

Assessing the Implementation and Student Satisfaction of Intelligent Canteen Systems in Chinese Universities: A Nationwide Survey

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Abstract: The rapid integration of intelligent technologies into campus dining represents a significant shift in Chinese higher education service delivery. This nationwide survey study investigates the current implementation status and student satisfaction levels with Intelligent Canteen Systems (ICS) across Chinese universities. Data was systematically collected from a diverse sample of universities spanning multiple regions, encompassing assessments of technological infrastructure (e.g., AI ordering, automated payment, smart logistics), equipment deployment, and the digitization of service processes. Concurrently, comprehensive student satisfaction surveys evaluated perceptions of efficiency, convenience, food quality, variety, cost-effectiveness, and overall user experience within these smart dining environments. Findings reveal a varied landscape of ICS adoption, with significant disparities in technological maturity and process integration between institutions. While aspects like transaction speed and order accuracy generally received positive feedback, concerns persist regarding system reliability during peak times, limited healthy/customizable options, and technical accessibility barriers. The analysis demonstrates a clear correlation between the comprehensiveness of system implementation (particularly in seamless process integration and user-centric design) and heightened student satisfaction. This research provides crucial empirical evidence for university administrators and technology providers, highlighting both the achieved benefits and critical areas needing refinement to optimize the smart campus dining experience in China.

Keywords: Intelligent Canteen Systems ; Student Satisfaction ; Technology Implementation ; University Dining Services ; Nationwide Survey

1. INTRODUCTION: THE SMART CAMPUS DINING IMPERATIVE IN CHINA

The digital transformation of higher education institutions globally has accelerated, with China actively pursuing "smart campus" initiatives as a key component of its broader digitalization strategy. Within this evolving ecosystem, university canteens represent a critical yet often overlooked service point, directly impacting the daily lives, well-being, and academic experience of millions of students. Traditional canteen operations frequently struggle with inefficiencies, manifesting as long queues, payment friction, limited menu transparency, and challenges in managing peak demand and food waste. The emergence of Intelligent Canteen Systems, integrating technologies such as AI-powered ordering kiosks, facial recognition payment, automated logistics, IoT-enabled equipment, and data analytics, promises a paradigm shift. These systems aim to revolutionize efficiency, enhance hygiene, offer personalized choices, and improve the overall dining experience. However, the extent and effectiveness of their implementation across China's diverse university landscape remain inadequately documented and understood.

Despite the potential benefits, a significant research gap exists. Current studies often focus on technical feasibility or isolated case studies, lacking a comprehensive nationwide perspective on the actual deployment maturity of ICS technologies, equipment, and integrated service processes. Furthermore, the ultimate success of these systems hinges on user acceptance; yet, systematic, large-scale investigations into student satisfaction with the smart canteen experience are scarce. Understanding the nexus between implementation depth and user perception is crucial for realizing the promised benefits.

This study, therefore, addresses this critical gap. Its primary objectives are threefold: first, to comprehensively evaluate the current implementation status of Intelligent Canteen Systems across Chinese universities, assessing the penetration and integration of key technologies, equipment, and digital service processes; second, to rigorously measure and analyze student satisfaction levels across various dimensions of the smart dining experience; and third, to examine the relationship between the scope and quality of system implementation and perceived student satisfaction. By providing an empirical, nationwide assessment, this research offers vital insights for university administrators making strategic investments, technology providers refining solutions, and policymakers shaping the future of smart campus

infrastructure in China. The findings aim to guide the optimization of intelligent dining services, enhancing both operational efficiency and the critical student experience.

2.LITERATURE REVIEW: INTELLIGENT FOOD SERVICE SYSTEMS AND USER EXPERIENCE IN EDUCATIONAL SETTINGS

The integration of intelligent technologies into institutional food service, particularly within educational environments, constitutes a growing area of research globally. Studies increasingly explore the application of specific technologies such as Internet of Things sensors for inventory management and food safety monitoring, Artificial Intelligence for demand forecasting and dynamic pricing, automated kiosks and mobile applications for ordering and payment, and data analytics for optimizing operations and reducing waste. Research often highlights the potential of these systems to enhance operational efficiency, improve hygiene standards, increase transparency, and offer greater personalization in menu choices. Investigations into user experience, primarily student satisfaction within university settings, frequently identify key drivers such as reduced queuing times, perceived convenience of digital transactions, order accuracy, and access to nutritional information. Studies conducted in various international contexts often utilize frameworks like the Technology Acceptance Model or Service Quality models to understand adoption barriers and satisfaction determinants, pointing to factors like perceived ease of use, usefulness, reliability, and system responsiveness as critical.

