resources and implement minor adaptive adjustments to maintain service continuity when large-scale renovation is restricted. These three roles constitute a progressive logical chain of identification, promotion and compensation, while their practical effectiveness is constrained by structural factors including resources, institutions and organizational authorization.

5.1. Risk Identifier and Assessor

Social workers intervene in “Environment–Service” conflicts. They start with quick risk identification. Nursing staff focus on work efficiency. Administrators care more about cost control. Social workers have a unique professional view. They notice direct influences of physical environment on behaviors of older adults. They care about psychosocial meanings behind environment.

G: I organize older adults into a Safety and Environment Inspection Group. I collect their feedback. I report these feedbacks to management formally.

This practice reflects the participatory strategy adopted by social workers during the assessment stage. From the perspective of the Environment–Service–Person Collaborative Interaction Model, this marks the starting point of social workers’ evaluative feedback on the environment. Rather than speaking for the elderly on their own behalf, social workers build communication platforms to transform the personal experiences of older adults into collective

demands. This practice fulfills at least three functions. First, it enhances the persuasiveness of improvement proposals. Second, it strengthens the elderly's sense of self-efficacy and participation awareness. Third, it integrates scattered individual complaints into structured feedback lists, facilitating systematic handling by management departments. This aligns with the resilience-oriented working approach advocated by Greene et al. (2023). By empowering older adults, social workers help them shift from passive recipients of environmental predicaments to active providers of feedback.

K: I use two steps in my work. The first step is adaptive training. I walk with residents along difficult paths. I teach them safe ways to pass steps. I give them psychological encouragement. This method solves surface problems only. It does not change root causes. The second step is environmental advocacy. I work with rehabilitation therapists. We draft a simple improvement plan for the corridor. I attach case records of six months. These records show situations of residents. They give up rehabilitation or feel afraid of training because of steps.

The interview content clearly demonstrates two levels of the social worker's evaluative role: micro adaptive intervention and meso environmental advocacy. In accordance with the research framework, the primary adaptive training aims to enhance the individual coping capacity of older adults when the environment cannot be altered, which constitutes remedial adaptation. It serves as an essential approach for social workers to maintain the continuity of services, representing the intervention of social workers upon services.

Nevertheless, social workers do not confine themselves to this stage. They proceed to the second step: transforming case-based experiences into systematic evidence. By compiling half-year case records, designing simple renovation drawings, and establishing alliances with other professionals, social workers elevate individual difficulties into organizational issues that require institutional responses. This transition from temporary mitigation to fundamental resolution embodies the core professional competence that distinguishes social workers from other service practitioners.

5.2. Internal Advocate and Communicator

Social workers turn identified problems into real improvements. This work forms the core of adaptive practice. Social workers act as advocates at this stage. They use effective communication strategies. They help administrators and other departments notice problems. They help others understand importance of these problems. They push others to take improvement actions.

J: I reported the problem to logistics department at first. Staff told me the speed bump meets municipal requirements. It cannot be removed. I made a temporary solution. I arranged two staff members at the gate. They help wheelchair users pass in and out. The method needs too much labor. It cannot last for a long time. I made a detailed record later. I recorded all incidents in three months. These incidents show how speed bump blocks normal passage. I added feedbacks from residents. I submitted the record with photos to General Office.

This practice clearly reveals the core strategy of social workers in the role of advocates: shifting from verbal reflection to evidence-driven advocacy. After the initial casual feedback was

rejected by the logistics department on objective grounds of municipal requirements, social workers did not cease their efforts.

Confronted with the constraints of structural factors, social workers externalize implicit experiential knowledge. Through systematic documentation, including three months of continuous observation, incident statistics, collection of elderly residents' feedback, and photographic evidence, they convert invisible daily difficulties into presentable, comparable and traceable factual materials.

As emphasized by Greene et al. (2023), when individual voices are insufficient to drive institutional changes, evidence can construct a community of facts and enhance the organizational visibility of practical problems. Meanwhile, this strategy reflects the feedback loop through which social workers intervene in the environment, so as to cope with environmental constraints on service delivery.

J: I changed my expression when talking with Operations Manager. I got breakthrough progress. I described convenient access as a soft asset. It shows service quality of the institution. It influences community reputation directly. The institution approved my suggestion finally. Workers installed a portable rubber ramp next to the speed bump.

The experience shared by Interviewee J reveals an effective way of advocacy: Managers tend to prioritize institutional performance indicators such as institutional reputation, occupancy rate and resident satisfaction, rather than trivial environmental details. Social workers redefined the issue of speed bumps from a technical matter of accessibility renovation to a brand issue related to institutional soft power and public reputation within the community, thereby resonating with the core concerns of managers. By translating professional demands into shared organizational interests, social workers can greatly improve the likelihood of their suggestions being accepted and implemented.

K: I formed a Rehabilitation Support Team. Team members include rehabilitation therapists and nursing assistants. We put forward improvement suggestions to Nursing Department and senior management. Nursing Department worried about possible problems. A ramp may take up walkway space. It may block normal traffic. Rehabilitation therapists gave professional explanations. They confirmed gradient and width of the ramp meet safety standards. I collected real voices and opinions from residents. I reported these materials to General Manager together with other team members.

This typical case fully reflects the core function of social workers as coordinators in cross-professional collaboration. Rather than addressing environmental challenges on their own, social workers integrate the practical experience of nursing staff, the professional expertise of rehabilitation therapists, and the real needs and feelings of elderly residents into a persuasive joint proposal. This collaborative approach effectively makes up for the limitations of a single professional perspective. When environmental renovation involves the interests of multiple departments, opinions from different professional backgrounds can support one another, reduce managers' concerns in decision-making, and form compelling improvement proposals that are difficult to refuse. Chen & Lin (2024) also pointed out in their research on social workers in

medical-elderly integrated care institutions that social workers can effectively alleviate service fragmentation caused by physical environmental constraints through integrating service spaces and leveraging interdisciplinary linkage advantages. This represents an effective pathway for social workers to feed back to the environment via multi-professional collaboration.

5.3. Resource Coordinator and Broker

Comprehensive environment improvements cannot be finished at once. Social workers develop another set of adaptive strategies. They coordinate internal resources. They build external connections. They find practical solutions under current environment limits.

L: I provide personal guidance for new residents on the first day. I help them get familiar with room layout. I use easy-to-understand methods. I tell them locations of light switches, call buttons and bathroom. I record unreasonable design elements. I make a list of personalized micro-modification suggestions.

The practice of Interviewee L reflects social workers' flexible coordination capacity in resource integration. When large-scale environmental renovation is not feasible, social workers turn to personalized and low-cost interventions. They help the elderly adapt to the existing environment through on-site guidance, visual signs and tailored suggestions. Although such measures cannot fundamentally resolve inherent design flaws, they can effectively ease the elderly's frustration and reduce potential safety risks in the short term. From the perspective of the Environment–Service–Person Collaborative Interaction Model, this refers to the pathway through which social workers directly intervene in services. Specifically, they sustain service continuity via minor adaptive adjustments, and reduce the elderly's sense of frustration as well as potential safety risks.

J: The institution approved a portable rubber ramp. Workers put it next to the speed bump. People can store it when not in use. They take it out when wheelchairs need to pass.

Faced with the rigid rule that speed bumps could not be removed, social workers avoided the simplistic thinking of either full renovation or no adjustment at all, and instead found a middle solution: installing removable temporary ramps.

While this solution cannot completely renovate the environment, it removes the last accessibility barrier under current conditions, while complying with municipal requirements and meeting the practical needs of the institution.

This reflects the creative intervention of social workers on the environment. When the inherent attributes of the environment cannot be altered, social workers innovate its modes of utilization. Such ability to make flexible and creative compromises constitutes an essential professional competency for social workers working under resource constraints.

L: I set up a standard process. All new residents receive formal environment guidance. I designed a checklist. Nursing assistants and I check the room together in the first week. We finish the checklist item by item. Some problems can be solved by quick micro-modifications. We use a fast approval process. We finish these changes in short time.

This approach reflects how social workers elevate their work from individual case adjustment to institutional improvement. By designing inspection checklists, clarifying clear timelines and responsibilities, and setting up a dedicated fast-response channel, social workers turn previously scattered and experience-dependent informal practices into standardized, replicable, and sustainable working procedures. Social workers attempt to improve structural constraints so as to sustain the continuity of service delivery.

6. Practical Pathways for Enhancing Social Workers' Adaptive Capacity

Previous analysis shows a clear fact. Social workers show strong initiative in handling “Environment–Service” conflicts. Their adaptive practice faces many limits. These limits include insufficient professional knowledge, weak institutional support, no formal feedback channels and bad cross-professional cooperation. People need to improve adaptive capacity of social workers systematically. Improvements happen at four connected levels. They are individual ability, team cooperation, organizational support and institutional guarantee.

6.1. Individual Level: Consolidating Professional Foundations and Enhancing Adaptive Skills

Social workers need to improve environment observation ability. They need to learn systematic recording methods. Adaptive practice starts with sensitive environment awareness. Current environment observations are often separate. They lack systematic records and accumulation. Social workers need to turn subjective feelings into presentable evidence. This change helps improve advocacy effects. Social workers should form a standard habit. They observe and record environment conditions regularly. Records should include clear information. They mark time and location of observation. They describe specific environmental flaws in detail. They explain concrete influences on service delivery and resident safety. They put forward possible improvement directions.

Social workers need to improve professional assessment ability. They need to analyze relations among environment, behavior and psychology. Professional trust of social workers relies on clear expression. They need to turn simple judgments into professional analysis. They need to explain why certain designs do not work well. Social workers need basic knowledge in related fields. These fields include environmental psychology, environmental gerontology and dementia-friendly design. Reflective Professionalism theory puts forward a core idea. Social workers need to understand relations between theory and practice. They need to reflect on case work under social environment framework. These reflective views also apply to physical environment assessment. Social workers should improve environment assessment ability systematically. They can take targeted learning and external training. They can read related academic literature.

Social workers need to optimize advocacy strategies. They need to improve communication skills. Research shows a clear rule. Advocacy becomes more effective when connected with administrator concerns. These concerns include safety risks, operation cost and institutional reputation. Social workers should change expression ways. They should not only use moral appeals. They should add simple cost and benefit analysis. They explain potential risks of no

actions. They describe expected benefits of improvements. Social workers should learn to use data to support opinions. They use evidence to strengthen persuasion. They use real cases to make problems more concrete.

6.2. Team Level: Strengthening Internal Collaboration and Sharing Practical Wisdom

Institutions should build experience sharing mechanisms. They should promote knowledge transfer within social work teams. Research finds many effective solutions. Individual social workers develop these methods to handle environment challenges. These practical wisdoms often stay at individual level. They are not systematic. They are not shared within the team. Scholars point out clear features of practical knowledge. It interacts with specific situations. It stays implicit in individual minds. It develops in dynamic ways. Team members need to communicate actively. They need to reflect together. These steps help share and spread practical knowledge. Social work teams can hold regular experience sharing meetings. They summarize effective strategies from individual practice. They turn these strategies into unified guidance for the whole team.

