Article

Research on the Construction and Key Technologies of a Central Platform for Smart Education Resources in Higher Education: A Case Study of the Practical Implementation of an Online Learning Platform at a University

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Abstract: Amid the trend of digital transformation in education, the construction of a central platform for educational resources in higher education has emerged as a key initiative to enhance educational quality and optimize resource allocation. While universities worldwide are actively exploring digital transformation paths tailored to their unique needs, they continue to face challenges such as fragmented educational resources and a lack of synergy. Accordingly, this paper proposes a framework for constructing a central platform for smart education resources in universities. The core objective is to integrate diverse educational resources by establishing a platform system for data aggregation, governance, and sharing through unified standards and interfaces. The construction framework encompasses several layers, including infrastructure, a capability engine layer, an application service layer, an open capability layer, and business systems. It aims to enhance the efficiency of teaching and research, as well as the quality of administrative decision-making, by enabling efficient resource allocation, deep data mining, and leveraging artificial intelligence. This paper also introduces the key technologies in its construction, including: enhancing the platform's cloud-native capabilities, establishing standardized interface specifications, creating an atomic service model for technical capabilities, and comprehensively improving the platform's business responsiveness, capacity for scalable innovation, service quality, and the noteworthy new model of AI-powered content management. Looking ahead, the central platform for educational resources is expected to deepen its integration with emerging AI technologies, further expand the scope of resource sharing, and contribute to building a more open, efficient, and personalized smart education ecosystem, thereby providing a powerful impetus for the high-quality development of higher education.

Keywords: central platform for smart education resources; educational resource sharing; platform construction; artificial intelligence (AI)

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1. Introduction

With the rapid development of digital technologies, significant changes have occurred in school education, as well as in student learning environments and methods. Following extensive practice during the pandemic, the hybrid teaching model, which is based on online instruction and integrated with offline practical activities, is increasingly becoming a common pedagogical approach in higher education institutions [1,2]. In this context, the development of online course materials and the efficient management and application of educational resources have emerged as critical challenges and essential components of smart campus construction for universities. While many institutions have

made beneficial attempts and explorations by building educational resource management platforms, a more advanced approach is required. Deeply integrating technologies such as the mobile internet, cloud computing, big data, and artificial intelligence with the management and application of educational resources to create an intelligent, university-wide central resource platform is a highly promising direction. Such a platform would establish profound connections and integration with classroom teaching, online instruction, and academic administration. Furthermore, its underlying media processing, AI, and tooling capabilities could be leveraged to empower other applications. This represents one of the key viable paths to facilitate the digital and intelligent transformation and upgrading of future education.

2. Research Background

The digital transformation of education has become an inevitable trend in the development of global higher education [3]. Data shows that as of May 2024, the number of MOOCs in China exceeded 76,800, with a cumulative total of 1.277 billion learning instances, demonstrating a vigorous development trend [4]. Numerous domestic universities are actively investing in the construction of online teaching platforms, exploring digital transformation paths that align with their own characteristics. Online teaching platforms in higher education can be broadly categorized by teaching method as follows:

1) Live-streaming instruction platforms, which conduct teaching through real-time broadcasts, simulating traditional classroom scenarios with real-time interaction between instructors and students, such as DingTalk's online classroom and ClassIn.
2) Educational media resource platforms, such as China University MOOC, Chaoxing Erya, and MIT's OpenCourseWare project.
3) Hybrid learning platforms, which combine various teaching methods like live-streaming, pre-recorded lectures, online discussions, assignments, and assessments, significantly enhancing teaching efficiency and student engagement [5].

Peking University launched its "PKU School" online education platform in 2020. Zhejiang University's "Learning at ZJU" platform caters to multiple application scenarios, offers diverse learning activities, supports anytime-anywhere teaching, and features intelligent resource application services and learning trajectory tracking [6]. Tsinghua University has independently developed the smart teaching tool "Rain Classroom" and is actively engaged in building both asynchronous and synchronous online teaching resources [7].

However, universities both domestically and internationally still face numerous challenges in educational resource integration and digital construction. These include fragmented educational resources, where resources are difficult to circulate effectively between different disciplines and departments, and a lack of synergy, where resources in teaching, research, and administration are not fully coordinated, thereby limiting overall efficiency [8-10]. In this context, building a central platform for smart education resources in universities — to integrate various internal resources and enable data aggregation, governance, and sharing — has become a critical task for improving the quality of higher education and advancing its modernization.

