Design and Implementation of Personalised Learning Support System

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Abstract: Based on the popularity of electronic devices, education is changing from a single learning model to diversified learning, and the field of education is experiencing a paradigm shift from standardized teaching to personalized learning. At present, countries are also carrying out the popularization of personalized learning. This study summarizes the intelligent personalized learning system based on multi-level architecture in view of the limitations of the traditional education system "one-man", aiming at empowering the education essence of "teaching students in accordance with their aptitude" through technology. So that students can find a truly suitable learning mode through the learning system, the system adopts a four-layer architecture design, and recommends suitable personalized learning systems. Future research will focus on intelligence, explore the efficiency of personalized learning system, such as solving learning strategy problems through ai, and verify the usability of personalized learning system, and attract students to accept personalized learning model by building system innovation. In addition, people's identification and popularization of personalized learning will also become an important research topic.

1 INTRODUCTION

With the interdisciplinary integration of artificial intelligence, big data analysis and cognitive science, the education system has gradually shifted from "one-to-one" standardized teaching to "people-oriented" personalized service. This transformation is not only driven by the development of technology, but also reflects the return of the essence of education, which is to respect the individual differences of learners and realize the goal of teaching students in accordance with their students' abilities. For learners, finding the resources that meet their needs from a large number of learning resources is very important for learning efficiency and self-study effect (Wang and Gao, 2022).

And with the rapid development of various mobile devices, such as mobile phones, tablets, laptops, GPRS technology and Bluetooth technology popularity, gradually become our main tool for learning, another new survey conducted by Newzoo's Global Mobile Market Report 2019 shows that the popularity of smart phones is high: 82.9% in the UK, 79.9% in Germany, 79.1% in the US, 77.5% in France, 74.3% in Spain, 70.4% in South Korea and 66.3% in Russia (Bourekkache et al., 2020). In Algeria, the smartphone penetration rate is 38.1%, which is considered an important rate (Bourekkache et al., 2020). Because of the popularity of these devices, it has become difficult for our study life to leave online learning, so having an excellent personalized learning system is essential for learning efficiency. And on a global scale, The United Nations Educational, Scientific and Cultural Organization, UNESCO states that "access to quality education means access to personalized learning", highly emphasizing the promise of this approach for addressing uneven outcomes in school education. As J. Groff puts it, personalized learning is essential because it is "entirely consistent with the science of learning" (Zhao and Wu, 2025).

It is proposed in InfoTech that adaptive resource recommendations (or building a personalized learning path) should be made in a dialogue with the learner, and he should have the possibility to select some suggested new content or activity. This paper proposes a knowledge model to ensure adequate recommendation of dynamically generated learning paths and to store various approved and well-annotated learning paths for future reuse (Ivanova, 2023). The architecture design of personalized learning system is the key to realize personalized education. An effective personalized learning system should contain these aspects, including user

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interaction layer, server layer, data access layer, database layer. The user interaction layer is mainly responsible for collecting the basic information of learners, and effectively displaying and recommending learning resources to students. The server is mainly responsible for analyzing the user model and finding a suitable learning path for learners. The data access layer is mainly responsible for ensuring the security of data entering the data database and reviewing whether the data is normal or not to ensure the security of user data. The database layer is mainly responsible for storing data and facilitating learners to call data, and can also give visual charts for users to view data efficiently and clearly.

2 THE OVERALL ARCHITECTURE DESIGN

The user side is responsible for the display and processing by the web interface, and the interactive interface directly facing the learner, showing the graphical interface of the student learning, teacher monitoring and other modules, as well as the corresponding security protection. It can intuitively show the function of the system to the user, provide users with a convenient and quick experience, but also consider the user experience, and operation and maintenance.

The server layer (business logic layer) is the core area of the system, responsible for receiving and processing the information transmitted by the user end, can carry out the centralized management of complex business, technology selection, code governance, etc., which may affect the performance.

The database is mainly responsible for providing an interface for the server to realize the addition, deletion and modification of data. The use of the database can make the data more durable and reliable, and can also make the query and optimization more efficient, but the problems such as operation and maintenance complexity and security need to be solved. Figure 1 shows the overall architecture of personalized learning.