Teams need to develop standard adaptive tools and working templates. Members share practical experiences. They turn mature adaptive strategies into formal working tools. Standardization makes adaptive practice more consistent. It makes practice more evidence-based. It improves overall problem-solving efficiency of the team.

Teams need to build peer support and supervision mechanisms. Social workers put forward suggestions many times. These suggestions get delayed or refused. Social workers feel frustrated easily. They may experience job burnout. Teams can set up peer support and supervision system. Members talk about challenges and dilemmas regularly. They discuss coping strategies together. The system improves psychological resilience of the team. It keeps long-term motivation of team members.

6.3. Organizational Level: Securing Managerial Mandate and Constructing Collaborative Networks

Social workers should communicate proactively. They show management value of adaptive work. Many adaptive efforts happen behind daily scenes. Administrators cannot notice these efforts easily. Social workers can use multiple channels. These channels include work briefings, case reports and monthly summaries. They update management about progress and results regularly. Administrators can recognize unique contributions of social workers in environment optimization. Management will treat social workers as problem solvers. They will not regard them as troublemakers. Social workers will get stronger work support naturally.

Social workers should push for formal work rules. Environment assessment should be added into official job descriptions. Current environment observation and advocacy work lack clear identity. They are not listed as formal job duties. Social work teams can talk with management. They ask to add related tasks into formal roles and assessment rules. These tasks include environment risk identification, user feedback collection and improvement suggestion submission. The change turns adaptive practice into formal duty. It is no longer an informal extra task.

Social workers should build cross-professional cooperation networks actively. Cooperation improves professional level of advocacy. It makes advocacy more persuasive. Social workers can take the first step. They build formal communication channels with Nursing and Logistics departments. All parties join in problem identification. They carry out joint assessment. They push for improvement suggestions together.

6.4. Institutional Level: Promoting Feedback Channels and Refining Response Mechanisms

Institutions should build formal environment feedback systems. Current communication relies on informal ways. Social workers mention suggestions in elevators. They talk about problems in dining rooms. These ways are flexible. They have an obvious defect. People cannot track suggestion status clearly. They do not know whether suggestions are received, reviewed, accepted or refused. Social workers can push for a formal feedback system. It handles environment improvement suggestions. The system has clear and traceable steps. It starts with suggestion submission. It includes receipt confirmation and progress update. It ends with result feedback to submitters.

Institutions can build a quick response system for micro environment modifications. Some improvements do not need large investment. They do not change building structure. Social workers can push for simplified approval process. They ask for a small special fund. Frontline problems can get quick attention and solutions. Long approval procedures will not delay improvement work.

Social workers should seek chances to join early design of environment projects. They can negotiate with management actively. They take part in planning and design stages of modification projects. They put daily observations and accumulated experiences into design details. Newly renovated spaces will meet user needs better. It avoids repeated changes and resource waste.

7. Conclusion

Through qualitative analysis, this study has examined internal relations between two factors. These factors are age-friendly modifications and implementation challenges of integrated care services. It highlights adaptive roles of social workers. It explains practical logic of these roles under complex environment. Results show a clear phenomenon. Physical environment has many flaws and blind spots. These problems appear frequently in specific service scenes. They act as hidden barriers to service efficiency. The finding supports a core idea of environmental gerontology. Environment is not a static background for services. It interacts with human behavior, emotion and well-being dynamically. Environment influences older adults in a two-way way. People are shaped by surroundings. They also adapt to and change surroundings actively.

Social workers face these challenges. They do not accept environment limits passively. They develop active adaptive roles. They use assessment, advocacy and coordination strategies. They keep service continuity when environment and care do not match well. This study puts two factors into a unified analysis framework. These factors are age-friendly modifications and adaptive roles of social workers. It explains a clear interactive mechanism. Environment limits

service delivery. Service needs push social workers to take actions. Social workers give feedbacks to promote environment improvements.

Small details of physical environment are hidden but decisive. They influence service quality deeply. International research proves a close relation. Good physical environment relates to high care quality in long-term care settings. Institutions that pay attention to environment details achieve better results. Residents have higher life quality. They show higher care satisfaction. They keep better cognitive functions. Social workers act as key mediators. They bridge gaps between environment and services. Their advocacy and coordination work is irreplaceable. It pushes environment improvements. It helps raise overall care standards.

Environment influences services mostly through small details. Social work shows its value at these points. Social workers cannot change all conditions. They can make small and careful adjustments in each service case. These adjustments keep care continuity. They pass on human care and warmth. The finding offers important implications for similar institutions. They do not need to wait for large-scale environment renovations. They can recognize and support frontline adaptive wisdom. They do not need to pursue perfect ideal design. They can support professional initiatives of social workers under current limits. These small adaptive actions seem ordinary. They form the most basic guarantee for high service quality.

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Evolution of Knowledge Production and Reconstruction of Communicator Roles in the AIGC Era

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Abstract

The iterative development of AI-generated content (AIGC) technologies has given rise to a new paradigm of knowledge production and dissemination. Drawing on a systematic literature analysis, this study reviews the evolutionary trajectory of traditional knowledge production models. The study focuses on the transformative changes driven by the AIGC-powered "human–machine collaboration" paradigm—particularly in terms of dynamic mechanisms, organizational methods, quality control, and value orientation. On this basis, the paper examines the challenges faced by traditional communicators, including the erosion of authority and the weakening of gatekeeping functions. It argues that communicators need to transition into multiple new roles: strategist in human–machine collaboration, facilitators of higher-order thinking, critics of algorithmic ethics, and emotional liaison. Finally, a dialectical examination is conducted on potential issues arising from the new paradigm. The paper aims to provide a theoretical reference for building a sound knowledge ecosystem, where a dynamic network of actors, technologies, and institutions can work cohesively in the production, dissemination, and use of knowledge.

Keywords: AIGC; Knowledge Production Models; Roles of Communicators; Human–Machine Collaboration; Knowledge Ecosystem

1. Introduction

Under the tide of digitalization, AIGC is reshaping the landscape of knowledge production and dissemination at an unprecedented pace, driven by its ability to generate multimodal content and process data efficiently.The evolution of knowledge production models has always moved in step with technological development. The transition from Mode 1 to Mode 2 proposed by Michael Gibbons and his colleagues, together with the later addition of Mode 3 by Elias G. Carayannis and others, forms a classic analytical framework (Chen, 2023). However, AIGC is beginning to move beyond the logic of existing models by integrating data and algorithms in new ways, giving rise to a form of human–machine collaborative knowledge production: in which human judgment

and intention are combined with the generative and analytical capabilities of AI systems, enabling more efficient and scalable knowledge creation. At the same time, the knowledge dissemination environment has undergone dramatic changes. Under the impact of knowledge equalization and intelligent production brought by AIGC, traditional knowledge communicators, who once served as knowledge authorities and information gatekeepers, are now facing multiple challenges such as the erosion of their authority and the weakening of their functions. The reconstruction of their roles has become inevitable.This paper follows the main line of "evolution, transformation, and reflection." It analyzes the internal mechanisms behind the dissolution and reconstruction of the communicator's role, and offers a critical discussion of the new knowledge ecology shaped by AIGC. The goal is to provide academic support for the healthy development of knowledge production and dissemination in the AIGC era.

2. Research Methodology

The foundational data for this study was gathered through a systematic literature review. This involved:

(1) Source Selection: An extensive search of high-impact international databases (e.g., Web of Science, CNKI) was conducted using keywords such as "AIGC," "Knowledge Production Mode," "Communicator Role," and "Human–Machine Collaboration."

(2) Inclusion Criteria: Priority was given to peer-reviewed journals published between 2023 and 2026 to ensure the analysis reflects the most recent advancements in generative AI and communication theory.

This study adopts an evolution–transformation–reflection analytical framework, combining comparative paradigm analysis, role theory, and critical–normative evaluation. It first traces the historical evolution of knowledge production models, then analyzes the transformation of communicator roles under the AIGC paradigm, and finally provides a critical reflection on the emerging knowledge ecology.

3. Evolution and Breakthrough: The Paradigm Shift of Knowledge Production Models Driven by AIGC

3.1. The Basis of Evolution: A Review of Paradigms from Mode 1 to Mode 3

The way knowledge is produced has always evolved alongside broader technological and social change. The progression from Mode 1 to Mode 3 offers a useful starting point for understanding how knowledge systems have gradually expanded in terms of participants, organization, and purpose.

Mode 1 refers to a more traditional, discipline-based form of knowledge production. It is largely carried out by individual scholars working within academic institutions, with a primary focus on developing theoretical knowledge. In this model, knowledge production tends to remain relatively closed and confined within specific academic communities.

Mode 2 marks a shift toward more application-oriented and interdisciplinary forms of knowledge production. Here, research is increasingly shaped by practical needs and involves collaboration between universities, industries, and other institutions. As a result, knowledge is valued not only for its theoretical contribution but also for its usefulness in real-world contexts. Formal peer review also becomes more central in maintaining quality and credibility.

Mode 3 further expands this process by introducing a more open and networked approach. With the support of digital technologies, knowledge production becomes more distributed, involving not only institutions but also individuals and online communities. This makes the process more participatory and accessible. At the same time, quality control begins to rely not only on expert evaluation but also on forms of community feedback. However, despite these advances, knowledge production in Mode 3 is still largely driven by human actors and does not fully incorporate the capabilities of intelligent technologies.

Table 1. Comparison of Three Knowledge Production Modes

Dimension of Comparison	Mode 1	Mode 2	Mode 3
Core Agents	Individuals such as scientists and scholars	Organizations such as enterprises and research institutions	Institution + individual + community driven network
Driving Mechanism	Driving Mechanism	Social application needs	Curiosity + application needs + network connection
Value Orientation	Pursuit of truth	Pursuit of truth + social utility	Pursuit of truth + social utility + open sharing
Organizational Form	Disciplinary isolation	Interdisciplinary collaboration	Distributed collaboration
Quality Control	Limited peer review	Well established peer review system	Peer review + community feedback
Dissemination Characteristics	Traditional channels, limited reach	Parallel academic and applied dissemination	Internet driven, zero cost coverage

Table 1. shows a clear shift in knowledge production from closed, discipline-based systems to more open and networked forms. Across Modes 1 to 3, participation expands from individual scholars to institutions and eventually to distributed communities, while the focus moves from pure theory toward practical application and knowledge sharing. At the same time, organizational structures become more flexible, evolving from disciplinary boundaries to interdisciplinary and networked collaboration. However, despite these changes, Mode 3 remains largely human-driven and continues to face challenges in efficiency and consistent quality control at scale. In this sense, the AIGC paradigm represents a more fundamental shift rather than a simple extension, as it

introduces algorithmic systems as active participants in knowledge production, enabling faster, more scalable, and increasingly automated processes while also raising new concerns around reliability and accountability.

