AI-Powered Institution-Specific Virtual Personas: A Conceptual Framework for Proactive Student Services in Higher Education

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Abstract: Recent surveys indicate that over 80% of universities report inefficiencies in student services, including delayed responses and resource misallocation (EDUCAUSE, 2023; OECD, 2022). While large language models (LLMs) offer transformative potential, existing implementations frequently lack institution-specific adaptation and systemic integration. This study proposes a conceptual framework for LLM-driven institution-specific virtual personas to shift student services from passive response to proactive support. Integrating Service-Dominant Logic and learning analytics, the framework features: (1) dual-functional agents for transactional support and learning development; (2) dynamic profiling via multi-source data fusion; (3) cross-cultural adaptation mechanisms. Validated through Beijing International Studies University's implementation of "Tangxin Q&A" and "Haitang Youth", the framework enhances service efficiency while redefining student-centered service paradigms—highlighting critical avenues for affective computing, scalability, and ethical governance.

1. Introduction

The accelerated digital transformation of global higher education presents new opportunities and challenges for student services. Recent surveys indicate that over 80% of universities report inefficiencies in student services, including delayed responses and resource misallocation.These gaps directly impact student retention and satisfaction metrics[1].These manifest specifically as response delays, resource misallocation, and poor service experiences, which directly impact student achievement and campus satisfaction.

Concurrently, breakthroughs in artificial intelligence, particularly in large language models (LLMs), offer a new technological pathway for innovating higher education services. Existing research indicates that LLM-based virtual agent systems can improve service response times and enhance user experience[2]. However, most current studies focus on generic educational scenarios, lacking systematic design tailored to the specific needs of individual institutions. Specifically, current virtual agent systems suffer from two main limitations: first, their functional design is often confined to one-way information delivery, failing to achieve closed-loop management of service

processes; second, constrained by cross-platform data silos, the precision of services is difficult to guarantee.

This study therefore addresses the core question: How can we construct an institution-specific virtual persona framework, driven by large language models and integrating multi-source data, to realize a paradigm shift in student services from passive response to proactive support? Addressing this question holds practical significance for enhancing service effectiveness and student satisfaction in higher education institutions.

This study aims to develop a conceptual framework to achieve the following objectives: design a virtual persona architecture with dual functional modalities, accommodating both transactional processing and learning development support; establish a dynamic student profiling mechanism to drive the precision and contextualization of service delivery; and propose a culturally unbiased design and localization adaptation scheme to ensure the framework's potential for cross-institutional transferability.

2. Literature Review and Theoretical Foundations

2.1. Application of AI Virtual Agents in Higher Education

Current research indicates that applications of virtual agents in education primarily concentrate on three areas. In transactional support, Georgia Tech's "Jill Watson" system, leveraging a large language model for handling course inquiries, has demonstrated high accuracy and effectively reduced instructor workload[3]. In learning development, MIT's "Milo" agent utilizes affective computing to provide students with learning strategy suggestions, with empirical studies indicating its positive effect on boosting classroom engagement. Regarding technical integration challenges, Wise et al. [4] identify cross-system data compatibility and user acceptance as the main bottlenecks in current virtual agent applications. Despite these advancements, significant limitations persist in existing research. Firstly, most studies focus on single functional modules, lacking a coordinated design that integrates both transactional and developmental dimensions, resulting in fragmented services. Secondly, there is insufficient research on institution-specific adaptation mechanisms, making existing solutions difficult to transfer to universities in different cultural contexts. These limitations constrain the deeper application of AI virtual agents in the student services domain.

2.2. Theoretical Underpinnings of the Conceptual Framework

The theoretical foundation of this study stems primarily from Service-Dominant Logic[5], which positions students as value co-creators and fundamentally calls for a bidirectional, systemic approach to service design. SDL provides the theoretical basis for shifting from transactional interactions to bidirectional value co-creation. Learning analytics[6], conversely, enables the anticipation of student needs through multi-source data modeling, shifting service provision from experience-driven to data-driven. This technology can integrate student behavioral, academic, and psychological data to form a holistic student profile, providing the basis for service precision. The combination of Service-Dominant Logic and learning analytics collectively forms the theoretical basis for the conceptual framework in this study.

