

Exploring the path to building intelligent language laboratories in the era of digital intelligence

Xing Zhong

School of Foreign Languages and Cultures, Zhaoqing University, Zhaoqing 526061, China

Email: 463791153@qq.com

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Abstract

In order to promote the modernisation of language education and enhance the quality and effectiveness of teaching, this study focuses on the application value of intelligent language labs. It adopts advanced means such as virtual reality, augmented reality, artificial intelligence, cloud technology, etc. to build an immersive learning environment and achieve intelligent environment management, cloud resource connection, personalised teaching support and student behaviour analysis. The results show that the lab allows students to practice interactively in real contexts, ensures a comfortable learning environment through intelligent adjustment, enriches classroom content with cloud resources, allows teachers to adjust teaching methods according to students' feedback, and provides real-time learning feedback with artificial intelligence, which effectively promotes the application of language knowledge. In summary. As a new symbol of modern education, the intelligent language laboratory is not only an innovation of technical facilities, but also promotes the change of teaching methods, providing a broad space for language education and rich resource support.

Keywords

Intelligent Language Laboratory; Internet +; Language Training; Interactive Instruction; Context-awareness; Guarantee System

1. Introduction

An intelligent language laboratory is a laboratory equipped with high-tech hardware and intelligent software. Its user-friendly design and intelligent intervention enable advanced intelligent electronic devices for listening, reading, writing, and translation to facilitate seamless access to resources for teachers and students, and provide technical support for various advanced teaching designs [1,2]. Intelligent language laboratories, developed based on digital language laboratories, are constructed by integrating technologies such as virtual reality, artificial intelligence, big data, and the Internet of Things (IoT) in the "Internet+" era. They can rapidly and efficiently enhance the practical teaching effectiveness of language courses. The excellent prac-

tical teaching outcomes are primarily reflected in diverse classroom interactions, rapid access to teaching resources, engaging content presentation, immersive contextual awareness, and convenient management of the teaching environment. Currently, with the rapid development of information technology, most school laboratories face issues such as outdated hardware and software, slow update speeds, and low levels of management informatization (primarily manifested in delayed fault resolution). The existing hardware, software equipment, and management methods are no longer capable of meeting the demands of the rapidly developing information age. Advancing and improving the intelligent construction of language laboratories has become a primary development goal for many schools. Currently, most school intelligent laboratories are still in the initial stages of development, with limited improvements in experimental outcomes. Therefore, the construction of intelligent language laboratories requires collaborative efforts from multiple parties. Specifically, intelligent laboratory construction must seek appropriate pathways to enhance practical teaching outcomes while establishing a series of supporting measures in areas such as funding procurement, software (including staff training), and hardware infrastructure to ensure the practical implementation of intelligent laboratory planning and construction.

2. Analysis of the Main Features and Functions of School Intelligent Language Laboratories

Intelligent language laboratories inherit the original functions of traditional language laboratories while also incorporating the characteristics of modern AI and intelligent classrooms.

2.1. Main Features

2.1.1. Cloud-based Resource Library

Unlike traditional language laboratories, intelligent language laboratories store all text information, videos, and audio-related teaching resources on remote servers in the cloud. Students and teachers can meet all their classroom needs through simple, intuitive operations on intelligent handheld devices, while retaining the original functions of language laboratories, such as listening, speaking, reading, writing, and translation. Due to the special nature of foreign language teaching, a large amount of video and audio resources are used in the teaching process. These resources primarily include exam question banks, high-quality courseware, teaching videos, teaching audio files, as well as online audio-visual materials and various open courses. These resources are categorized and stored in the school's cloud-based resource library. The intelligent language laboratory simplifies host functions, with the cloud-based resource repository replacing the resource space on each terminal or computer; it is also easy to manage, enabling information sharing and low-cost maintenance [3,4].

2.1.2. New intelligent classroom environment

The intelligent language laboratory features a new intelligent classroom environment. This involves utilizing artificial intelligence recognition, cloud computing, sensors, wireless network transmission, and streaming media technologies to upgrade classroom equipment, improve the basic language teaching environment, enhance classroom safety, and facilitate more convenient and intelligent management.

2.1.3. Mobile Teaching and Learning Presentation

In traditional language labs, teachers and students typically have fixed seating arrangements. In contrast, the intelligent language lab enables various teaching activities in any WiFi-covered area (within the classroom), particularly allowing students to conveniently participate in case discussions and group interactions using classroom tablets or their own devices. Teachers can also seamlessly integrate into student interactions [2].