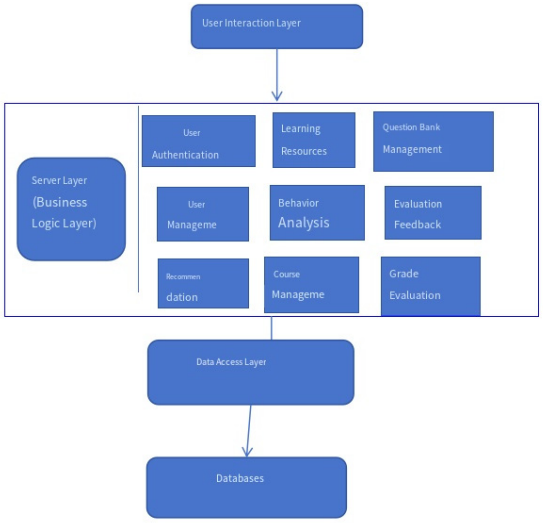

Figure 1: The overall architecture of personalized learning (Picture credit: Original).

3 TECHNOLOGY SELECTION

3.1 User Side Development

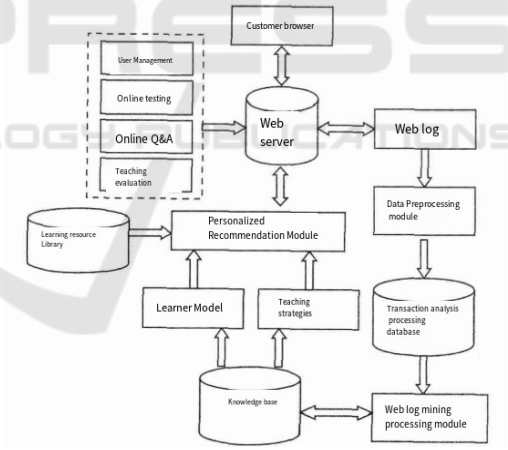

Figure 2: User-side personalized learning model (Zhang et al., 2023).

The system is mainly composed of six modules (as shown in Figure 2): login module, Web log mining processing module, knowledge base, personalized recommendation module, regular function module and learning resource library, as shown in Figure 2 (Zhang et al., 2023). When users log in, they must first register, and carefully fill in the questionnaire designed by the system administrator, generate user personalized information materials, and establish the initial user interest matrix for resources to avoid the

cold start problem of the system (Zhang et al., 2023). In the system have the function of traditional online learning system, such as user management, learning resource management, online testing, online answering questions and teaching evaluation, etc., at the same time the system also includes a core of personalized intelligent module - Web log mining processing module, in order to realize the learners and page clustering and learners learning rule, the analysis of learning style. When a user access to the system, the operation module mainly complete the following two aspects: first, using the K - Means clustering algorithm is analyzed, according to the learners and page two objects according to the similarity between them is divided into several groups, constitute a set of similar objects. If some pages are found to belong to the same group, other pages in the same group can be recommended to learners when learners access the pages (Zhang et al., 2023).

Since the user side is directly oriented to learners, there are many frameworks that can provide a better experience for users. For example, FeedbackFlow Dynamics studies the evolution of real-time feedback systems and user behavior (Devi et al., 2025). It investigates the impact of information and timed feedback on user engagement. By allowing users to modify timing and input types, interfaces become more interesting and responsive. The EmoFeedback interaction model incorporates user emotions into the design process, recognizing their significant impact on interface usability and aesthetics, by analyzing and responding to emotional signals, it enhances the user experience and contributes to the development of emotionally intelligent interfaces (Devi et al., 2025). The DynamicAdapt UX framework ensures a more satisfying, personalized, and contextualized experience for customers (Devi et al., 2025). Reactive flow design model assessment in a variety of screen sizes and optimize the design of the data flow and equipment (Devi et al., 2025).

