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The Integration Logic and Implementation Path of AR Technology Empowering Chinese Character Literacy Instruction in Lower Grades of Primary School

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Abstract: Chinese character literacy is the core of Chinese language instruction in the lower grades of primary school and serves as the foundation for students' reading, writing, and lifelong learning development. However, traditional literacy instruction often fails to align with students' cognitive characteristics at this stage due to its abstract content and monotonous instructional forms, resulting in low learning interest and poor instructional efficiency. Augmented Reality (AR) technology, with its features of virtual–real integration, immersive contexts, and strong interactivity, offers new possibilities for addressing these challenges. This paper explores the intrinsic integration logic of AR technology empowering Chinese character literacy instruction in lower primary grades and constructs a systematic implementation path. The study first elaborates on the educational value of AR technology and its alignment with the objectives of literacy instruction, then reveals the integration logic from three dimensions, including cognitive psychology. Finally, a comprehensive implementation framework is proposed from five aspects—top-level design, resource development, instructional models, teacher professional development, and evaluation systems—providing reference guidance for promoting the deep integration of information technology and basic education and for improving the quality of Chinese language instruction.

Keywords: Augmented Reality (AR); lower grades of primary school; Chinese character literacy instruction; integration logic; implementation path

Introduction

The *Chinese Language Curriculum Standards for Compulsory Education (2022 Edition)* put forward explicit requirements for literacy acquisition in the first learning stage, emphasizing not only the quantity of characters to be mastered but also the stimulation of students' learning motivation. In actual teaching practice, however, teachers face multiple challenges: the abstract connections among the form, pronunciation, and meaning of Chinese characters; the tedious nature of mechanical copying and flashcard recognition; and the difficulty students encounter in understanding and applying characters learned in isolation. The core issue lies in how to transform abstract written symbols into learning experiences that conform to children's cognitive development pattern.

At present, intelligent technologies are increasingly integrated into the field of education. With its distinctive feature of "overlaying virtual information onto the real world," AR technology preserves a sense of real-world anchoring while expanding perceptual dimensions. It can "animate" static Chinese characters by creating "hyper-realistic" learning contexts, which closely align with the psychological characteristics of lower-grade primary school students. Exploring the empowerment of Chinese character literacy instruction through AR technology is therefore a systematic endeavor. Going beyond a superficial discussion of AR as a mere instructional tool, this paper deeply analyzes its alignment with the intrinsic demands of literacy instruction, reveals the underlying logic of integration, and constructs a comprehensive implementation path, providing a conceptual framework for educators and researchers alike.

1. Educational Value of AR Technology and Its Alignment with Literacy Instruction

1.1 Core Educational Value of AR Technology

The core educational value of AR technology is highly significant. First, the integration of virtual and real elements creates an immersive learning environment. Without the need for cumbersome VR head-mounted displays, students can use tablets or similar devices to view vivid virtual objects embedded in familiar real-world settings, generating a strong sense of presence and authenticity. Second, multimodal interaction activates full-sensory engagement. AR technology supports multiple interaction modes, such as touch and voice input, enabling students to interact with virtual Chinese character models by observing their structures, listening to pronunciations, and triggering contextualized stories, thereby deepening memory and understanding [1]. Third, immediate feedback facilitates formative assessment. Built-in intelligent evaluation modules can capture and analyze students' learning behaviors in real time, providing personalized feedback that helps learners promptly correct errors and consolidate knowledge.

1.2 Precise Alignment Between AR Technology and Literacy Instruction Objectives

The aforementioned values of AR technology precisely address the three core demands of Chinese character literacy instruction.

(1) Responding to the demand for "concretization": AR technology can "deconstruct" and "revitalize" Chinese characters. For example, when a student recognizes the character mu (木), a flourishing tree appears on the screen; when identifying the character xiu (休), an animation shows a person resting against a tree. By visualizing character origins and structural logic, this approach makes the cultural meanings embedded in Chinese characters immediately comprehensible.

(2) Responding to the demand for "contextualization": AR technology can construct micro-narrative learning scenarios. For instance, when learning vocabulary related to a "supermarket," students can scan a corner of the classroom with a tablet and instantly transform it into a virtual supermarket. Shelves are filled with products labeled with Chinese characters, and students must locate items according to a shopping list (also composed of Chinese characters). In this process, character recognition becomes an essential tool for task completion, allowing meaning to emerge naturally.

(3) Responding to the demand for "engagement and enjoyment": AR technology inherently embodies the principles of gamification. Game elements such as treasure hunts, puzzles, and role-playing can be seamlessly integrated into AR-based literacy applications. Through "learning by playing," students unconsciously complete a large volume of efficient literacy practice, making the learning process both enjoyable and challenging.