2.1.4. Automatic Storage of Class Data

The smart language lab can integrate teacher and student course-related information on mobile devices to form a course storage archive, enabling access to class schedules and records of teacher-student interactions.

2.1.5. Diversified Interaction During Instruction

Through text, audio, and video technologies—especially audio and video—clear and smooth real-time interaction between two or more participants can be achieved, enhancing classroom atmosphere and improving language teaching effectiveness.

2.2. Main Functions

2.2.1. Promoting Language Education Reform

School intelligent language laboratories can provide advanced language teaching technologies and methods to promote reforms and innovations in language education. The laboratory can offer teachers and students more personalized and precise language instruction, thereby improving the quality and efficiency of language teaching.

2.2.2. Enhancing Language Teaching Quality

School intelligent language laboratories can provide comprehensive technical support for language teaching, including areas such as pronunciation, listening, speaking, reading, and writing. The laboratory can offer students a richer and more diverse language learning experience, thereby improving their language proficiency and skills.

2.2.3. Promoting Innovation and Development in Language Research and Language Services

School intelligent language laboratories can provide technical and data support for language research and language services, thereby promoting innovation and devel-

opment in these areas. The laboratory can offer more accurate and comprehensive data support for language research and provide more personalized and precise services for language services.

3. Basic Pathways for the Construction of School Intelligent Language Laboratories

As mentioned above, domestic schools are continuously advancing the construction of intelligent laboratories. In the field of intelligent language laboratories, they are also increasing investments to ensure that such laboratories not only reflect the general characteristics of intelligent laboratories but also integrate the actual needs of language teaching, highlighting the intelligent features of language instruction.

Based on the construction objectives of intelligent language laboratories, schools should closely follow the basic path of “emphasizing the intelligent presentation of (classroom) content, resource acquisition, environmental management, timely interaction, and contextual awareness,” continuously improving the software and hardware conditions of language laboratories.

3.1. Improving Content Presentation Effects

During foreign language laboratory classes, necessary board writing is required. Writing on a blackboard can sequentially present class content, but traditional chalk writing not only hinders environmental cleanliness but also results in suboptimal blackboard display effects. Therefore, it is necessary to procure intelligent blackboards that support various writing tools (such as chalk, water-based pens, and touch pens), particularly interactive electronic whiteboards (a “smart interconnected blackboard + touch-screen all-in-one” dual-screen mode). An interactive electronic whiteboard is a “chalkboard” tool connected to a digital projector and computer, featuring touch-sensing functionality. The projector displays images from the computer screen onto the whiteboard, while teachers can control the computer (teaching computer) by directly touching the electronic whiteboard or using an electromagnetic induction pen) [5, 6]. These boards not only possess all the functions of ordinary blackboards but also have unique features in terms of teaching content, operational control, resource management, and interactive communication, such as achieving diverse information processing of teaching content, intuitive and transparent operational control, real-time recording and analysis of the teaching process, and more convenient communication between teachers and students.

Intelligent blackboards can also demonstrate intelligent presentation advantages. The writing displayed on such blackboards is clear, can be electronically stored and reviewed, and supports electronic scanning and downloading. In the future, the procurement, maintenance, and flexible use of intelligent blackboards will be a top priority in the construction of intelligent language laboratories.

The content presentation in intelligent language laboratories, in addition to the

aforementioned visual aspects, also manifests in a good audiovisual integration experience. Therefore, the laboratory should be equipped with multiple large-sized multi-touch LCD screens (detailed in the following sections). High-performance audio-visual systems can create a clear, smooth, and comfortable audio-visual environment.

3.2. Promoting Intelligent Environmental Management

Intelligent management of language laboratory environments (classroom layout, equipment, physical environment, electrical safety, network, etc.) involves establishing intelligent control functions to achieve remote control of laboratory equipment (including lighting, air conditioning, power supply, network, etc.) using IoT technology and other means. Multiple pre-set application scenarios can be configured to support multi-window view teaching, synchronized network-based remote teaching, and seamless switching between in-class teaching modes and post-class assignment modes. The system can also match classroom environment equipment with personalized teaching services, combining and controlling them as needed. Additionally, electronic class signs can be set up to enable real-time communication with service staff (via network-based remote access). The goal of intelligent management is to enhance experimental teaching comfort and efficiency through simple one-click operations.