At the same time, interface design plays a vital role in improving user experience and promoting product development (Qiu, 2024). By implementing a series of targeted optimization measures, such as adopting card design, expanding the search bar, and increasing the user comment section, we successfully solved the problem of information overload caused by user feedback. This makes the overall site clear visual effect is more intuitive, allows the user to quickly find interested project (Qiu, 2024). These optimizations not only improve user efficiency, but also significantly improve user satisfaction and loyalty (Qiu, 2024).

User experience evaluation in this framework employs the PrEmo (Product Emotion Measurement) instrument, a validated psychometric tool for quantifying affective responses to design stimuli through 14 discrete emotional dimensions (Jiao, 2022). Grounded in Desmet's theoretical emotion framework, the methodology operationalizes four core components: 1) product evaluation protocols, 2) attentional engagement metrics, 3) appraisal-induced affective states, and 4) product attribute-emotion mapping. Participants interact with purpose-designed product prototypes that embody specific functional objectives, aesthetic principles, and attention-guiding features. Affective outcomes are subsequently quantified through dynamic visual stimulus presentations using affect-encoded animation sequences (Jiao, 2022).

3.2 Server Layer

3.2.1 Micro Server Scheme

The combination of using Spring Boot with Spring Cloud Spring Boot with its "convention over configuration" design concept, provides developers with a quick build Spring application convenient tools. Spring Cloud further spring-based Boot, focusing on service governance under the micro service architecture, provides a set of perfect solutions, covering service routing, registration and discovery, load balance, monitoring, and many other aspects. These features make the Spring Cloud micro service architecture for building the preferred method of (Chen et al., 2024). The use of microservice cluster can disintegrate the complex scientific research management system into a series of independent and loosely coupled services, which significantly improves the automation and information level of the system (Wang, 2024).

3.2.2 Distributed Server Solution

This distributed server architecture employs multiple nodes to minimize service delays in real-time systems (Yanase et al., 2021). Under this design, each user connects to a dedicated server node for event transmission. The assigned server aggregates user-generated events, disseminates them across the network for synchronization, processes all collective events through coordinated computation, and ultimately relays the processed results back to corresponding users for subsequent operations (Yanase et al., 2021). The maximum number of users in the server is given in the form of the server capacity,

and to process events in the order in which they occur at the user side, the delay between the user and the server and the delay between the servers are corrected to the maximum delay DU between the user and the server and the maximum delay DS between the servers, respectively (Yanase et al., 2021). Therefore, in the Distributed Server Processing (DSP) approach, it requires 2DU+DS. Compared with the CP, it will have an extra step to events with other server synchronization (Yanase et al., 2021). However, since the server location is closer, the latency between the user and the server is lower, so the communication latency can be reduced (Yanase et al., 2021).

3.3 Data Access Layer

The overall system architecture (as shown in Figure 3) includes three parts, which are the front-end and back-end management interface, the server and the client, and the program code is deployed on the server. The system takes the operation and maintenance control module as the core, including the access entrance of safety certification, configuration management and monitoring and audit functions. The safety certification covers two sub-modules of login authentication and proxy authentication, and the monitoring and accounting page sets up three sub-modules of operation and maintenance monitoring, session cutting and audit analysis. The configuration management page covers three sub-modules of personnel, equipment and policy management (Jia, 2024).

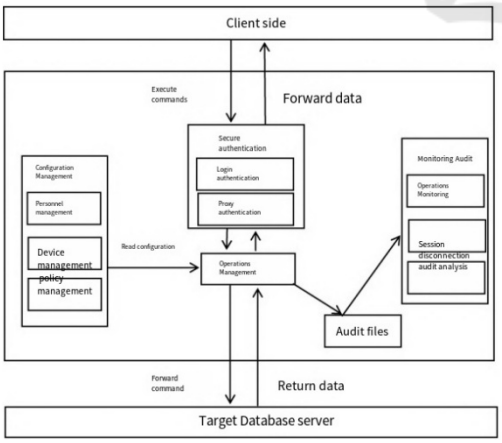

Figure. 3: Overall architecture of Data access layer (Jia, 2024).