3.2. A New Paradigm of Knowledge Production Driven by AIGC

3.2.1. Shift in Driving Mechanism: From Human Curiosity and Application Needs to the Dual Drive of Data and Algorithms

The traditional driving forces of knowledge production mainly came from human curiosity about the world and the application needs of social development. With the emergence of AIGC technology, the driving mechanism of knowledge production has shifted. Massive amounts of data and algorithms now provide a new driving force for knowledge production. Through deep analysis and learning of data, AIGC can uncover potential patterns that are difficult for humans to detect, facilitating the generation of innovative knowledge outcomes. At the same time, the continuous improvement of algorithms can enhance the rigor and quality of AIGC-generated content. This process also helps overcome certain limitations of human cognition. As a result, knowledge production increasingly reflects an interaction between human intention and algorithmic exploration (Fu & Li, 2025).

3.2.2. Transformation in Organizational Form: From Institutionalized, Interdisciplinary, and Distributed Collaboration to Distributed, Agent Enhanced Real Time Production

Traditional knowledge production was mainly carried out by scholars and research institutions. With the development of AI technology, the mode of knowledge production has changed to agent enhanced real time distributed production. After the emergence and widespread use of AIGC, the barrier to knowledge production has been greatly lowered. Anyone can use AIGC to produce and disseminate knowledge, becoming a node in distributed production (Guo & Zhang, 2023). Take science popularization, which requires a high level of expertise, as an example. Creators can use AIGC to quickly access the latest professional research results from around the world, and then process them into easy to understand science content for dissemination. The whole process is simple and efficient, without relying on too much external support.

3.2.3. Reshaping of Quality Control: From Peer Review to Algorithmic Assessment and Human Machine Collaborative Verification

From Mode 1 to Mode 3, the quality control of knowledge production relied on peer review. In the AIGC era, the scale of knowledge production has expanded rapidly and the speed of dissemination has accelerated. The traditional peer review method can no longer meet current needs in terms of efficiency and coverage. Under these conditions, AIGC is reshaping quality control systems. Instead of relying solely on manual evaluation, these systems now combine algorithmic assessment with human–machine collaboration (Jiang et al., 2025). This transformation has already taken place in the publishing field, publishers like Elsevier is already using AI assisted screening tools to conduct completeness and plagiarism checks (Elsevier, 2025).

3.2.4. Expansion of Value Orientation: From the Pursuit of Truth and Social Utility to Inclusiveness and Creativity

Traditional knowledge production was driven by the human pursuit of truth and the needs of social development. In the AIGC era, knowledge production has become more accessible. The barrier to knowledge production has been greatly lowered, allowing ordinary people to participate in the creation and dissemination of knowledge. Duolingo for example, an application that is used to teach and help practice foreign languages, have incorporated AI into their application, allowing for lessons adapted real time based on learner's response (Duolingo, 2023). In addition, AIGC relies on large amounts of data to complete its creative work, which to some extent provides people with diverse intellectual inspiration and stimulates their innovative ideas.

4. Crisis and Transformation: Reconstructing the Role of Knowledge Communicators in the AIGC Era

While AIGC technology is driving changes in the way knowledge is produced, it is also having a disruptive impact on the stability of the traditional knowledge communicator role. The functions of traditional communicators as knowledge authorities, information gatekeepers, and providers of basic skills are gradually disappearing. They are beginning to shift toward new roles in human machine collaboration.

4.1. The Dissolution of Roles: Challenges Facing Traditional Communicators

4.1.1. The Erosion of Knowledge Authority

In the traditional knowledge production system, communicators relied on their professional expertise and information screening abilities to establish a certain level of authority within a given field. However, with the development of AIGC technology, knowledge production and dissemination are becoming increasingly democratized and accessible to the general public. Ordinary people can now use AIGC to create professional level content. Teachers are no longer the sole providers of knowledge in the classroom, and journalists are no longer the fastest information publishers for breaking news. The knowledge authority of traditional communicators has been undermined.

4.1.2. The Weakening of Gatekeeping Functions

Traditional communicators acted as information gatekeepers, that is, those who screen, filter, and process information before passing on quality knowledge to the audience. AIGC technology has brought information dissemination into an era of decentralization. A large amount of user generated content and AI generated content is flooding into communication channels, and the speed of information dissemination has become very fast (Li et al., 2025). Traditional communicators can no longer achieve comprehensive control and screening of information, and their gatekeeping function has been greatly weakened.

4.1.3. The Declining Value of Basic Skills

Traditional communicators needed to possess good basic skills in information collection, editing, and dissemination. However, AIGC technology can efficiently perform these tasks, delivering well written copy, reports, videos, and other content quickly and with good quality.Taking news as an example, AI can instantly produce structured news reports such as sports events and financial coverage, and can automatically proofread and format the content. The substitutability of traditional communicators' basic skills has increased, steadily weakening their core competitiveness and leaving them trapped in the dilemma of skill updating and role transformation.

4.2.Role Reconstruction: Moving Toward a New Paradigm of Human Machine Collaboration

4.2.1. Curator and Conductor in Human Machine Collaboration

In the AIGC era, knowledge content is growing exponentially, leaving audiences trapped in information overload. In this context, communicators should act as human machine collaborative knowledge curators, integrating, screening, and optimizing vast amounts of information to provide audiences with personalized and precise content services. In addition, they need to coordinate their working relationship with AI, much like a symphony conductor directing the work of various intelligent agents, ensuring that these agents cooperate and work together to jointly complete the production and dissemination of knowledge (Liu & Zhang, 2023). In the operation of science popularization accounts, for example, communicators can guide AI to produce first drafts of short science videos based on audience interests and preferences, and then adjust and improve based on audience feedback, thereby producing high quality science content (Liu et al., 2023).

4.2.2. Guide of Higher Order Thinking and Cognitive Coach

AIGC can generate a large amount of content, but it is not good at cultivating audience's innovative thinking and critical thinking. Communicators, on the other hand, can fully leverage their own strengths, transforming from traditional information disseminators into guides of higher order thinking and cognitive coaches. Take a hot topic as an example. In the process of information dissemination, communicators can build a discussion structure that contains multiple levels and multiple perspectives around the topic, allowing audiences to engage in discussions from different angles and sides, and prompting behaviors that demonstrate critical thinking and creative expression.

4.2.3. Critic of Algorithmic Ethics and Value Anchor

The development of AIGC cannot be separated from the support of algorithms, but algorithms themselves come with certain biases and value deviations. For example, algorithms can intensify information cocoons and may also contain false information, leading to ethical problems and misleading the audience's understanding (Wang, 2025). Communicators should possess a certain level of digital literacy and algorithmic awareness, view algorithms critically, and reveal to audiences the risks that exist in AIGC outputs.

4.2.4. Connector of Emotional Value and Community Builder

The content generated by AIGC is a recombination of large amounts of existing information. It lacks real feelings and life experiences, and therefore has limited human warmth and emotional connection. Communicators can make full use of their own strengths by transforming themselves into connectors of emotional value and builders of communities. On the one hand, they can incorporate human care into the process of knowledge production and dissemination, making the content more engaging and story like (Xiao, 2024). On the other hand, they can create online communities and organize interactive activities around relevant topics, forming knowledge dissemination circles with a sense of belonging and cohesion.

5. Challenges and Reflections: A Dialectical View of the AIGC Knowledge Ecology

While the reconstruction of communicator roles reflects an adaptive response to the AIGC-driven environment, these changes also introduce new uncertainties and structural risks. The same conditions that enable human–machine collaboration and decentralized knowledge production—such as algorithmic mediation and large-scale content generation—can give rise to challenges related to inequality, ethical accountability, and the stability of knowledge systems. In this sense, role transformation and emerging risks are closely intertwined. This section therefore examines the key tensions within the evolving AIGC-driven knowledge ecosystem.

5.1. The Paradox of Knowledge Equalization and the Digital Divide

AIGC technology allows more and more people to participate in knowledge production and dissemination, which to some extent promotes the development of knowledge equalization. However, it may also widen the digital divide. Differences in digital access and digital skills exist across regions and between different groups of people. Some individuals cannot fully take advantage of the convenience brought by AIGC technology, which may worsen inequality in knowledge acquisition. For example, remote areas often have weak network infrastructure, making it impossible for some people to access the internet. In addition, elderly people may lack basic digital skills and therefore cannot use AIGC technology effectively.

5.2. Concerns over Content Homogenization and the Dilemma of Innovation

The content generated by AIGC is essentially a reorganization and imitation of existing information, lacking true innovation. The stories, articles, and other materials it produces often share similar plots and expressions, making them largely indistinguishable and highly homogenized. When a large amount of AIGC generated content floods communication channels, it can on the one hand reduce the audience's reading experience, and on the other hand dampen human motivation for innovation. In the long run, this is not conducive to the innovation and development of knowledge.

5.3. The Ambiguity of Responsibility Attribution and Ethical Misconduct

The application of AIGC technology has blurred the boundaries of knowledge production. When AIGC-generated content involves false information or infringements (Zhang & Yang,

2025), responsibility becomes difficult to assign. This includes ambiguity among technology developers, users, and content communicators. Moreover, due to the low transparency of algorithmic processes, biases and ethical misconduct are more likely to occur (Zhang et al., 2025). With regard to issues such as portrait rights and intellectual property rights, legal protection is difficult to obtain, and there is a lack of unified standards for determining originality and attributing copyright. This ambiguity can lead to legal disputes and hinder the healthy and orderly development of knowledge production.

5.4. The Long Term Risk of the Erosion of Human Subjectivity

The development of AIGC has given rise to a human machine collaborative model of knowledge production. However, excessive reliance on AIGC technology by humans may lead to the erosion of human subjectivity (Zhu et al., 2025), and with it, the decline of human capacity for independent thinking. Furthermore, AIGC relies on algorithmic technology. While algorithms bring convenience to information dissemination, they also deepen the filter bubble effect, narrowing people's cognitive horizons to a certain extent. The ability of humans to think independently and make judgments is also at risk of being weakened. All of these factors mean that as humans enjoy the convenience brought by AIGC, they may lose their own subjectivity and their leading role in innovation.

6. Conclusion and Outlook

The advancement of AIGC technologies is reshaping the landscape of knowledge production, driving a paradigm shift toward human machine collaboration and data driven processes. Within this evolving context, knowledge communicators are confronting emerging challenges and progressively transitioning toward a human machine collaborative model. Meanwhile, the AIGC mediated knowledge ecology faces persistent issues including the digital divide, content homogenization, ambiguous attribution of responsibility, and the erosion of human subjectivity. Addressing these challenges requires coordinated efforts from technology developers, educators, policymakers, and society at large, with the goal of achieving complementary human machine strengths and fostering a more inclusive, innovative, and healthy knowledge ecosystem.