The layout of intelligent language laboratories should be flexible and diverse, with experimental equipment and physical environment management comprehensively considering lighting, networking, power supply, air conditioning, computers, projectors, and other equipment, as well as environmental factors such as lighting and temperature. While advancing intelligence and informatization, all types of equipment should strengthen network security protection.

3.3. Strengthen the refined production of teaching resources and personalized services

In addition to configuring a professional recording and broadcasting system, it should be used in conjunction with high-definition cameras equipped with advanced image recognition technology to achieve real-time intelligent positioning of teachers and students, enabling seamless switching between interactive teaching scenarios and close-up displays from multiple angles. Additionally, through the operation of the recording system's main control module, full intelligent control, live streaming, and production of high-definition cameras can be achieved [7,8], with broadcast-grade 4K or higher-level recording used for top-tier language course recording. For schools with multiple campuses, it is recommended to design a recording system that includes simple and easy-to-operate remote control video editing, live streaming, and on-demand services.

First, establish a cloud-based high-definition video resource library. Based on the

teaching environment requirements of language laboratory courses in listening, speaking, reading, writing, and translation, high-definition videos allow teachers and students to authentically experience the course scenarios, thereby evoking visual, auditory, and emotional resonance among them. Students can also gain a deeper understanding of language and its application. During the learning process, auditory and visual information is processed simultaneously, enhancing learning efficiency and improving learning outcomes [9,10]. Foreign language videos can be produced using non-linear video editing systems or professional recording systems; they can also be obtained from authoritative websites offering the latest foreign language news and educational resources. Foreign language videos can expand students' language knowledge and cultural literacy. Viewing high-definition videos with bilingual subtitles allows students to engage both their visual and auditory senses simultaneously, effectively improving their listening skills and reading comprehension abilities [11,12].

Second, enhance personalized services for language teaching resources. In addition to improving basic personalized services in laboratories (such as on-demand access), more personalized teaching services should be developed. For example, by assessing students' foundational knowledge, targeted personalized learning materials can be provided, and students with similar abilities can be automatically grouped into intelligent teams to facilitate group interaction and teaching support. Widgets can be used to integrate teaching resources from multiple channels, or to customize personalized language learning scenarios for students. Additionally, students' learning habits and browsing behavior can be tracked and relevant data collected. Through data analysis, personalized learning resources can be pushed to students [13]; teachers can also be provided with selectable teaching explanation modes and classroom auxiliary tools.

3.4. Promoting Diversified Teaching Interaction

3.4.1. Improving Multi-Screen Interaction

In the intelligent upgrade of language laboratories, wireless display, high resolution, and dual large screens can be used to enhance demonstration effects; this promotes students' sharing and presentation of learning content and achievements[14]. To support interaction in language teaching, language laboratories should include interactive video, images, and handwriting. Interaction should also be applied between groups and individuals, between groups and teachers, and between groups[15]. The large screen at the front of the classroom should support multiple signal inputs, including PC mixed screen projection and mobile device signals, facilitating side-by-side comparisons.

3.4.2. Expanding Diverse Interaction

Currently, student group discussions and demonstrations, teacher-student communication, assignment submission and upload, and student calls are the most basic in-

teractive functions in laboratory classrooms. Visual interaction functions should be more widely applied and promoted in smart language laboratories, meaning that smart language laboratories can also develop other interactive (visual interaction) functions, such as evaluation, liking, voting, quick response, and random selection of participants. These functions can be integrated into professional language teaching software. During human-machine interactive activities, the operation requirements should be simple and user-friendly. In the classroom, touchscreen all-in-one devices can be used conveniently, allowing users to switch between writing and display functions using different gestures. Some touchscreen all-in-one devices can also accommodate teachers of different heights, with the display window capable of moving up and down[16]. Additionally, traditional chalkboard writing and ordinary whiteboard writing in language laboratories should be updated to interactive electronic whiteboard software, effectively enhancing the teaching effectiveness of language-related board writing.

3.4.3. Conducting virtual scenario interactions

Building 3D virtualized scenes can to some extent compensate for the lack of real-life scenarios in language laboratory practical teaching sessions, enhancing the classroom experience. Expanding the application of virtual reality (VR) technology in foreign language experimental teaching enhances participation and personalized experiences in foreign language instruction, as well as real-time interactivity in classroom teaching. Schools can introduce and improve VR technology (establish VR training rooms) during the construction of intelligent language laboratories to enhance the laboratory equipment functions related to virtual simulation courses.