There are many kinds of database security threats, which need to be paid attention to and protected. The following article will list the security matters that need to be paid attention to SQL Injection. This is a form of attack in which malicious code into the front end (Web application) and transmitted to the backend database (Jiao, 2022).

Due to SQL injection, computer attackers have unrestricted access to all the data contained in the database. There are two possible types of such code attacks: SQL injection against standard databases and NoSQL injection against massive databases (Jiao, 2022).

Database vulnerabilities and misconfigurations. This can also happen when the database is found to be absolutely inaccessible due to misconfiguration (Jiao, 2022). Many database systems maintain preset credentials and setup options by design, a critical consideration given that malicious actors possess advanced technical expertise. These cyber attackers routinely leverage architectural deficiencies and improper configuration settings as entry points to compromise organizational networks (Jiao, 2022).

Denial of Service (DoS) incidents specifically target system availability by overwhelming database infrastructure, resulting in two primary consequences: impaired operational efficiency and potential service interruption that renders critical assets unreachable (Jiao, 2022). While such attacks preserve data confidentiality, they force organizations to incur substantial operational expenses through extended downtime and remediation efforts (Jiao, 2022). Ultimately, persistent unavailability of web services fundamentally undermines the service's core value proposition, negating its functional purpose despite maintained data integrity (Jiao, 2022).

Decentralized data management presents critical security challenges when handling sensitive information. Organizations frequently maintain extensive repositories of confidential records without implementing comprehensive data governance frameworks, creating attack surface proliferation through orphaned datasets and legacy storage systems (Jiao, 2022). Compounding this challenge, the continuous influx of newly generated critical information within dynamic data ecosystems makes systematic monitoring inherently complex. This operational reality exposes both archival and recently ingested data assets to potential security breaches before proper safeguards can be implemented (Jiao, 2022).

Database backup risks. It is best to back up a proprietary repository within the specified time frame (Jiao, 2022). Curiously, however, database backup files are also completely unattacked. As a result, database backup leaks are a frequent security breach (Jiao, 2022).

Excessive privilege allocation in database systems creates substantial security exposure. While role-based access differentiation is fundamental to database operations (Jiao, 2022), three primary privilege escalation vectors emerge: non-essential privilege retention (maintaining permissions exceeding operational requirements), legitimate access overreach (exploiting authorized privileges for unauthorized activities), and dormant credential exploitation (leveraging inactive access rights). Empirical studies indicate approximately 80% of corporate network breaches originate from insider threats, with over-provisioned access rights significantly increasing attack surface vulnerability through privilege creep mechanisms (Jiao, 2022).

Malicious software propagation vectors demonstrate sophisticated attack methodologies through credential hijacking mechanisms. Advanced persistent threats typically compromise endpoint devices to establish command-and-control channels, subsequently exploiting legitimate user credentials through three operational phases: session co-option (hijacking authenticated connections), privilege escalation (leveraging authorized access levels), and lateral movement (penetrating enterprise networks via compromised accounts). Forensic analysis confirms 62% of such breaches originate from malicious payloads executing privilege escalation protocols using authenticated user contexts (Jiao, 2022).

3.4 The Database Layer

Cache operates as an advanced object-oriented database system, utilizing a multi-dimensional transaction processing architecture to enable distributed data management. This system establishes a consistent data model structure, allowing data manipulation via standard SQL queries while offering integrated development utilities to accelerate database implementation, particularly for web-based applications. Additionally, the platform features XML object compatibility and enables cross-language interoperability through support for .NET, ActiveX, C++, EJB, Java, JDBC, ODBC, SOAP, Perl, Python, and XML protocols (Goswami and Sharma, 2021).

Teiid, a data integration technology, supports virtualization of various types of databases; Through such virtual databases, data sources such as relational databases, Web databases, and application software such as ERP and CRM can be accessed in real time (Wada et al., 2010). Virtualization technology so that data analysts or other users can use all ubiquitous databases as if they were a single database, thus helping to reduce the workload of users (Wada et al., 2010).