3. Conceptual Framework Design for the Institution-Specific Virtual Persona

Addressing the issues of functional fragmentation and inadequate institution-specific adaptation highlighted in prior literature, this study draws on Service-Dominant Logic (SDL), which positions students as value co-creators and fundamentally calls for a bidirectional, systemic approach to

service design. At the same time, the integration of learning analytics offers both the data infrastructure and methodological basis for addressing institution-specific personalized needs.

3.1. Core Concept of the Framework

The proposed conceptual framework for the institution-specific virtual persona follows a "Data–Persona–Ecosystem" triadic design logic. At the Data Layer, it integrates multi-source platform data—such as that from academic affairs, student affairs, and the library—to construct a dynamically updated student profile. At the Persona Layer, it deploys a virtual agent with two functional modalities: Transactional Support and Learning Development—enabling functional complementarity and data interoperability. At the Ecosystem Layer, it establishes an end-to-end student support network through context-sensitive service matrices and cross-platform integration.

3.2. Core Component Design

3.2.1 Dual-Functional Modality Virtual Agent Architecture

Building on existing practices in intelligent Q&A systems, this framework decomposes the virtual persona into two distinct functional components: the Transactional Support Agent and the Learning Development Agent.

The Transactional Support Agent primarily manages basic services—including round-the-clock information inquiries, resource navigation, and application submissions—using natural language interaction technologies to improve administrative efficiency. Technically, the system integrates a large language model (LLM), leveraging LLM reasoning for complex queries via semantic integration with institutional knowledge bases. Its innovative design features a dynamic greeting mechanism triggered by temporal markers (e.g., semester cycles, traditional holidays) and a service scenario tagging library, enabling context-aware, targeted service delivery. For example, it automatically delivers course selection guides at the beginning of the semester and recommends exam review resources during final examination periods. The Learning Development Agent focuses on higher-order needs like academic planning, mental well-being, and career development, providing personalized learning resources and growth guidance. Technically, the system develops multimodal interaction interfaces and generates personalized development pathways combined with behavioral data analysis. Its key innovation lies in establishing a closed-loop "Resource–Activity–Portfolio" system that encourages student engagement through an incentive points mechanism and records behavioral trajectories to produce dynamic competency assessments. For example, when a student seeks advice on career planning, the system automatically correlates their academic history, extracurricular experiences, and internship records to generate tailored career development recommendations.

These two agent types follow the design principle of data interoperability with functional decoupling: while sharing core student profile data, they differ in service contexts and interaction modalities, thereby forming a complementary service ecosystem.

3.2.2 Dynamic Student Profiling Drive Mechanism

To address the limitations of traditional static profiles, this framework introduces a three-tier dynamic modeling mechanism. Primary Dimensions encompass core domains such as academic performance, mental well-being, career readiness, and intercultural competence. Secondary Indicators are automatically derived from multi-source data—including grades, activity participation, and advising records. The Decision Engine uses machine learning algorithms to correlate changes in these indicators with potential service needs, enabling anticipatory

identification and proactive service initiation. This mechanism aims to transform service delivery from "passive response" to "proactive anticipation." For example, if the system detects a significant decline in a student's class attendance alongside reduced advising interactions, it can automatically deliver academic support resources and counseling recommendations, thereby improving service timeliness and targeting accuracy.

3.2.3 Institution-Specific Adaptation and Cross-Cultural Compatibility Scheme

To ensure broad applicability, the framework incorporates a dual-track adaptation mechanism. For Technical Adaptation, an institutional data platform is built using standardized protocols (e.g., Ed-Fi) to resolve cross-system data compatibility challenges and enable seamless integration with existing systems such as academic and student affairs management platforms. For Cultural Adaptation, the virtual persona features a culturally neutral appearance—avoiding culturally specific symbols—and supports multilingual switching and localized content repositories. Additionally, a content moderation algorithm based on sentiment analysis filters inappropriate expressions, ensuring that conversational outputs align with the target cultural context.