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Conceptualization, Siyang Xu and Shixue Xiong; methodology, Siyang Xu and Shixue Xiong; validation, Siyang Xu and Shixue Xiong; formal analysis, Siyang Xu ; investigation, Siyang Xu ; resources, Shixue Xiong; data curation, Siyang Xu and Shixue Xiong; writing—original draft preparation,Siyang Xu; writing—review and editing, Siyang Xu and Shixue Xiong; visualization, Siyang Xu ; supervision, Shixue Xiong; project administration, Siyang Xu and Shixue Xiong; funding acquisition, Siyang Xu and Shixue Xiong. All authors have read and agreed to the published version of the manuscript.

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A Survey on the Social Application Dilemmas of Virtual Digital Humans from the Perspective of Digital Ethics

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Abstract

Advances in artificial intelligence and virtual-physical integration have enabled widespread adoption of digital human technology across media, finance, healthcare, and entertainment sectors. Based on their service characteristics, social applications of digital humans fall into three categories: service-oriented, companion-oriented, and assistant-oriented. Growing intelligence, broader accessibility, expanding scenarios, and extending boundaries bring urgent ethical challenges. This study employs questionnaires and interviews to examine public understanding of digital ethics, technology adoption, social impact, and future outlook across all age groups and professions. The research identifies key issues in cognition, application, social impact, and legal regulation. Four directions emerge: fostering rational technological ethics, clarifying social and corporate responsibilities, strengthening government oversight to alleviate public anxiety, and improving laws for multi-party governance. These findings offer guidance for healthy industry development and ethical governance.

Keywords: Digital Human; Digital Ethics; Classification of Social Applications; Public Cognition; Supervision Suggestions

1. Introduction

A digital person is defined as a humanoid entity that is generated through computer graphics technology, constructed through modeling, driving, rendering and other processes, driven by real people or algorithms, and can be presented on multimodal devices. It simulates human services and interactions. Assigning it a specific identity, designed to reduce psychological distance, and enabling more realistic emotional interaction (Chen, 2025). They usually possess three characteristics: anthropomorphic appearance, anthropomorphic behavior, and anthropomorphic interaction capabilities.The rapid development of industries and the continuous expansion of market scale are the characteristics of the current development of digital humans in China. They have been widely applied in various industry scenarios such as e-commerce, media, tourism, and

finance.According to the "China Digital Human Development Report (2024)", the core market size of digital humans in China is expected to be extremely large, surpassing 40 billion yuan by 2025 and driving the growth of related industries to an amount of over 600 billion yuan.In this context, accurately defining its legal nature and clearly delineating the boundaries of its activities are regarded as of crucial significance for promoting the healthy development of the industry and fostering new productive forces.

The development of digital humans has always been a core area where multiple disciplines intersect. As a result, the impact brought about by this intersection has widely permeated the social, technological and economic fields.At the technical and industrial level, Li et al. (2022) defined the subfields of companion-type digital humans. They defined the core attributes of companion-type digital humans as being driven by emotions, also explaining the key user characteristics such as the home environment and the Z-generation, and more importantly, they also proposed specific suggestions for the design of the appearance and the optimization of interaction.The situation in terms of ethics and social impact is more complex. Zhao et al. (2025) conducted an analysis based on generative AI. The risks such as the value orientation of digital human-related applications, technical decision-making deviations, and value loss have been clearly identified. The three-dimensional path for ethical reconstruction has thus been emphasized. This is something that requires vigilance. Liu et al. (2025) approached from the perspective of human subjectivity, analyzed the problems such as weakened autonomy and reversed subject-object relationship caused by digital humans, and advocated achieving human-machine symbiosis through technological ethics reconfiguration and boundary delineation. Zhao et al. (2025) addressed the issues of protecting portrait rights in the application of digital human technologies such as AI face-swapping, and pointed out that there are three major dilemmas in this regard. They also highlighted that the challenges at the legal regulation level are equally prominent. We propose a solution involving the collaboration of multiple laws and the construction of scenario-based rules. This is the key way out.

In summary, the current research direction is more focused on exploring the cutting-edge characteristics of digital humans in multiple dimensions and across multiple disciplines. It also integrates resources from various disciplines such as computer science, sociology, and law for interdisciplinary research, and has identified research topics such as technological iteration, industry expansion, and exploration of specific scenario demands.However, as digital humans are widely applied in various scenarios, ethical conflicts and risks have become increasingly prominent. Moreover, the existing research lacks the definition of digital human ethics and the analysis of risk governance.This article focuses on the cognition and impact of ethical and moral risks in the application of digital humans, providing theoretical support and practical references for the healthy and sustainable development of the digital human industry.

From the perspective of the technological evolution process, the development of digital humans can be roughly divided into four stages (as shown in Figure 1). From the 1980s to the early 21st century, the early digital humans were mainly used in film and television production, relying on manual creation, with long production cycles and high costs. In the 21st century, with technological advancements, the industry entered its infancy stage. Digital humans shifted

towards a profit-oriented direction, and virtual idols gradually emerged. After 2010, the industry entered its growth period and fully embarked on the path of industrialization. Digital humans utilized digital technologies to enter fields such as virtual influencers and online hosts. Since 2020, the integration and breakthrough of technologies such as deep learning, computer vision, AIGC and large models have enabled digital humans to enter the era of intelligence. They possess perception, understanding and interaction capabilities, and can achieve low-cost, large-scale and scenario-based applications, becoming intelligent digital entities capable of multi-modal interaction, with exclusive knowledge and preliminary emotional capabilities.

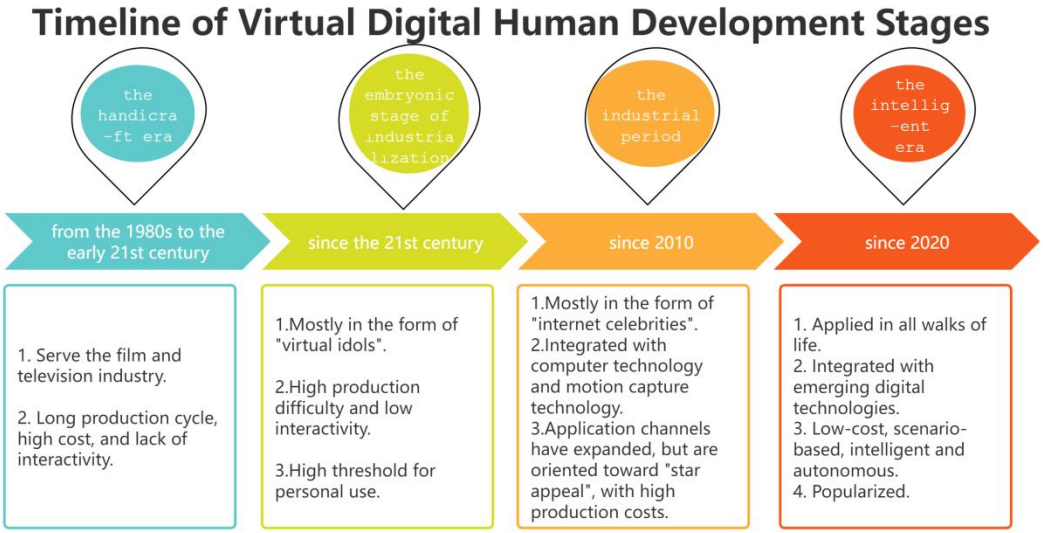

Figure 1. Time chart of digital human development stage

2. Social Application of Digital Human

After 2020, with the deep integration of digital technology and artificial intelligence, the digital person industry has accelerated its development, with diverse application scenarios, and has widely penetrated into multiple industries such as media, finance, and healthcare.Based on the differences in core functions and application goals, the social applications of digital humans can be classified into three types: service-oriented, companion-oriented, and assistant-oriented (as shown in Figure 2).

2.1. Service

The core objective of service-oriented digital humans is to replace or assist real humans in completing standardized service processes. The ultimate goal is to reduce costs, increase efficiency, and enhance user experience.For instance, through AI computing, large language models, the relevant industry knowledge bases and industry business rules and requirements that they serve, as well as after learning and understanding, special digital humans. Service-oriented digital humans have relatively mature application scenarios in the media and financial fields.Due to its commercial goals and practical application, the online media industry is the most mature industry for the implementation of digital humans. According to the data from "The

Comprehensive Collection of Digital Human Application Scenarios in China (2024)", media-based digital humans account for 50% of the total number of scenarios in the nutrition sector. Specifically, they are divided into 5 types: virtual idols, media hosts, etc. In the financial industry, service digital humans have achieved efficiency improvement and process innovation through AIGC (Artificial Intelligence + Generative Creativity). In the field of online media, digital characters such as "Gu Xiaoyu" from Zhejiang Satellite TV incorporate "traditional culture", possessing cultural IP. They have successfully conveyed typical cultural scenarios and have gained widespread attention and affection. This has also brought considerable popularity to similar traditional Chinese-style virtual characters. The creation of these digital characters has given rise to a series of digital IPs and digital film and television works for promotion.The representative in the financial field is the "digital employee" of China Construction Bank. The digital person takes on roles such as online "intelligent customer service" and "wealth management consultant", leveraging technologies like AI and big data to become a typical carrier of intelligent services for industry research and customer care that are available 24 hours a day and highly efficient and accurate.

However, the widely used service-oriented digital humans also face many related risks and concerns regarding application ethics:In the field of media, cultural and creative IP digital characters are prone to issues such as infringement of portrait rights and personality rights, and also involve the issue of digital personality. The intelligent customer service in the financial sector has issues such as the leakage of users' personal data. Moreover, the algorithms have biases and there are phenomena of service discrimination, which violate basic ethical principles such as informed consent, the minimum necessary use of data, and data security. Furthermore, the phenomenon of digital humans replacing traditional jobs will also further highlight the issue of employment anxiety in society, and increase the ethical conflicts related to the rights and fairness of workers affected by digital technology substitution.

2.2. Companion

One of the goals that companion digital humans aim to achieve is to meet users' emotional needs, such as social companionship, emotional comfort, and emotional support. To fulfill these functional requirements, advanced AI technologies, large language models, emotional computing, storage and memory technologies, and artificial intelligence are needed to create digital humans that are emotionally expressive and logical.Due to the rapid and intense development of modern technology and the fast-paced lifestyle, people have a strong need for emotional companionship in their solitary lives. This includes young people living alone and elderly people in empty nests, etc. This has led to an increasing demand for companion digital humans (Li, 2022). These products can provide personalized companionship for users across different time and space. They can express emotions and offer psychological comfort to users in front of various user groups. In China, such products exist, such as Xingye and Cat Box App. There are also digital humans that users can choose to create digital human images for chatting and playing, opening up more demand scenarios.

Excessive reliance on digital humans will prevent people from leaving the real world to interact with them, leading to a decline in their social skills and making it difficult for them to interact

with others. Moreover, since collecting and storing emotional data is an infringement of privacy, the "fake empathy" of digital humans will cause people to lose their true emotions, resulting in emotional dislocation and hindering the normal recovery of their psychology. Therefore, people are all worried that these "human-like non-human" digital beings might not be able to withstand the scrutiny of moral and ethical standards, potentially causing significant ethical and moral issues.