3.4.4. Strengthen the recording and analysis of interactive information in language teaching classrooms

In addition to traditional laboratory testing functions such as automatic scoring, class rankings, and score distribution lists, intelligent language laboratories should also strengthen comprehensive recording and analysis functions, i.e., the entire process of students' pre-class preparation, practice, and classroom assignment completion should be recorded. In particular, classroom interaction recording functions (such as large-screen display of scores, bonus points, rankings, and frequency) should be improved. By analyzing classroom records (especially interaction situations), weaknesses in classroom teaching can be identified and improved.

3.5. Improve the construction of intelligent context awareness

Context primarily refers to the basic environment and teaching behavior in language teaching. Context awareness manifests as the ability to perceive the physical environment and teaching behavior of the intelligent language laboratory. This is reflected in the experience of physical facilities, such as classroom space and teaching equipment, as well as interactions between teachers and students during teaching

(including interactions with teaching resources), students' responses during learning, and teachers' experiences of teaching situations. In this context, context awareness primarily refers to the automatic recording of student behavior during class, facilitating the analysis of classroom effectiveness. To this end, intelligent devices such as interactive hosts, high-definition cameras, and eye-tracking devices can be used to record students' facial expressions and behavioral gestures; analyzing these recordings using image technology and artificial intelligence technology can help improve course teaching effectiveness [17,18].

Intelligent language laboratories in schools should gradually be equipped with and improved with new technologies (IoT technology) and new devices such as eye trackers, facial recognition, motion capture, and visual analysis to monitor teaching behavior data from teachers and students in language classrooms before, during (with a focus on), and after class. Currently, convenient methods include equipping students with smart bracelets or similar devices to collect attendance records and data on their postures and emotions during class, enabling the perception of student behavior.

In summary, the application of intelligent laboratory teaching instruments can achieve companion-based, panoramic automatic data collection, generating big data on teaching operations, and providing support for teaching management (including electronic attendance, student performance feedback, etc.), teaching guidance, educational assessment and evaluation (such as classroom teaching effectiveness assessment), and other areas.

4. Establishment of a Support System for Smart Laboratory Construction

4.1. Financial Support

The construction of smart language laboratories in schools requires substantial financial support, including equipment procurement, talent recruitment, and technological research and development. Laboratory construction requires various forms of financial support, including government funding, corporate investment, social donations, and efforts to enhance the conversion rate of research outcomes.

First, regarding government grants, the government invests significant funds in scientific and technological innovation, and laboratories can obtain financial support by applying for government grants. However, government grants typically require laboratories to conduct research in specific fields and achieve certain research outcomes. This necessitates the school to implement corresponding incentive measures to encourage faculty and staff to actively participate in research. Second, regarding corporate investment, laboratories collaborate with enterprises in specific fields to jointly develop projects, thereby securing funding support. Third, regarding social donations, laboratories showcase their research outcomes and value to the public to attract donations from the community. Finally, in terms of improving the conversion

rate of research results, the laboratory strengthens technology conversion and intellectual property protection, converting research results into commercial value to obtain more funding support. Adequate and stable funding is an important guarantee for the development of language laboratories. Therefore, laboratories need to actively seek various forms of funding support, establish long-term cooperative relationships, strengthen technology conversion and intellectual property protection to ensure the long-term development of the laboratory.

4.2. Equipment and Facilities

The construction of a school-based intelligent language laboratory requires advanced equipment and facilities, including speech recognition devices, hearing test devices, oral assessment devices, and reading test devices. Laboratory construction should be based on the laboratory's research and teaching needs, with advanced equipment and facilities selected accordingly.

Before selecting equipment and facilities, it is necessary to determine the laboratory's research and teaching needs. After determining these needs, compare the performance and prices of different equipment and facilities. By referencing professional journals, attending exhibitions and seminars, and other methods, gain a thorough understanding of the equipment and facilities available on the market, including various models and brands. By reading product manuals, referencing professional evaluations, and consulting professionals, compare the performance and prices of different equipment and facilities. After comparing the performance and prices of different equipment and facilities, select those suitable for the laboratory's needs. Additionally, consider factors such as quality, performance, price, maintenance, and warranty. Furthermore, with the continuous advancement of technology, the pace of equipment and facility upgrades is accelerating. To maintain the laboratory's cutting-edge status, it is necessary to regularly update equipment and facilities.