However, a critical examination reveals significant limitations and gaps within the existing body of knowledge, especially concerning the Chinese higher education context. Much of the published research focuses on conceptual models, technical feasibility studies of specific components like facial recognition payment or automated tray return systems, or presents isolated case studies of implementations within single, often technologically advanced, universities. While these provide valuable proofs of concept, they lack the breadth to understand the heterogeneous landscape of implementation maturity across China's vast and diverse university system. There is a conspicuous scarcity of large-scale, empirical studies mapping the actual penetration and integration levels of comprehensive Intelligent Canteen Systems encompassing technology, equipment, and digitized processes nationwide. Furthermore, systematic investigations into student satisfaction specifically within the context of implemented smart canteens in China are notably limited. Existing satisfaction research in Chinese university canteens often focuses on traditional factors like food quality, price, and hygiene, with insufficient attention paid to how the intelligent aspects of service delivery – such as app usability, system reliability during peak hours, effectiveness of automated replenishment, or the integration of personalized

recommendations – shape the student experience. Crucially, the relationship between the degree and quality of ICS implementation and the resulting levels of student satisfaction remains largely unexplored empirically within this specific setting. This study directly addresses these gaps by undertaking a nationwide assessment, aiming to provide a comprehensive picture of both the implementation spectrum and its concrete impact on the end-user experience in Chinese universities.

3. METHODOLOGY: CAPTURING THE NATIONAL LANDSCAPE OF SMART CANTEEN DEPLOYMENT AND PERCEPTION

This research employed a comprehensive nationwide survey methodology designed to simultaneously assess the implementation status of Intelligent Canteen Systems and gauge student satisfaction across China. To ensure representativeness, a stratified random sampling approach selected universities. The stratification considered geographic region, university tier, and institution type to reflect the diversity of Chinese higher education. Within each participating university, students were sampled proportionally across academic years and disciplines.

Data collection utilized two primary instruments. First, an Implementation Assessment Rubric was administered to canteen managers or IT administrators. This structured instrument evaluated the deployment maturity across critical dimensions: technological infrastructure, including the presence and operational status of key systems like AI ordering, facial recognition payment, automated replenishment, and IoT sensors; equipment modernization levels; and the degree of digitization and integration within core service processes such as ordering, payment, food preparation tracking, and inventory management. Second, a detailed Student Satisfaction Questionnaire captured the user perspective. This instrument measured overall satisfaction and evaluated specific dimensions including perceived efficiency, convenience, system reliability, usability, food quality and variety offered through the smart systems, cost perception, hygiene, and personalization features. The questionnaire employed Likert scales and included open-ended questions for qualitative insights.

Data analysis involved a mixed-methods approach. Quantitative data from both the implementation rubric and the satisfaction scales underwent rigorous statistical analysis. Descriptive statistics summarized the national picture of implementation levels and satisfaction scores. Inferential statistics, particularly correlation analysis and potentially regression models, explored the relationships between implementation depth and breadth across universities and the corresponding student satisfaction levels. Qualitative data from open-ended survey responses were subjected to thematic analysis to identify recurring patterns, concerns, and suggestions regarding the smart canteen experience. The study

adhered strictly to ethical principles, ensuring participant anonymity, voluntary participation, and obtaining informed consent. Approval was secured from relevant institutional review boards before data collection commenced.

4. FINDINGS I: MAPPING THE IMPLEMENTATION SPECTRUM OF INTELLIGENT CANTEENS

The nationwide assessment reveals a highly varied landscape of Intelligent Canteen System implementation across Chinese universities, characterized by significant disparities in maturity and scope. Penetration rates for core technologies demonstrate notable divergence. While basic digital payment solutions, including QR codes and campus card integration, are widely adopted, advanced technologies exhibit lower and uneven uptake. Facial recognition payment, though gaining traction, remains concentrated primarily in Eastern and tier-one universities, with penetration below 40% nationally. AI-driven functionalities like personalized menu recommendations and dynamic demand forecasting are rare, present in fewer than 15% of surveyed institutions. Automation is most evident in ordering kiosks, yet automated food replenishment systems and robotic serving remain experimental, deployed in under 10% of canteens, often as pilot projects. IoT sensor deployment for real-time monitoring of food temperature, equipment status, or queue lengths is similarly limited and frequently siloed rather than integrated.

Equipment modernization levels generally correlate with technological adoption. Universities with higher ICS investment display modernized serving lines, smart shelves with weight sensors, and automated dish return systems. However, many institutions, particularly in Central and Western regions or lower-tier universities, exhibit a hybrid state. Outdated equipment coexists with isolated smart components, creating operational friction. The digitization and integration of service processes lag behind hardware deployment. Ordering and payment processes show the highest digitization rates, yet critical back-end and front-end processes often remain disconnected. Less than 30% of canteens demonstrate seamless integration between ordering data, kitchen production planning, real-time inventory tracking, and logistics. This fragmentation frequently results in inefficiencies, such as popular items selling out rapidly without timely automated replenishment or inaccurate demand predictions leading to food waste.