2.3. Assistant

The main purpose of using assistant-like digital humans is to serve as an enabler in an individual or a specific professional field, aiming to assist users in performing certain tasks and enhancing their productivity, decision-making ability, etc. Digital humans can invoke various tools and complete tasks in multiple scenarios, achieving task automation and a one-stop experience, thereby saving users' working time and energy. The assistant-type digital humans will be positioned as "tools" to enhance the productivity and decision-making ability of users. They can be frequently invoked and perform tasks in multiple scenarios. The application of such human-machine collaborative digital humans as tools in the medical field is aimed at improving industry efficiency and providing innovative services (Liu et al., 2025). For instance, Tencent's "Miying" serves as a digital doctor for assisting in medical diagnosis and screening. It can facilitate early disease screening and possesses core functions of AI medical imaging and AI medical diagnosis, which can alleviate the problem of insufficient medical experience among grassroots doctors.

However, the controversy caused by the "misdiagnosis" liability brought about by digital human doctors in the medical field, the "black box" nature of the algorithms in decision-making, and the emergence of digital human assistance tools, in turn, will also give rise to key factors such as criticizing the "true skills" and "true profession" of professionals.

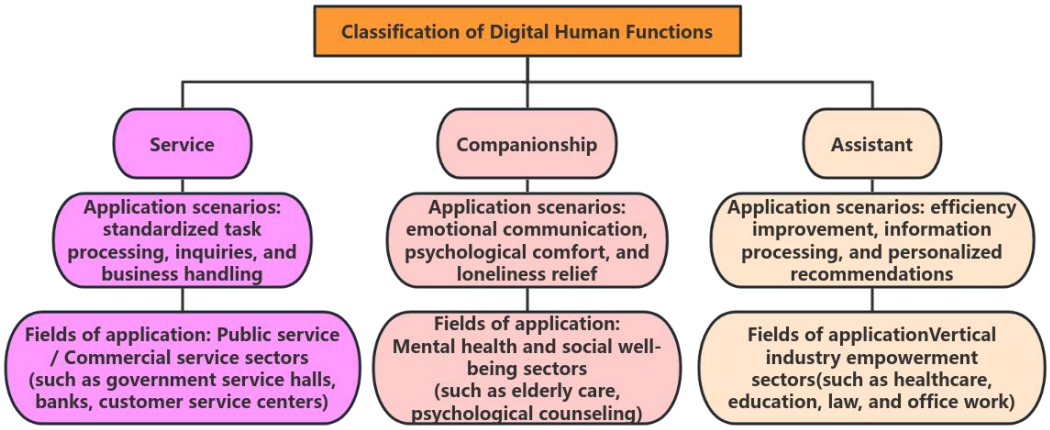

Figure 2. Classification diagram of three function types of digital human

3. Overview of Digital Humans

With the rapid development of artificial intelligence technology, digital humans will undergo more significant technological innovations and have broader application prospects. However, the digital ethical issues that arise during its application in society also urgently require a correct

understanding.Based on this, this article conducts questionnaire and interview surveys to explore many digital ethical issues arising from the social applications of digital humans.The questionnaire survey was conducted through random sampling, and a total of 654 valid questionnaires were collected. The gender distribution of the samples was balanced, and the age range covered all stages, with a majority being young people. The occupations of the interviewees covered a wide range, with students and enterprise employees being the majority, and the population structure was representative.The questionnaire survey was conducted from three major dimensions: the ethical perception of digital humans, the social applications of digital humans, and the impact of digital human applications on society. At the same time, interviews were conducted with the users and stakeholders of the three types of digital humans, thereby achieving more detailed data results and enabling multi-dimensional analysis.

3.1. Ethical Cognition of Digital Human

To explore the differences in the perception of ethical responsibilities and risk boundaries regarding digital humans among various identity and occupation groups, this study conducted a survey on the ethical issues that digital humans might bring about (see Figure 3). It can be seen that the student group is most concerned about "risk of privacy data leakage" (36.05%), "replacement of human jobs" (37.98%), and "algorithm bias and discrimination" (46%). Professionals have more prominent concerns about "emotional deception" and "job replacement". Employees of public institutions, educators, and the elderly group have relatively balanced risk concerns.This indicates that there are significant differences in the perception of digital risks among different identity and occupational groups. The student group, due to their higher educational level and better understanding of digital technology, is more sensitive to core risks. While the working and middle-aged elderly groups have a more dispersed perception of risks and place greater emphasis on the impact on their own rights and interests, reflecting the significant influence of identity and occupational scenarios as well as interests concerns on the perception of digital technology risks.

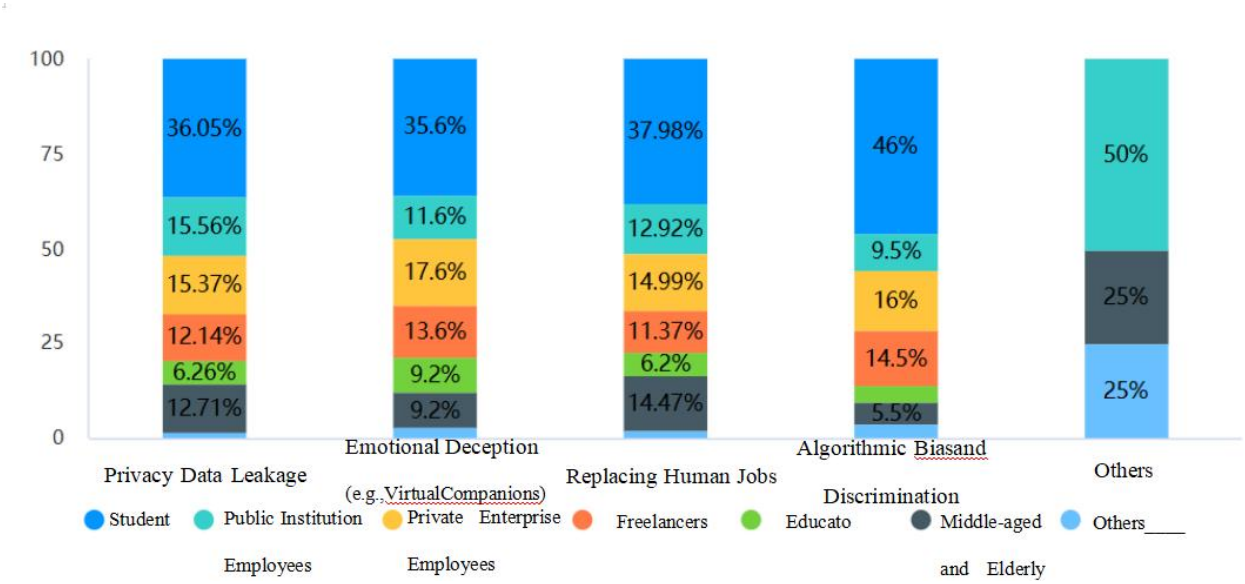

Figure 3. Ethical issues that digital human may cause in the opinion of respondents with different identities and occupations

In order to study the respondents' perception of the adequacy of current legal regulation for digital humans, the "evaluation of the adequacy of digital human legal regulation" and the "whether they support the government to formulate specific ethical norms for digital humans" were cross-analyzed (see Figure 4). Among those who believe that the current regulatory framework is "very complete", the proportion of those who support the government in formulating ethical norms is 97.36%, while in the "partially covered" group, the proportion of those who support the formulation of norms is 97%. Overall, it shows that "the group that has a strong perception of the adequacy of digital person legal regulation is more supportive of the formulation of digital person ethical norms".This result indicates that the concept of regulatory awareness is an important foundation for consolidating the social consensus on digital person ethics governance. The public's trust in the existing regulatory system directly affects their acceptance and support for the construction of ethical norms. It also provides important insights for the government to promote the formulation of digital person ethical norms and to unite social forces. That is, it is necessary to first enhance regulatory education and raise the public's awareness of the existing regulations, so as to better promote the implementation of specialized ethical norms and form a governance pattern where regulation and ethics work together.

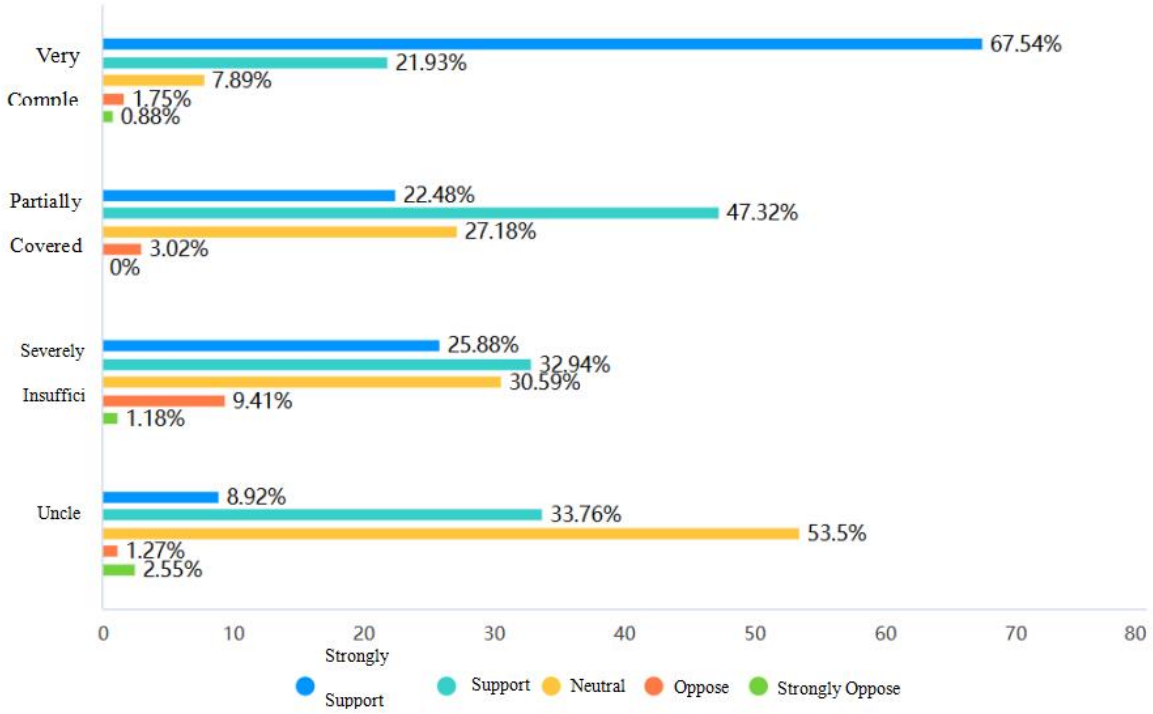

Figure 4. Whether it supports the development of digital human ethics norms and the cognition of the adequacy of digital human legal supervision

Furthermore, in order to gain a deeper understanding, we sought to explore the respondents' perceptions of digital humans. The results indicated that 58.72% of the respondents stated that they would clearly mark the "non-human nature" of digital humans to ensure the transparency and right to information. This reflects, in a certain way, the commonality that the application of digital human technology requires regulation.60.4% of the respondents believe that the widespread use of digital humans will not undermine interpersonal relationships, and they have expressed their support for the future development of digital humans.Currently, digital humans are still in the

nascent stage. More than half of the respondents have expressed an optimistic or neutral attitude towards their interpersonal impact. As future technologies continue to evolve and applications become more mature, the positive value of digital humans in social scenarios will become more prominent, and public concerns related to them will gradually be alleviated.