3. Concept, Construction Strategy, Content, and Objectives of a Central Platform for Smart Education Resources in Universities

The concept of the "central platform" architecture was inspired by the Finnish gaming company Supercell [11]. Zhang et al. defined a "central platform for omnimedia teaching resources" as an application logic system or architecture driven by media-type resources, which uses digital media processing and intelligent service technologies as its foundational underlying capabilities to support front-end teaching operations [11].

This paper proposes that a central platform for smart education resources in universities is a digital infrastructure platform based on the central platform concept, designed to provide comprehensive, efficient, and intelligent resource services for higher education teaching and learning activities. By integrating various dispersed educational resources within a university and applying advanced information technologies for analysis and mining, it offers intelligent services to faculty and students. The platform aims to support various university operations, including teaching, research, and administration, thereby promoting innovation in educational models and enhancing the quality of education.

Since 2020, a certain university, building upon its existing teaching resource repository, has adopted a "Platform + Resources + Services" triad as its construction strategy. The goal is to achieve resource development, teaching interaction, and resource sharing by creating an internal central platform for smart education resources. Through a holistic approach to the construction of this comprehensive resource platform, the university ensures that it not only provides robust services for resource aggregation and sharing but can also serve as a foundational service platform for all future digital teaching initiatives.

The construction of the central platform for smart education resources involves several key stages: resource collection, transcoding, production, intelligent processing, management, and distribution. The core construction objectives are as follows:

3.1. Build a Digital Educational Resource Platform to Aggregate and Integrate High-Quality Internal Resources

The primary goal is to aggregate and integrate diverse information resources within the university, including those from smart classrooms, regular lecture capture systems, faculty-contributed teaching materials, various event recordings, and external partner resources. This consolidation will establish a university-level digital teaching resource management platform.

The platform can be integrated with regular lecture capture systems, allowing for the selective inclusion of high-quality classroom recordings into the repository. It provides open online tools to assist teachers in editing resources, thereby creating an agile method for resource development and rapidly accumulating a large volume of institution-specific resources.

Through this platform, high-quality internal teaching resources can be digitized, including lectures by renowned professors, academic literature, textbooks, supplementary materials, and courseware. Once digitized, these diverse resources are not only easy to disseminate and use but can also be preserved long-term, becoming strategic assets for the university.

3.2. Promote Open Sharing, Interconnection, and Interoperability of University-Level Digital Teaching Resources

Leveraging the university-level digital resource management platform, a multi-dimensional collaborative mechanism will be established by integrating cross-departmental resources from both inside and outside the university. This will create an open and shared educational ecosystem, enabling the efficient integration and precise delivery of high-quality resources. This system breaks down traditional barriers to resource circulation, forming a sustainable development model of "joint construction, sharing, and common use", which effectively promotes the value transformation and performance enhancement of educational resources.

In terms of resource interoperability, the intelligent educational resource management platform will automatically generate resource tags and support multi-dimensional, intelligent search applications. In resource management, it will achieve interoperability between online and offline teaching resources, as well as among different systems. By building a unified educational resource management platform, centralized storage of

online and offline teaching resources is realized, and resources from all levels of departments and systems are managed uniformly. This fosters a new educational resource ecosystem characterized by interoperability, joint construction, and shared use.

3.3. Empower Related Business Platforms and Extend the Service Scope of Resource Management Capabilities

The platform will integrate the technical engines and business service capabilities of the resource management platform, providing standardized service interfaces to empower various university business platforms. This comprehensively extends the core processing capabilities of digital educational resources, helping to upgrade and re-engineer traditional business processes. By unifying the management of the university's effective network resources, their utilization can be maximized. The construction and organization of digital teaching resources will be based on academic disciplines and majors, enabling joint construction, sharing, and common use of resources across all institutional-level specializations, thus ensuring the continuous accumulation of the university's soft assets. This will establish standards, norms, technologies, tools, and methods for digital teaching resources. A professional resource management system integrated with a unified portal will be established to meet the needs of students' learning, teaching and research activities, faculty professional development, and alumni continuing education.

4. Platform System Architecture

The central platform for educational resources primarily consists of five layers: the Infrastructure Layer, the Capability Engine Layer, the Application Service Layer, the Open Capability Layer, and the Business Systems Layer. The architecture is illustrated in the Figure 1 below.