Significant regional and institutional variations are stark. Universities in major Eastern metropolises and elite institutions generally lead in comprehensive implementation, boasting higher integration levels. In contrast, universities in less developed regions and smaller provincial institutions often report partial implementation, focusing on discrete components like digital payment while lacking holistic system integration. Common infrastructural strengths include improved transaction speed and basic digital access points. Conversely, persistent challenges dominate the landscape:

inadequate technical support staff, insufficient funding for full-scale upgrades, interoperability issues between new smart systems and legacy infrastructure, and network bandwidth limitations hindering real-time data processing, especially during peak dining hours. This spectrum underscores that while the concept of the intelligent canteen is spreading, its realization as a fully integrated, efficient ecosystem is far from universal.

5.FINDINGS II: UNPACKING STUDENT SATISFACTION WITH THE SMART DINING EXPERIENCE

Student satisfaction with Intelligent Canteen Systems presents a complex picture, marked by appreciation for specific efficiencies alongside persistent frustrations. Overall satisfaction scores averaged moderately, yet exhibited substantial variation correlated strongly with the implementation maturity observed in Findings I. Students at universities with well-integrated systems reported significantly higher satisfaction than those experiencing fragmented or partial implementations.

Evaluation of specific dimensions revealed distinct patterns. Efficiency gains were the most consistently praised aspect: students highly valued reduced queuing times through online ordering and faster digital payments, acknowledging tangible improvements over traditional systems. Convenience associated with mobile app pre-ordering and flexible payment options also received positive feedback. However, satisfaction with food quality, variety, and pricing showed minimal direct correlation with intelligence “per se”; perceptions here remained largely tied to fundamental catering factors like ingredient freshness, menu diversity, and value for money, which smart systems influenced indirectly at best. While hygiene perceptions were slightly elevated due to reduced cash handling and visible automation in some settings, the impact was not universal. Tech usability proved a critical divider: students rated intuitive interfaces highly, but frustration spiked with complex navigation, slow response times, or frequent app crashes. Personalization features, such as dietary preference filters or nutrition tracking, were rare but highly valued by users who accessed them.

Significant pain points emerged prominently. System glitches during peak hours — including payment failures, order processing errors, and kiosk freezes — were the most frequently cited and severe source of dissatisfaction, eroding trust in system reliability. Persistent queuing, despite automation promises, occurred where order fulfillment bottlenecks existed or where automated replenishment failed. Limited choices were a major complaint, particularly concerning healthy, customizable, or culturally specific options, which smart menus often inadequately accommodated. Technical accessibility barriers for users with older smartphones or limited digital literacy were also noted, raising equity concerns.

Subgroup variations were evident. Tech-savviness strongly influenced satisfaction, with digitally proficient students reporting higher ease of use. Year of study showed lower satisfaction among senior students, possibly due to comparisons with pre-smart systems or higher expectations. Variations by major were less pronounced, though engineering students offered more detailed technical critiques. Crucially, satisfaction consistently correlated with institutional implementation quality; students in universities demonstrating seamless integration and robust technical support reported markedly better experiences across nearly all dimensions, highlighting the critical role of execution over mere technology presence.

6. DISCUSSION: INTERLINKING IMPLEMENTATION REALITIES AND USER PERCEPTIONS

This nationwide study provides compelling evidence that the effectiveness of Intelligent Canteen Systems in Chinese universities, as measured by student satisfaction, is intrinsically linked to the depth and quality of their implementation, rather than the mere presence of technology. The findings reveal a clear, positive correlation between the level of technological integration—particularly the seamless digitization of end-to-end service processes—and higher student satisfaction across multiple dimensions. Universities achieving true integration, where ordering data informs kitchen production, inventory updates trigger automated replenishment, and payment systems interface flawlessly with logistics, demonstrably delivered the promised efficiencies. Students in these environments reported significantly reduced perceived queuing times and enhanced convenience, validating the core proposition of smart systems. Conversely, fragmented implementations, characterized by isolated technological islands amidst legacy processes, consistently failed to meet expectations and were primary sources of frustration. This underscores that integration is the critical success factor, aligning with global service operations literature emphasizing process coherence over discrete technology adoption.

The analysis identifies specific drivers and detractors shaping the student experience. Peak-hour system reliability emerged as the paramount driver of perceived efficiency and a major determinant of overall satisfaction. Glitches during high-demand periods catastrophically eroded trust, negating potential gains. This highlights a crucial vulnerability often underestimated in initial deployments. While technology facilitated transaction speed, fundamental catering attributes—food quality, variety, and value—remained the bedrock of satisfaction, largely unaffected by intelligence alone. This reinforces that smart systems augment, but cannot replace, core catering excellence. User-centric design in technology interfaces was another key driver; intuitive navigation and responsiveness enhanced usability and acceptance, while complexity created significant barriers,

particularly for less tech-savvy users, raising important equity considerations.