To explore the preference scenarios for service-oriented digital humans among different age groups (Figure 5), among the scenarios preferred by people under 25 years old, the majority of those who use e-commerce platforms/app customer service (46.55% and 41.48%) are teenagers. The 26-35 age group has the highest concentration of preference for digital representatives of financial institutions and government services (62.02%); the 36-50 age group has relatively balanced preferences across various fields. Among people over 50 years old, those who prefer digital services related to government affairs have the highest proportion (41.18%). This indicates that the preference habits of different age groups are highly consistent with the "focus" of their lives. The "focus" of the youth group leans more towards high-frequency, life-oriented services in their daily lives, while the "focus" of the middle-aged and elderly groups tends to be on financial and government-related functional services. In order for these digital humans to better design and reasonably arrange the needs of consumer scenarios, these data are worthy of reference.From this, it can be seen that the preferences of different age groups vary greatly. The precise layout and differentiated demands in the digital human industry are supported by data and guided in a certain direction.

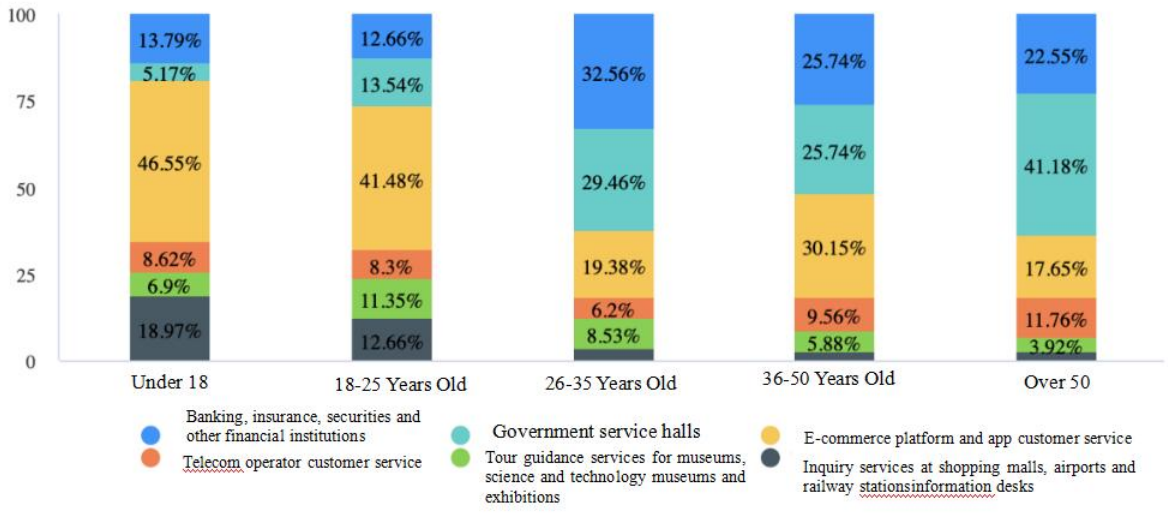

Figure 5. Application scenario preferences of digital human of respondents of different ages

Through the investigation, it was found that the perceptions of the surveyed groups with different identities and occupations were different. The respondents believed that the reasons for the rapid development of digital humans were focused on the ability to reduce long-term labor costs, improve the efficiency and stability of services, collect data, and optimize products (see Figure 6). This indicates that digital humans have become a trend in the digital transformation of various industries. They achieve significant reduction in long-term labor costs and stable improvement in service efficiency by replacing repetitive human work. At the same time, they provide data sources for product optimization by collecting user interaction data. Therefore, digital humans have demonstrated extensive application value in multiple scenarios such as

government affairs, business, and public services, adapting to the digital needs of different identity and occupation groups, and becoming an important technical force driving the development of the digital economy.

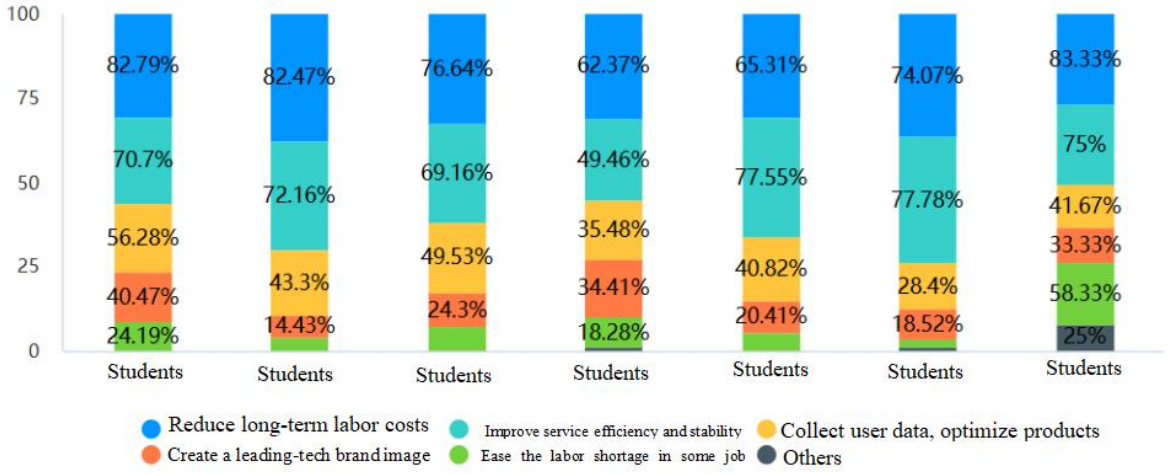

Figure 6. reasons why respondents with different identities and occupations think digital humans are developing

3.2. Social Application of Digital Human

At present, digital human applications have permeated multiple fields such as media, finance, healthcare, and tourism. On the basis of benefiting various fields, the main motivation for enterprises to deploy digital humans is to reduce labor costs, improve service stability, and optimize products.

To explore the preferences of respondents for the use of service-oriented digital humans, a cross-analysis was conducted on the types of service-oriented digital humans that different occupational groups of respondents were more inclined to use (see Figure 7). There were significant differences in the preferences of different identity groups for the application scenarios of service-oriented digital humans.Students prefer to use the customer service of e-commerce (50%), inquiries at shopping malls/airports/train stations (61.54%), and guided tours at museums/science centers (50.94%), etc. Private enterprise employees use it in financial business scenarios such as banking, insurance, and securities (37.23%). Public institution staff members use it in government service halls (31.54%); middle-aged and elderly people's choices are mainly concentrated in government service halls (24.83%) and operator customer service (15.79%). Young people attach great importance to the related scenarios in their daily lives. The salaried workers are concerned about the "practical scenarios" that are closely related to their work and life. The elderly prefer to use a certain type of basic "public services".This indicates that an individual's identity and occupation have a significant impact on the preferences for service-oriented digital humans. Different social groups have different living scenarios, living habits, and actual needs, which directly affect the willingness of the groups to use such digital humans.

Therefore, when implementing the promotion of service-oriented digital humans, it is necessary to conduct differentiated design and service design based on different user scenarios, in order to enhance their applicability and acceptance.

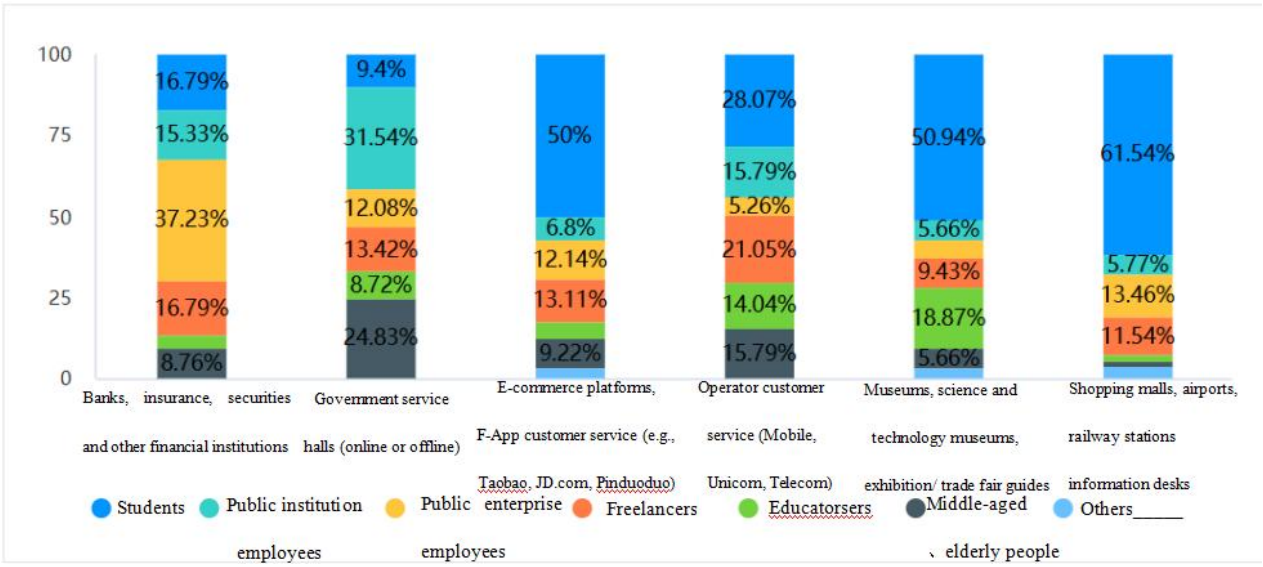

Figure 7. Scenario of service digital human used by respondents with different identities and occupations

In order to study the respondents' preferences for using companion-type digital humans, we analyzed the readiness of representatives from different social and occupational groups to form emotional attachments with such digital characters (see Figure 8). Among the student group, the proportion of those who answered "not very prepared" was particularly high (43.48%); while the responses of government officials, self-employed individuals, and educators were relatively balanced. The proportion of employees in private enterprises who "completely refuse" is particularly high (25%); while the elderly have the highest proportion indicating "complete willingness" (20.99%).From the analysis of intentions, it can be seen that the willingness to use is highly correlated with the needs of the group and usage habits. Therefore, when implementing the promotion of service-based digital products, it is necessary to simplify the operation for different groups and make appropriate scene adaptations, so as to enhance the overall acceptance and usage rate, and strengthen trust building.