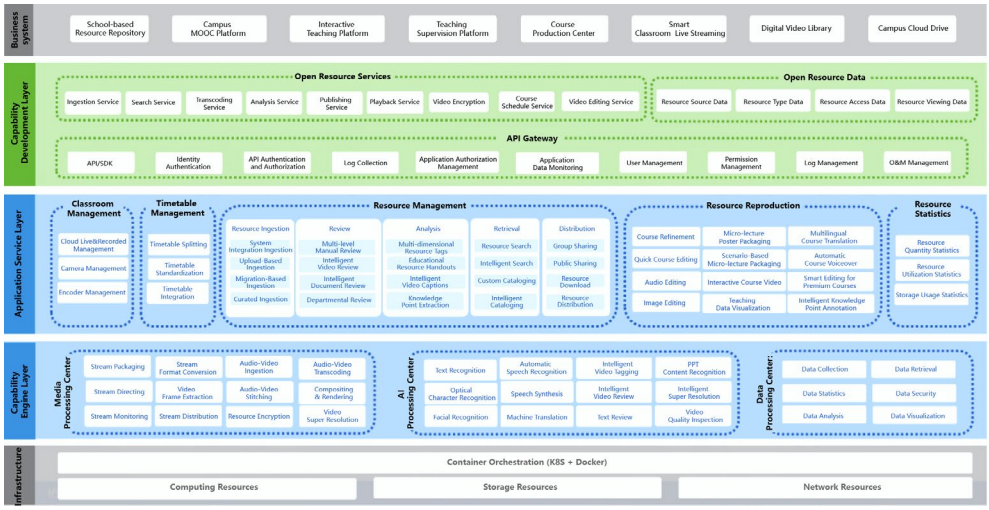

Figure 1. Overall Architecture of the Central Platform for Educational Resources.

The Infrastructure Layer adopts a container orchestration architecture (K8S + Docker) to provide the necessary foundational resources such as computing, storage, and networking for the upper layers. Container orchestration enables unified resource management and, in conjunction with an intelligent O&M system, facilitates the management of the entire infrastructure.

The Capability Engine Layer provides application support components for the upper-level systems. It is divided into centers based on capability, including a Data Processing Center, a Media Processing Center, and an AI Processing Center.

The Application Service Layer implements the backend support for the central platform, covering classroom management, timetable management, resource management,

resource repurposing, and resource statistics. It enables a full-process, end-to-end output of capabilities.

The Open Capability Layer integrates various system interfaces to provide unified and secure output interfaces, achieving "outward-facing capability openness and inward-facing service integration". It offers multi-dimensional support for enterprise operations, system O&M, and external partners.

The Business Systems Layer consists of applications that cater to various scenarios in the education sector. This includes integration with the institution's resource repository, MOOC platform, interactive teaching platform, supervision platform, course production center, regular lecture capture systems, digital media archive, and campus cloud drive.

4.1. Infrastructure Layer

The Infrastructure Layer of the central educational resource platform provides the fundamental resource environment required for the operation of all layers above it, including computing, networking, storage, and security. This layer supports a multi-tenancy management model and offers elastic scaling of basic resources based on the actual load of the upper-level applications. It provides standard virtual computing capabilities for the platform through servers, operating systems, management software, and virtualization software, delivering computational services for structured, semi-structured, and unstructured data. As the foundational service of the central platform, this computing service is the bedrock upon which all upper-level educational applications run.

4.2. Capability Engine Layer

This layer is divided into three centers based on function: the Data Processing Center, the Media Processing Center, and the AI Processing Center.

4.2.1. Data Processing Center

The Data Processing Center aggregates various data generated by upper-level business applications and integrates data from external third-party sources. It standardizes this data according to business logic and provides a continuously scalable data analysis platform. Driven by business needs, it fully mines the value of data to provide corresponding data services for upper-level applications in various domains. Driven by demand, this data central platform facilitates the flow and fusion of multi-source, heterogeneous data from all business lines and terminals. It establishes a unified data plane for centralized aggregation, computation, analysis, and monitoring, forming a layered data architecture with a unified base layer, a common intermediate layer, and multiple application layers.

4.2.2. Media Processing Center

The Media Processing Center provides a foundational video engine, supporting the integration of basic media capabilities such as transcoding, rendering, super-resolution, and streaming media processing. It offers a convenient data processing channel for unstructured data storage and, based on accumulated technical expertise, covers ultra-high-definition 4K media processing capabilities. Services of the media processing platform include A/V transcoding and composition, video rendering, video splitting, and video stream matrix services. The center's services, including A/V transcoding, rendering, and image processing, are provided through standardized APIs, allowing for fast and easy integration. It also manages, monitors, and provides callbacks for capability invocations, meeting media processing requirements for various scenarios.