4.3. Data Support

The construction of a school's intelligent language laboratory requires a significant amount of data support, including speech data, text data, and corpora. The laboratory's construction must establish a comprehensive data management and sharing mechanism, collaborate with relevant language resource repositories, and obtain and share related language data.

Determine the sources and types of data: Before establishing data management and sharing mechanisms, it is essential to identify the sources and types of data. A secure, reliable, easy-to-maintain, and scalable data management system that supports multiple data types will help the laboratory effectively manage and store data. Strengthen collaboration with relevant language resource repositories to enable the laboratory to quickly obtain or share relevant language data. For example, collaborating with institutions such as language research centers and language resource repositories can provide access to a large volume of language data and corpora.

Establishing a data sharing mechanism enables the laboratory to share data with other research institutions and scholars, promoting research collaboration and academic exchange. However, the data sharing mechanism must consider data confidentiality and copyright issues and establish corresponding data sharing agreements. Strengthen data quality management, including data collection, cleaning, annotation, and verification, to ensure data accuracy and reliability. Additionally, the laboratory should regularly update data to ensure its timeliness and relevance.

4.4. Team Building

The construction of the school's intelligent language laboratory requires the establishment of a high-level team, including teachers, technical personnel, and laboratory technicians. The laboratory's construction requires the recruitment of talent with relevant disciplinary backgrounds and technical capabilities, the establishment of efficient team collaboration mechanisms, and the enhancement of the laboratory's research and teaching standards.

Before recruiting talent, it is necessary to determine the laboratory's talent needs, including disciplinary specialization, technical capabilities, and work experience. For example, if the laboratory is conducting speech recognition research, it will need to recruit talent with relevant disciplinary backgrounds and technical capabilities. When recruiting and introducing talent, multiple channels can be utilized, such as job recruitment websites, campus recruitment, and talent markets. Additionally, the laboratory can collaborate with other schools and research institutions to jointly introduce talent.

Establishing an efficient team collaboration mechanism promotes communication and collaboration among team members, thereby enhancing the laboratory's research and teaching standards[19]. For example, regular team meetings can be held to formulate research plans and task assignments, strengthening communication and cooperation among team members. Enhance team members' professional capabilities and team spirit through strengthened team building and training. The laboratory can organize professional training, academic exchanges, and other activities, encourage team members to participate in relevant academic conferences and seminars, and improve their academic standards and research capabilities. Provide a good working environment and welfare benefits to attract and retain outstanding talent. For example, comfortable office environments, comprehensive welfare benefits, and sound promotion mechanisms can be provided.

4.5. Standards and Regulations

The construction of the school's intelligent language laboratory requires the establishment of a complete set of standards and specifications, including laboratory management specifications, data management specifications, and experimental process specifications. Laboratory construction must adhere to relevant standards and specifications to ensure the scientific rigor and reliability of research and teaching

activities [20].

Before establishing standards and specifications, it is essential to determine the content of the standards and specifications that the laboratory must comply with. For example, laboratory management specifications may include aspects such as laboratory safety management, equipment maintenance, and personnel management; data management specifications may cover data acquisition, processing, and storage; and experimental process standards can include experimental design, experimental operations, and data analysis. After determining the content of the standards and regulations that the laboratory must adhere to, relevant standards and regulations can be referenced for formulation. For example, the ISO 9001 quality management system standard and the ISO/IEC 17025 general requirements for the competence of testing and calibration laboratories can be referenced. When formulating standards and regulations, a dedicated standard-setting group or committee should be established, with the laboratory director or relevant experts serving as the group leader, and laboratory members jointly formulating the standards and regulations. The development of standards and regulations should consider the actual circumstances and needs of the laboratory while adhering to relevant laws, regulations, and ethical norms. The laboratory should also establish corresponding supervision and inspection mechanisms to ensure the effective implementation of standards and regulations[20]. Additionally, as the laboratory's research and teaching activities continue to develop and innovate, it is necessary to regularly update and improve relevant standards and regulations to align with the laboratory's evolving needs.

5. Conclusion

Currently, most school language laboratories still face certain lagging issues in aligning with information technology development. They should undertake partial or comprehensive renovations in hardware, software, and management aspects. Intelligent language laboratories represent a form of comprehensive renovation. In the future, school language laboratories should allocate more resources to renovate existing experimental facilities, thereby promoting new breakthroughs in intelligent construction aspects such as content presentation, resource acquisition, teaching interaction, situational awareness, and environmental management, to meet the demands of rapid information technology development on language teaching.

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