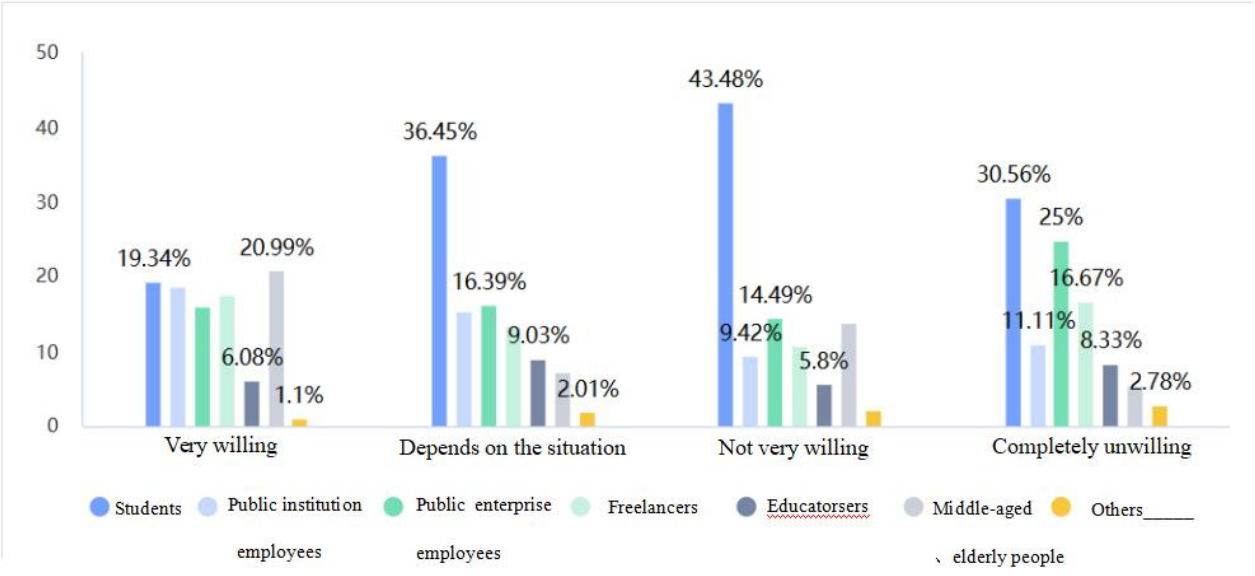

Figure 8. Willingness of respondents with different identities and occupations to place emotional sustenance on accompanying digital human

In order to investigate the preferences of respondents for the use of tool-type digital humans and the reasons for their usage among different occupational groups, this study conducted an in-depth analysis of the chart data (see Figure 9). In terms of the results, the student group showed a recognition rate for each of the various usage motivation options that was consistently over 30%, far exceeding that of other groups. The working class tend to have a higher balanced proportion in recognizing the functional value among the practical motives; the middle-aged and elderly group, on the other hand, have a relatively lower overall proportion in each motive option (below 15%), and they are only relatively interested in the option of more vivid and interesting interaction experience / feeling more intimate and accompanied. The tool-type digital humans that have been widely adopted are closely related to the motivation and professional identity of their usage. Students are easily attracted by novelty and use it out of curiosity; the working class pays more attention to practical functions and the ability to achieve real value; while the needs of the middle-aged and elderly tend to be more towards traditional services. It can be known that the user's motivation for using the product is closely related to their age and occupational identity, as well as the usage scenario. Therefore, focusing on the work scenario to achieve differentiated adaptation for the target audience is a key point during the product's launch and promotion.

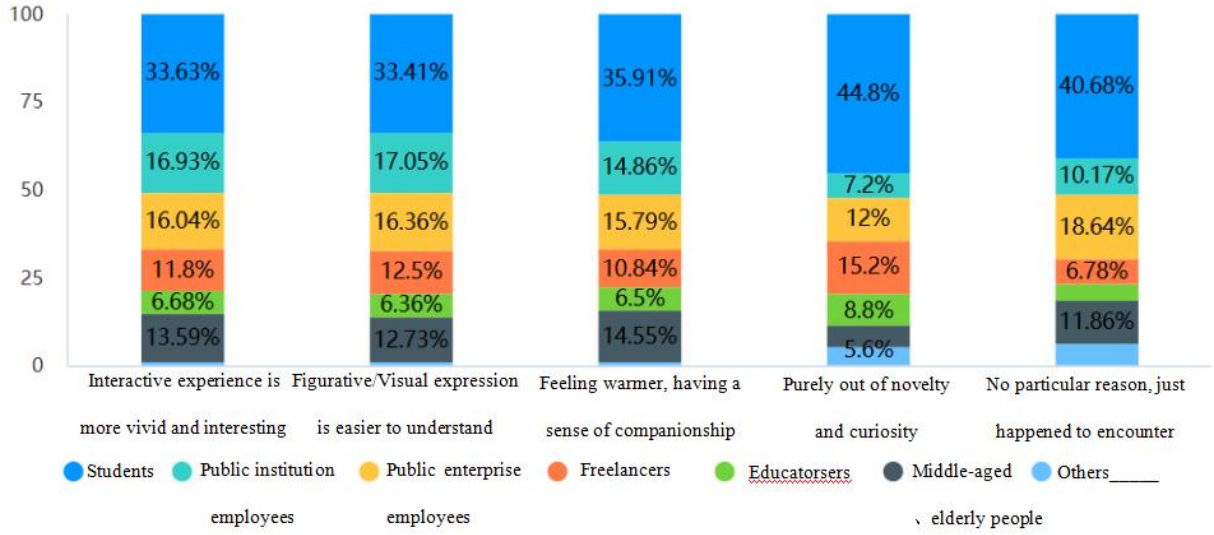

Figure 9. Reasons why respondents of different identities and occupations use tool digital human

3.3. Future Prospects of Digital Human

With the widespread application of digital humans in various industries, they are having an equal impact on all aspects of human society - including work, learning and daily life.The majority of opinions are positive - they believe that the use of digital humans can help enhance efficiency, promote economic development (76.91%), and change the form of social interaction (53.98%). However, some groups also expressed concerns that it might "aggravate the from this, it can be seen that the motivation for usage is closely related to age, occupation, and usage scenarios. When implementing the product's launch and promotion, one should focus on the working scenarios and carry out differentiated designs.unemployment problem" (45.87%) and trigger "new ethical controversies" (26.76%). At the same time, 69.27% of the respondents

believe that in the next ten years, digital humans will replace some occupations. This not only reflects a rational understanding of the impact of technology, but also shows concerns about different application scenarios. The majority hold an optimistic attitude.

The overall attitudes of respondents of different identities and occupations towards the development of digital human technology show a differentiated distribution (see Figure 10). The student group is more inclined towards "cautious (requiring strict supervision) (38.43%)", "neutral" (34.12%), and "optimistic" (30.70%), presenting a characteristic of expecting development while also attaching importance to risks. The employees of private enterprises (24.32%) and self-employed individuals ("pessimistic" 21.62%) have relatively higher proportions of such attitudes. The attitudes of employees in public institutions, educators, and the elderly group are more moderate, with a relatively balanced distribution of "optimistic", "cautious" and "neutral" attitudes.It can be seen that social and occupational identities significantly influence attitudes towards the development of digital humans. The student group is characterized by both optimism and caution. Market practitioners have a more acute perception of technological risks, while public service workers and the elderly tend to show a more stable attitude.This reflects the varying degrees of the connection between different professional fields, life scenarios and digital technology, which in turn affects their acceptance and trust of digital technology.

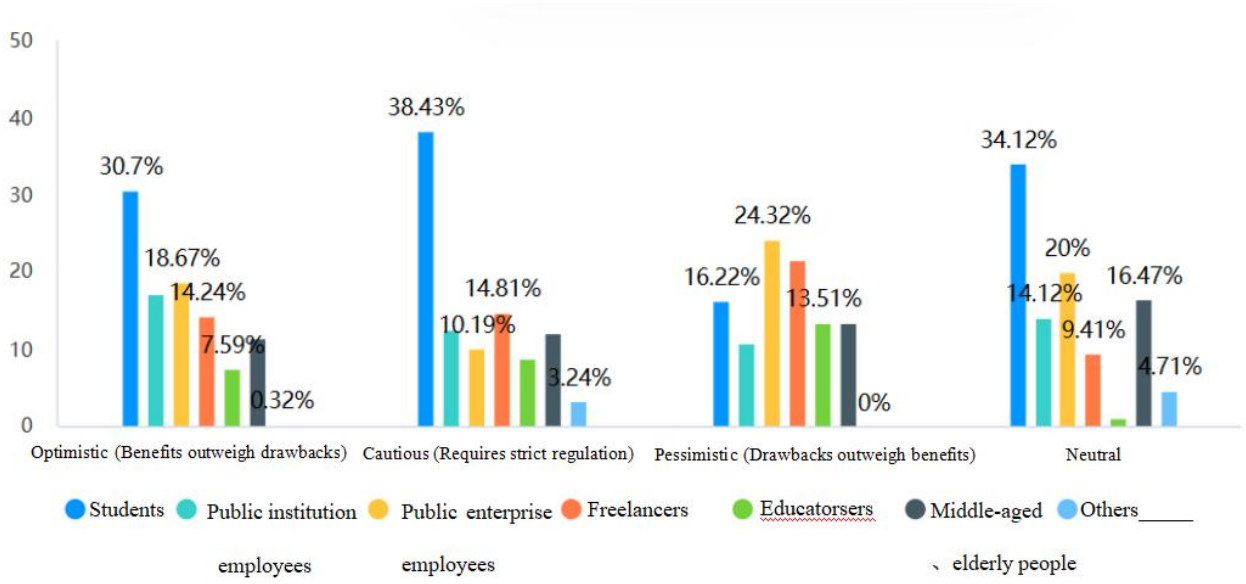

Figure 11. Overall attitudes of respondents with different identities and occupations towards digital human technology development

4. Challenges Faced by the Social Application of Digital Human from the Perspective of Digital Ethics

4.1. Cognitive Level: Technology Trust, Information Symmetry, Lack of Ethical Standards

The overall perception of digital humans and artificial intelligence technology among the general public is relatively fragmented. The primary difference lies in the fact that people from different occupations and social statuses have significant variations in their perception and

preferences towards digital humans, which consequently affects their confidence and acceptance of this technology. For instance, people in their middle age or older, and those who prefer the digital world, place greater emphasis on the "importance of ethical responsibility". Secondly, the problem of information asymmetry is quite serious. In the current application of digital humans, the openness and transparency of information are insufficient, which fails to guarantee the right to know of consumers. Moreover, the public also lacks a clear understanding of the laws and regulations related to digital humans.Finally, there is the issue of lacking ethical norms. Although everyone agrees that digital humans should have ethical requirements and behavioral restrictions, currently there is no specific and executable standard in the industry to measure what constitutes reasonable ethical behavior.This has led to a chaotic situation in terms of ethical management. People from different occupations and with different identities have different understandings of the ethical risks associated with digital humans. Due to the lack of unified standards for judgment, various ethical disputes have made people more skeptical about the safety of this technology, thereby affecting the healthy development of the entire industry.