4.2.3. AI Processing Center

The AI Resource Processing Platform supports the integration of foundational AI capabilities such as text recognition, character recognition, speech recognition, multilingual translation, and PPT recognition. It provides upper-level businesses with necessary A/V

AI application capabilities like intelligent recognition, editing, and review. It offers standardized access and management for basic AI engines, enabling the integration and unified management of multiple third-party AI engines and providing O&M and operational capabilities for AI administrators.

Its functions include:

Content Pre-processing: Supports video pre-processing, audio pre-processing, audio track separation, and intelligent segmentation.

Face Recognition: Analyzes and identifies specific individuals from faces appearing in video frames and recognizes faces that match custom-defined features.

Text Recognition: Provides intermediate results, outputting recognized text from images, including subtitles and titles.

Speech Recognition: Provides intermediate results, outputting a textual transcript of speech and dialogue in videos, with support for Chinese.

Natural Language Processing (NLP): Extracts keyword tags from recognized text and speech content using mature NLP technologies.

4.3. Application Service Layer

The Application Service Layer is the backend support of the central platform, encompassing the entire lifecycle of educational resources: collection, transcoding, production, intelligent processing, management, and publishing.

4.3.1. Educational Resource Collection and Aggregation

The resource collection and aggregation module is the primary tool for resource consolidation. It resolves issues common in traditional methods (e.g., QQ, FTP), such as the need to decompress and transcode files after transfer, or files being unusable. This module enables resources to be automatically ingested into the repository during transfer, making them immediately available for use. Aggregation methods include resource uploads, ingestion from regular lecture capture streams, file synchronization, and management of live-stream resources.

4.3.2. Educational Resource Processing

Current A/V technology provides a rich set of lightweight, template-based A/V processing and editing tools based on a CMS. Users do not need to install any third-party software or copy/download resources. By simply logging into the platform, they can perform various education-specific editing tasks, such as micro-course packaging, premium course editing, and teaching data visualization. These online tools help users edit educational resources more simply and conveniently. Integration with common third-party internet tools also empowers regular teachers and even students with resource processing capabilities, enhancing production efficiency and thereby fully and deeply unlocking the value of accumulated resources to revitalize the educational resource pool.

4.3.3. Educational Resource Management

The resource management platform provides key functional pages such as "My Shares" and "My Groups" for users managing their personal educational resources. Through the platform's "sharing" and "distribution" mechanisms and the establishment of a "discovery" library, high-quality resources from all disciplines can be aggregated into a single platform where they can be previewed, saved, and used. The platform also enables statistical analysis of all relevant resource data, fostering a model of joint construction and sharing of the university's online teaching resources.

4.3.4. Intelligent Processing of Educational Resources

Leveraging the platform's AI capabilities, this function provides course content analysis, speech recognition, and lecture note extraction for educational resources. By intelligently processing resources, it adds structured attributes to unstructured educational content, making it more convenient to use and providing auxiliary support for smart teaching.

1) AI technology identifies key information in resources (e.g., people, scenes, objects, content keywords) and generates structured tags.
2) Speech recognition is applied to video and audio resources to transcribe spoken content into text, creating subtitles for educational videos.
3) OCR technology analyzes video-based educational resources to extract and present content from the instructor's blackboard or PPT slides in the form of lecture notes.

4.3.5. Educational Resource Publishing

Before any resource is published, a multi-level review process can be configured. Once approved, the content distribution system uses standard interfaces to publish unified campus news, interactive content, and multimedia teaching materials to various terminals, such as PCs, WeChat official accounts, and H5 sites. Faculty and students can then access digital teaching resources like text, on-demand video, and live streams via PCs, mobile phones, and other devices over the internet.

4.4. Open Capability Layer

While centralizing the management of various resources, the central platform can also provide integration services for external applications. It leverages the streaming media service advantages of a unified resource repository to offer capability support for the resource storage, delivery, playback, and even AI analysis and intelligent processing needs of various applications.

When external applications use the central platform's resource integration services, they can be authenticated through the learning platform's permission system. Authentication and authorization support the API token method to obtain user and classification information. The resource list API supports querying resource lists for specific users, and separate APIs provide preview and publishing addresses for specified resources.

The central platform for smart education resources will provide third-party platforms with open-function APIs, open application tools, and open resource data analysis. It will offer capability and resource support for traditional online education platforms, creating a centralized teaching resource hub that integrates storage, management, production, analysis, and statistics.