3.3. Framework Implementation Pathway

The framework will be implemented in three sequential phases. The Foundation-Building Phase involves deploying the Transactional Support Agent to manage high-frequency queries, while simultaneously establishing the institution-specific knowledge base and conducting system stress testing. The Functional Deepening Phase integrates the Learning Development Agent, develops a library of learning scenario resources, and initiates dynamic student profiling. The Ecological Expansion Phase fosters integration between online services and offline campus activities as well as digital communities, creating a cohesive online-offline service ecosystem.

4. Case Study: Practical Implementation of the Conceptual Framework at Beijing International Studies University

The practice at Beijing International Studies University (BISU) offers a representative validation context for the proposed conceptual framework. In 2024, BISU launched Tangxin Q&A—a smart education system (Version 1.0)—whose core design principles closely align with those of this study. By integrating a Chinese-language large language model (LLM), the system has built a knowledge base containing over 7,500 frequently asked questions from students and faculty. It delivers 24/7 natural language-based support across three key domains: student affairs consultation, emotional companionship, and personal development guidance. Building on this foundation, the university further advanced the systematic development of Haitang Youth, an institutional AI avatar, demonstrating a deep integration of artificial intelligence into localized educational contexts.

4.1. Functional Modality Development

The evolution of Tangxin Q&A exemplifies the dual-functional agent architecture. Powered by the DeepSeek-V1 LLM, the system enables multi-dimensional reasoning and self-correction for complex queries. A dynamic interaction mechanism between the semantic understanding engine and the institution-specific knowledge base has significantly improved response accuracy in practice. Context-aware services are enhanced through a culturally grounded greeting system based on traditional Chinese solar terms, forming a hybrid service matrix that combines automated push notifications with seamless human handover. Preliminary data show an average response accuracy of approximately 82%, a notable improvement over the initial rule-based engine (~60%), and a

reduction of about 30% in routine administrative workload for faculty (estimated from interviews with 20 instructors). With ongoing algorithmic optimization and knowledge base refinement, the system is projected to reach the target accuracy of 85% in the next phase.

4.2. Data-Driven Profiling Mechanism

The implementation of a smart student profiling model provides a concrete realization of the dynamic student persona framework. BISU has integrated four primary dimensions—Cultural Initiative, Communication Competence, Global Governance Readiness, and Growth Self-Efficacy—along with their secondary indicators, into its digital platform, establishing a comprehensive tracking system for holistic student development. This approach not only innovates process-oriented assessment but also enables data-informed decision-making by mapping longitudinal growth trajectories from enrollment to graduation. Operational data indicate that the system can proactively anticipate student needs. For instance, in career counseling scenarios, it automatically correlates academic records, competition experiences, and internship histories, achieving an effectiveness rate of 78.3% in generating personalized development pathways.

4.3. Ecosystem Construction

The ecosystem layer is fully embodied in the Smart Community initiative. After gaining broad student acceptance, the platform has been upgraded to offer an integrated service chain: information dissemination → online registration → points redemption → growth portfolio. By precisely matching student needs and available resources, and incorporating modules such as orientation programs, mental health courses, and career planning workshops, the system establishes a behavioral incentive mechanism that promotes active engagement. Tracked participation patterns generate dynamic community portfolios, providing empirical support for a multidimensional, ecology-based education and nurturing model.

4.4. Cultural Adaptation and Institutional Identity

The strategic deployment of the Haitang Youth IP illustrates the effectiveness of the institution-specific adaptation scheme. The character has been incorporated into cultural products for major events—including graduation, orientation, and role-model celebrations—and widely disseminated through digital formats such as emoji packs and wallpapers. More importantly, its integration with campus activities and field projects has established a synergistic "Haitang Youth + Tangxin Q&A" AI model, enabling a bidirectional "human–machine–human" communication loop. This operationalizes the "AI + daily education" paradigm in a culturally resonant and institutionally meaningful form.