4 CONCLUSION

Based on the interdisciplinary perspective, this study summarizes an intelligent personalized learning system. Through the four-layer architecture of "user interaction layer, business logic layer, data access layer and database layer", it integrates a variety of methods and combines a variety of hot core technologies to solve the pain points of low resource adaptability and rigid learning path in traditional education. The study shows that the learning system is not only a technology, but also the promotion of education reform. In the future, the technology will take the essence of education as the carrier to build a humanized and intelligent learning ecological model. There are still many challenges in personalized learning system, such as data collection and privacy, algorithm bias, user diversity and effect verification. In the future, both technology developers and users will collaborate to solve these challenges.

REFERENCES

Bourekkache, S., Tigane, S., Kazar, O., and Kahloul, L.: ‘Mobile and personalized learning system for computer science students,’ 2020 Sixth International Conference on e-Learning (econf), Sakheer, Bahrain, 2020, pp. 189-193

Chen, Z., Wu, J., Ma, F. Z.: ‘Application Development Research based on microservice architecture’. Technology News. 2024

Devi, V. S. A. et al.: ‘Designing Intuitive User Interfaces in Human-Computer Interaction for Enhanced Digital Experience,’ 2025 International Conference on Intelligent Control, Computing and Communications (IC3), Mathura, India, 2025, Pp. 637-643

Goswami, P. K., and Sharma, A.: ‘An Intelligent Shift Towards High-Performance Database Engines Including Autonomous Databases Using Derived Transient Objects from the Persistent at the Runtime,’ 2021 IEEE International Conference on Technology, Research, and Innovation for Betterment of Society (TRIBES), Raipur, India, 2021, pp. 1-5

Ivanova, T. I.: ‘Knowledge-Based Semi-Automatic Selection of Personalized Learning Paths,’ 2023 International Conference on Information Technologies (InfoTech), Varna, Bulgaria, 2023, pp. 1-4

Jia, J. Y.: ‘Application of Big Data Technology and MySQL Database’. Integrated Circuit Applications. 2024

Jiao, Z.: ‘Research and Application of Human-Computer Interface Based on User Experience,’ 2022 7th International Conference on Intelligent Computing and Signal Processing (ICSP), Xi'an, China, 2022, Pp. 1417-1420

Jiao, Z.: ‘Research and Application of Human-Computer Interface Based on User Experience,’ 2022 7th International Conference on Intelligent Computing and Signal Processing (ICSP), Xi'an, China, 2022, Pp. 1417-1420

Qiu, L.: ‘Application of Deep Learning-Based User Intent Recognition in Human-Computer Interaction,’ 2024 5th International Conference on Intelligent Computing and Human-Computer Interaction (ICHCI), Nanchang, China, 2024, pp. 549-552

Wada, Y., Watanabe, Y., Syoubu, K., Sawamoto, J., and Katoh, T.: ‘Virtual Database Technology for Distributed Database,’ 2010 IEEE 24th International Conference on Advanced Information Networking and Applications Workshops, Perth, WA, Australia, 2010, pp.214-219

Wang, H., and Gao, Z.: ‘Research on Personalized Service Path of Learning Resources by Data Driven,’ 2022 International Symposium on Educational Technology (ISET), Hong Kong, Hong Kong, 2022, pp. 143-147

Wang, Y.: ‘Research on Scientific Research Management System Based on Microservice Architecture’. Electronic Engineering and Products World. 2024

Yanase, S., He, F., and Oki, E.: ‘Approximation Algorithms to Distributed Server Allocation With Preventive Start-Time Optimization Against Server A Failure’, IEEE Networking in Letters, vol. 3, no. 4, pp. 191-195, Dec. 2021

Zhang, J., Jing, S. Y., Linag, S.: ‘Research on personalized learning resource recommendation model based on Web log mining’. 2023 3rd International Conference on Electronic Information Engineering and Computer Communication (EIECC). 2023

Zhao, J. Y., Wu, J.: ‘Artificial Intelligence Empowering Personalized Learning: The Path Analysis of K-12 Education Digitization in the United States’. Journal of Comparative Education. 2025