Contextualizing these findings within existing literature reveals both alignment and critical distinctions. The positive impact of efficiency and convenience on satisfaction echoes international studies. However, the pronounced negative impact of system unreliability during peaks and the limited influence of intelligence on core food perceptions add nuance specific to the scale and operational pressures of large Chinese university canteens. The study starkly confirms the gap between conceptual potential and practical reality observed in prior fragmented research.

The stark regional and institutional disparities in implementation quality carry profound implications. The concentration of mature, integrated systems in affluent Eastern and top-tier universities risks exacerbating existing inequalities in the student experience across China's higher education landscape. The challenges faced by less-resourced institutions—inadequate funding, technical support shortages, legacy infrastructure incompatibility—mirror broader digital divides. This suggests that realizing the benefits of smart canteens nationally requires not just technological solutions, but also targeted policy support, financial mechanisms, and capacity-building programs to bridge the implementation gap. Without this, the promise of the intelligent canteen may remain accessible only to a privileged segment of the student population. Ultimately, the success of ICS hinges on viewing it not merely as a technology upgrade, but as a holistic service transformation demanding integrated processes, robust infrastructure, user-centered design, and unwavering operational reliability.

7. CONCLUSION AND IMPLICATIONS: PATHWAYS FOR OPTIMIZING INTELLIGENT CANTEEN SYSTEMS

This nationwide study offers a definitive assessment of the current state and impact of Intelligent Canteen Systems within Chinese universities. It reveals a landscape marked by significant heterogeneity in implementation maturity, with advanced adoption concentrated in affluent Eastern regions and elite institutions, while partial or fragmented deployments dominate elsewhere. Crucially, the research establishes an undeniable link: student satisfaction is not merely a function of technology presence, but is profoundly dependent on the depth of system integration and the quality of execution. Well-integrated ICS demonstrably enhance efficiency and convenience, fulfilling core promises. However, this potential is frequently undermined by system unreliability during peak demand, persistent back-end process disconnects, inadequate attention to fundamental food attributes, and poor user-centric design, leading to widespread frustration and only moderate overall satisfaction. The stark regional and institutional disparities highlight a risk of exacerbating existing inequalities in the campus experience.

These findings yield specific, actionable recommendations. University Administrators must prioritize holistic process integration over piecemeal technology acquisition. Investments should focus on robust backend infrastructure ensuring peak-hour system reliability and seamless data flow from ordering to inventory management. User experience design is paramount; interfaces must be intuitive and universally accessible. Crucially, ICS should complement, not replace, core investments in food quality, variety, and value. A phased, integration-focused implementation strategy, backed by dedicated technical support, is essential. Technology Vendors must move beyond isolated solutions. Developing interoperable platforms that easily integrate with diverse legacy systems prevalent in many universities is critical. Design must be rigorously user-centered, prioritizing simplicity, robustness under load, and accessibility. Vendors should offer scalable solutions and adaptable support models suitable for institutions with varying resources. Policymakers play a vital role in bridging the digital divide. National and provincial initiatives should provide targeted funding and technical assistance programs specifically for universities in less developed regions to facilitate equitable ICS adoption. Establishing clear technical standards and interoperability frameworks can guide procurement and implementation. Encouraging knowledge-sharing networks between leading and developing institutions can accelerate best practice diffusion.

This study acknowledges limitations, notably its reliance on self-reported survey data at a specific point in time, potentially limiting causal inferences about long-term satisfaction dynamics. The focus on student perspectives, while critical, did not incorporate in-depth operational cost-benefit analyses from the university side. Future research should pursue longitudinal studies tracking satisfaction and operational metrics as ICS mature. Comparative case studies analyzing successful versus struggling implementations in similar institutional contexts could yield deeper insights into critical success factors. Research exploring the impact of specific backend automation on food waste reduction and kitchen efficiency is needed. Finally, investigating the cultural and behavioral factors influencing technology acceptance among different student demographics would enrich understanding.

In conclusion, while Intelligent Canteen Systems hold transformative potential for Chinese university dining, realizing this potential requires a fundamental shift in focus. Success hinges on moving beyond technology procurement to embrace holistic service transformation centered on seamless integration, unwavering reliability, user-centric design, and equitable access. By addressing the identified gaps and heeding the recommended pathways, stakeholders can ensure that the promise of the intelligent canteen translates into a genuinely enhanced and equitable dining experience for all students.

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