4.2. Application: Deficiencies in Technology Risk Control, Vertical Research and Development, and Data Security

Digital humans are confronted with three major challenges: technical risks, research and development barriers, and security hazards. Firstly, the risk of "artificial intelligence hallucinations" in professional scenarios is particularly prominent.In professional fields with strong industry attributes such as finance, healthcare, and law, the information produced by digital humans often suffers from information distortion and logical errors. Ordinary people, lacking professional knowledge, have difficulty in distinguishing between true and false information, which leads to property losses or erroneous decisions. Secondly, there are significant gaps in the research and development of these industries. Even though the technology for general-purpose digital humans is relatively advanced, the development costs for specialized digital humans for various different niche fields are extremely high, it is difficult to break through key core technologies, and the required resources are enormous. For small enterprises, this is an unbearable burden, thus resulting in uneven technological research and development levels across the entire industry. Finally, there is an increasing concern regarding personal privacy and information security. Currently, many people have doubts about the data security protection capabilities. During the communication with digital humans, digital humans will obtain users' personal information, voice data, preferences, and even some biological features, etc. During the storage, transmission, and application processes, there is a possibility of being leaked, abused, and illegally traded, which greatly reduces people's willingness to use related technologies.

4.3. Impact: Lack of Employment Security, Emotional Guidance and Social Psychological Counseling

The public has dual concerns regarding the application of digital humans - namely, job replacement and emotional alienation. Nearly half of the respondents are worried that the widespread use of digital humans will exacerbate the unemployment problem, with risks concentrated in repetitive labor positions such as customer service, shopping assistants, and basic assistants, especially in fields that have already adopted AI and digital human-assisted

applications.The risk of alienation at the emotional level beyond this also attracts attention. With the rapid development of digital human application, there is basically no necessary social psychological counseling.The research found that nearly 70% of the respondents expressed varying degrees of concern about the potential emotional impacts that digital humans might have.The long-term use of companion-type and emotionally interactive digital humans may cause users to gradually become overly dependent on virtual relationships, resulting in a weakening of their willingness and ability to engage in real-life interpersonal interactions. This, in turn, can deepen feelings of loneliness and reduce social skills, potentially impacting emotional connections in the real world[4].However, with the rapid development of digital human applications, there is basically no necessary social psychological counseling.

4.4. Legal Supervision: Deficiency of Rights and Interests Definition, Classified Supervision and Legislative Adaptation

The main problem in the industry is the lagging of laws and regulations. Digital humans have various attributes such as identity, property, and personality. The rights holders and objects are complex. However, the relevant legal systems in our country have not made clear provisions on this matter. There are also no corresponding regulations regarding infringement of rights and how to assume responsibility.However, due to the different application fields, there is no unified classification and regulatory approach for digital humans. At present, there is also no good connection in terms of ethical and moral requirements, technical standards, and legal regulations. Moreover, the law itself also has certain lagging characteristics.Due to the current imperfect legal provisions in our country, there are no clear and specific regulations. As a result, it is difficult to make fair and reasonable judgments in judicial practice. What is more serious is that because of the rapid development of digital human technology, new application scenarios, ethical issues, and infringement forms have emerged, causing the legal regulations to lag behind the development needs of the industry. The disconnection between law and reality has brought greater challenges to the protection of rights and the governance of the industry.

5. Countermeasures and Suggestions

5.1.Rationally Recognize Technical Ethics and Establish the Concept of Technical Ethics

Digital humans are an emerging industry that has emerged as a result of the development of artificial intelligence. It requires the public to possess the necessary digital literacy and AI discrimination skills, so that they can make independent judgments in daily use and neither blindly rely on nor one-sidedly deny digital human technology.In the face of new issues such as career changes and emotional interactions brought about by technology, we should view them from a developmental perspective and actively adapt to the lifestyles and working methods of the digital age. Rationally understand the working characteristics of digital humans, resist false information, be vigilant against rumors and hype about AI and digital humans on the internet, actively identify the sources of information, and not spread unverified negative remarks. While enjoying the convenience of technology, we should consciously abide by network norms, establish correct technical ethics concepts, use technology reasonably and express ourselves

rationally, jointly create an objective, inclusive and positive public opinion environment. At the same time, with an inclusive attitude, we should witness the technological iteration, and take practical actions to eliminate the adverse effects on public opinion, laying a good social foundation for the healthy and orderly development of the digital human industry (Research Group of the Political and Legal Affairs Commission of the CPC Shenzhen Municipal Committee, 2025).

5.2. Clarify the Responsibilities of Society and Enterprises, and Jointly Build an Ethical and Moral System

As the main body for the research and application of current digital technologies, enterprises must prioritize the establishment of an ethical and moral framework as a common defense line. Therefore, it is necessary to enhance data verification capabilities and introduce cross-information and verification mechanisms to ensure the accuracy and authenticity of the output content. Moreover, information generated by AI should be forcibly labeled with the source and thinking chain, so as to serve as a verification prompt in sensitive fields such as finance and healthcare, thereby avoiding the risk of "artificial intelligence illusion". In addition, enterprises should continuously establish automated and risk warning mechanisms, attach importance to the timely correction of algorithmic deviations and other issues within the enterprise, and conduct large-scale tests before the launch of enterprise technical algorithms to ensure the quality of information. At the same time, enterprises should jointly build industry-related standards, unify industry security standards, and consolidate the dual foundations of technology and ethics.

The corresponding society should also establish a diversified joint supervision mechanism to create a rational and favorable environment. The public should view new technologies without discrimination and accept the arrival of the digital age with an open mind. They should objectively assess the impact of new technologies on employment and emotional communication, and refrain from making sweeping condemnations. The society should have positive publicity to resist false information and create a favorable public opinion environment. In addition, a collaborative governance mechanism integrating social supervision, industry self-discipline, and public participation can guide all parties in society to participate, adopt an open and inclusive attitude to accompany technological iteration, cooperate with enterprises, and jointly promote the healthy, orderly and sustainable development of digital person technology.

5.3. Strengthen Government Supervision and Promote the Resolution of Moral Bottom Line Anxiety

The public's concerns about digital humans are essentially a projection of their anxiety regarding digital ethics, encompassing not only ethical and privacy issues but also other real-world concerns. More importantly, there are also deep concerns regarding job replacement and emotional alienation. Additionally, it is necessary to consider how to accelerate the establishment of regulatory standards and ethical norms for the digital person industry, clearly define the boundaries of technology application, data security requirements, and responsibility division, and implement specialized supervision in key areas such as finance, healthcare, and education. This

indicates that a sound mechanism for content review and risk warning is extremely necessary. Implementing mandatory requirements such as source annotation and verification for AI-generated information can effectively prevent potential risks brought about by AI illusions. Therefore, the government needs to promote full-process supervision while encouraging technological innovation. To achieve this, the government should not only stimulate technological innovation but also implement the entire chain supervision, improve the cross-departmental collaborative governance system, and increase the punishment for data leakage and infringement abuse. By using institutional constraints and continuous supervision, a safe and regulated environment can be created for the development of digital humans. To address public concerns, it is necessary to collaborate with industry associations to promote the popularization of digital person ethics and safety knowledge. Targeted publicity should be conducted for different groups to enhance the overall digital literacy of the public, which is also crucial. Through various forms such as short videos and public service advertisements, technical norms can be explained in a more accessible way. This helps to reduce misunderstandings caused by information asymmetry. To foster a rational and inclusive social cognitive environment, it ultimately requires the long-term joint efforts of multiple parties.

5.4. Improve Laws and Regulations and Establish a Multi Party Co Management Mechanism

According to the preliminary investigation, it is known that the current respondents generally believe that there is a need for unified and comprehensive laws and regulations to regulate the morality, application scope, and rights-related aspects of digital humans. Therefore, it is necessary to classify and legislate for the different application scenarios of AI and digital humans, clarify the responsibilities and authorities, and promulgate relevant legal provisions. The government should take the lead, and all major enterprises should respond positively (Wang et al., 2025). Classify and regulate digital human services in fields such as finance, healthcare, and law, and clearly ensure the security of user data and the accuracy of products. Relax the regulation on digital humans in fields such as culture, tourism, and IP promotion, so as to provide them with development space. At the same time, it is necessary to strengthen supervision over related contents such as portrait rights and copyrights (Zhao, 2025). Multi-party supervision is implemented, with the government departments, enterprises and users mutually supervising each other to ensure that digital humans continue to be used according to their original functions. In addition, in the implementation and supervision of laws and regulations, a multi-party supervision mechanism should be established. Through government supervision, enterprise self-discipline and user supervision, the boundaries of each party's rights and responsibilities should be clarified to achieve a regulatory closed loop. The government departments should undertake the responsibilities of legislation, law enforcement and supervision. Enterprises should fulfill their main responsibilities and compliance obligations. Users should have the channels of supervision, reporting and rights protection. The three parties should collaborate to form a united force to ensure that the digital human technology always operates within the framework of the law, and to lay a solid legal foundation for the long-term healthy development of the industry.

6. Conclusion

Driven by technology, digital humans are rapidly integrating into all aspects of social life. They are becoming a new driving force for the growth of the digital economy and are supporting all social developments in various application scenarios. With the rapid development of related industries, various potential risks have emerged, and various discussions have also involved ethical conflicts, data application security issues, and widespread concerns from the public, etc., which have greatly hindered the long-term healthy development of the digital person industry. Among these risks, the most prominent one is the risk of data privacy security. From the research, production to implementation of digital persons, a large amount of personal information data needs to be collected and processed. If the data is leaked or used illegally, it is very likely to cause irreparable harm to users. The feedback from the questionnaire shows that we can indeed see that the public is deeply concerned about this.

Meanwhile, service-oriented and assistant-type digital humans, due to their efficiency and low cost, are likely to replace real-world jobs (in some service industries) and some administrative positions. The change in existing employment types has caused social employment anxiety. The companion-type digital beings may also lead to emotional alienation. If users become overly dependent on companion-type digital beings, it will cause them to gradually lose their social skills in real-life situations, leading to a detachment from real-life interpersonal relationships. There is another major problem with the current state of the digital being industry: the related supporting systems and supporting frameworks are not yet complete. Relevant policies lag behind the development of technology, the criteria for identifying infringement are not clear enough, and there are many gaps in supervision. The emergence of these problems will inevitably affect the legitimate rights and interests of the majority of users, trigger a social trust crisis, and are not conducive to the development of the digital being industry. In response to the above discoveries about digital beings, it is necessary to form a multi-party joint and coordinated governance, accelerate the formation of a complete ethical governance system, speed up the unified formulation of reasonable global ethical rules, and conduct normative constraints on all stages of the development and application of digital beings, ensuring their innovation, always maintaining safety and compliance, and laying a foundation for the healthy and stable development of digital beings.

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