5. Key Technologies of the Platform

5.1. Enhancing Cloud-Native Capabilities to Adapt to Business Development Needs

By leveraging cloud-native capabilities, the central resource platform's elasticity, fault tolerance, and automated assurance can be significantly enhanced. This ensures the platform's high availability and capacity for iterative business development, enabling it to better provide business services and technical support to all faculty and students, existing campus-wide platforms, and external users.

5.2. Establishing Standardized Interface Specifications to Strengthen Platform Standardization and Openness

The central resource platform possesses diverse technical capabilities. Based on a unified cloud platform, all deployed software must adhere to software development standards. Only by complying with these standards can the platform achieve mutual utilization

and support among multiple vendors and various business applications, thereby becoming a complete technical ecosystem.

5.3. Creating an Atomic Service Model for Technical Capabilities

The platform introduces the latest technologies to empower the business and technical capabilities of existing systems, extending the business dimensions of the entire ecosystem (Figure 2).

Figure 2. The Central Platform Model.

5.4. Comprehensively Improving the Platform's Business Responsiveness

The construction of a central platform fundamentally changes the traditional monolithic application architecture. Whereas components in monolithic applications are characterized by high coupling and strong dependencies, the central platform model shifts towards loose coupling and low cohesion. When faced with new business requirements, these components can be quickly and efficiently assembled — much like "building blocks" — to support the business, thereby enhancing overall response efficiency.

5.5. Comprehensively Improving the Platform's Capacity for Scalable Innovation

The central platform is planned at the university level to define its service scope. Through continuous updates and iterative support for business requirements, it can effectively summarize and plan the direction of business development, leading to business innovation. Concurrently, as the platform continuously iterates and accumulates capabilities based on evolving demands, its own abilities are constantly enhanced, facilitating rapid validation and support for new business ventures and models.

5.6. Comprehensively Improving the Platform's Service Quality

The construction of a central platform provides unified support for upper-level business applications. This allows the platform to concentrate technical resources on optimizing and upgrading the quality of its common capabilities, thereby improving the overall quality of the entire system.

5.7. A New Content Management Model Driven by Big Data + AI

This model explores the application of artificial intelligence in the collection, production, distribution, reception, and feedback of course resources. It employs various intelligent tools to significantly improve efficiency in the resource production stage. In the publishing stage, content is presented intelligently, transforming teaching materials from readable to visual, static to dynamic, and one-dimensional to multi-dimensional formats, thereby expanding their communication impact.

Through various intelligent engines and targeted algorithms, the platform manages both structured and unstructured data within course content. Combining a training approach that integrates fusion inference with manual correction, it achieves intelligent management of media content, providing users with more professional course content management and resource-sharing services. Learning process data, combined with AI, is used for knowledge system mining and learning system data analysis. This facilitates the construction of knowledge graphs and learner profiles, covering the entire "teaching, learning, assessment, and management" lifecycle to provide auxiliary support for instructional guidance and student development.

6. Conclusion

The construction of a central platform for smart education resources in higher education is a crucial initiative for advancing educational digitalization. It breaks down the barriers of fragmented resources within a university and provides solid support for teaching and learning activities through data aggregation, governance, and sharing. From a pedagogical perspective, instructors can conveniently access diverse teaching resources through the platform, enabling the design of personalized teaching plans and enhancing classroom quality. Similarly, students can obtain learning materials precisely tailored to their individual progress, thereby optimizing their learning experience. From an administrative standpoint, the central platform offers university management comprehensive and accurate data insights, facilitating scientific decision-making and achieving efficient governance. Since its launch, the online learning platform at a certain university has remained committed to its original mission of digitizing high-quality educational resources. Through continuous dedication to digital resource development, the platform has recorded over 260,000 total visits as of March 2025, providing a richer, more convenient, and more efficient resource aggregation and sharing hub for all faculty and students, ensuring that the benefits of digital education reach every member of the university community.

Despite the achievements made in the construction of these central platforms, numerous challenges remain, such as data security and privacy protection, as well as difficulties in achieving deep integration between different systems. Looking ahead, universities must continue to increase their investment to further refine the platform's construction. On one hand, it is essential to strengthen technological innovation and application. On the other hand, a focus on talent cultivation is needed to build a resource management team that is proficient in both education and information technology. Such a team will provide the necessary support for the platform's ongoing construction and optimization, ensuring that the full potential of the central platform for smart education resources in higher education is realized.

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