The BISU case demonstrates that the proposed framework's institution-specific adaptation mechanism is effective. Through the successful integration of Tangxin Q&A (functional carrier) and Haitang Youth (cultural carrier), it validates the feasibility and value of aligning technological solutions with distinctive campus cultures. The case clearly illustrates how each component of the conceptual framework can be implemented and interoperate within a real-world educational setting—confirming both its practical viability and its potential as a replicable model for peer institutions. This progression—from technical integration to ecological construction—reflects a broader transformation in intelligent student services: from instrumental tool use to value-driven co-creation.

5. Discussion

This study addresses the growing misalignment between student service provision and personalized needs in higher education. By proposing an institution-specific virtual persona framework, we seek to bridge the gap between technological empowerment and educational essence. The effectiveness of this framework extends beyond technical integration—it lies fundamentally in its reconfiguration of traditional service paradigms.

At the theoretical level, this work operationalizes Service-Dominant Logic (SDL) within smart education contexts. The dual-modality agent design establishes a bidirectional value co-creation channel between students and the service system. While the Transactional Support Agent ensures efficiency in routine services, the Learning Development Agent focuses on unlocking individual growth potential. This functional division overcomes the limitations of earlier single-purpose virtual agents. Moreover, dynamic student profiling serves not only as a technical mechanism but also as a practical pathway for realizing the "student-centered" ideal—transforming it from principle into actionable practice.

In terms of practical value, the proposed institutional adaptation model allows flexibility for diverse universities to implement context-sensitive solutions. The case of Beijing International Studies University demonstrates that the framework can be meaningfully aligned with an institution's unique educational philosophy and cultural traditions. Through the integration of Tangxin Q&A (functional carrier) and Haitang Youth (cultural carrier), the implementation balances technological capability with humanistic care. This design preserves the generalizability of the technical architecture while respecting institutional distinctiveness—enhancing its scalability across different higher education settings.

The primary contribution of this study is not the invention of novel technologies, but the systematic integration of existing theories and mature tools into a coherent, institutionally grounded conceptual framework. It addresses the critical "last-mile" challenge in translating theory and technology into real-world educational practice. That said, several challenges remain. First, data governance complexity persists—integrating cross-departmental data requires overcoming institutional silos and technical interoperability barriers. Second, ethical concerns arise: while dynamic profiling improves service precision, it also raises questions about data usage boundaries and algorithmic transparency. Third, the role demarcation between virtual agents and human counselors remains ambiguous; optimal human-AI collaboration models require further empirical exploration.

6. Conclusion

Grounded in the context of digital transformation in higher education, this study presents a conceptual framework for an AI-powered, institution-specific virtual persona. By integrating Service-Dominant Logic with learning analytics, we propose a comprehensive design comprising dual-functional agents, dynamic student profiling, and culturally responsive adaptation mechanisms.

The core value of the framework lies in enabling three key shifts: from unidirectional information delivery to bidirectional value co-creation, from experience-driven decisions to data-informed support, and from generic service models to institutionalized personalization. The implementation at Beijing International Studies University provides preliminary validation of its feasibility. The synergistic integration of Tangxin Q&A and Haitang Youth illustrates how technological systems can align with campus culture, creating a sustainable ecosystem that supports holistic student development.

Looking ahead, multiple avenues warrant further investigation. Technologically, advances in multimodal large models will enhance emotional intelligence and contextual awareness, enabling

more natural human-AI interactions. Practically, broader deployment across diverse institutional types is needed to refine adaptability. From a governance perspective, there is an urgent need to establish standards for data privacy, algorithmic ethics, and service quality assurance—ensuring responsible and equitable technology adoption.

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