2. Deep Integration Logic of AR-Empowered Literacy Instruction

The integration of AR technology with Chinese character literacy instruction is by no means a simple physical combination of "technology + content," but rather is grounded in profound pedagogical and psychological foundations. This integration logic can be elucidated from the following three theoretical perspectives.

2.1 Cognitive Load Theory Perspective: Optimizing the Information Processing Process

Cognitive Load Theory posits that human working memory has limited capacity, and excessive extraneous cognitive load—caused by poor instructional design—can crowd out cognitive resources needed for deep understanding and integration. In traditional literacy instruction, students are required to simultaneously

process abstract character forms, unfamiliar pronunciations, and obscure semantic explanations, which together constitute a heavy extraneous cognitive load. AR technology effectively reduces this extraneous load through spatial integration of information and multi-channel presentation. It integrates character form, pronunciation, and meaning—previously presented separately—within the same spatiotemporal coordinates, namely through virtual models overlaid on real objects or character cards [2]. When students see the character 鱼 (fish), a swimming fish appears before their eyes while the pronunciation "yú" is heard simultaneously. This synchronized and coordinated multisensory input enables smoother and more efficient information processing, freeing up additional cognitive resources for comprehension and memory, thereby enhancing learning efficiency.

2.2 Constructivist Learning Theory Perspective: Supporting Active Knowledge Construction

Constructivist learning theory emphasizes that knowledge is not passively received but actively constructed by learners through interaction with their environment. Effective learning occurs in contexts where learners can connect new knowledge with their prior experiences. AR technology creates an ideal interactive environment for such constructive learning. In AR-based literacy classrooms, students are no longer passive recipients of knowledge but active explorers and creators of meaning. They can independently select characters to explore and actively discover character formation principles—such as phonetic components indicating pronunciation and semantic components indicating meaning—through interaction with AR models (e.g., disassembling components, recombining characters, and embedding characters into sentences). For example, students can freely combine virtual modules representing different radicals (such as " 氵," " 木," and " 讠") with modules representing phonetic components (such as " 工," " 青," and "马"), visually observing the formation of characters such as " 江," " 河," " 松," " 柏," " 请," and " 话," while understanding their semantic categories. This process itself constitutes deep knowledge construction.

2.3 Embodied Cognition Perspective: Achieving Mind–Body Integrated Learning

Embodied cognition theory challenges the traditional disembodied view of the mind, arguing that cognition is rooted in the body's perceptual–motor system and that thinking and learning emerge from interactions between the body and the environment. For young children, bodily movement is a primary means of understanding the world. AR technology naturally supports embodied learning. When using AR for literacy instruction, students must move devices, adjust viewing angles, and perform gestures. These bodily actions are not incidental auxiliary behaviors but integral components of the cognitive process. When students walk around a desk to view the backside of a 3D character model, spatial orientation and understanding of character structure are internalized through bodily movement. When students use gestures to "grab" a radical and drag it to the correct position, hand–eye coordination and muscle memory related to character structure are simultaneously developed. This "learning by doing" mode results in deeper and more enduring learning outcomes.

3. A Systematic Implementation Path for AR-Empowered Chinese Character Literacy Instruction in Lower Primary Grades

3.1 Top-Level Design: Establishing Integration Orientation and Ethical Boundaries

First, the principle of prioritizing educational objectives must be clearly defined. When introducing AR technology, schools and educational authorities should consistently adhere to the principle of "education first, technology as a means." All technological applications should serve the literacy objectives stipulated in the *Curriculum Standards*, avoiding the pitfall of "technology for technology's sake." Clear guidelines for the application of AR in teaching should be formulated to regulate its scope, frequency, and instructional purposes [3]. Second, digital ethics and health safety must be carefully addressed. For young learners, ethical and health-related issues associated with AR use deserve particular attention. The duration of each AR session should be strictly controlled (recommended not to exceed 15 minutes), and devices must comply with child-centered ergonomic standards. Parameters such as screen brightness and blue light emission should meet established safety requirements. In addition, data privacy protection must be strengthened to ensure that students' learning data

are not misused.

3.2 Resource Development: Building a High-Quality and Systematic AR Content Repository

First, development should be closely aligned with textbooks and carried out in a systematic manner. AR content development should not be arbitrary or detached from instructional reality; rather, it must closely correspond to nationally approved primary school Chinese language textbooks. Systematic design can be conducted by unit or by thematic clusters (e.g., nature, family, school), ensuring seamless alignment between AR activities and classroom teaching progress. Each AR application should have clearly defined learning objectives, such as focusing on the discrimination of commonly confused characters or on understanding specific character formation methods (e.g., ideographic or phonetic–semantic compounds).

Second, cultural connotations and aesthetic value should be emphasized. AR content is not merely a technological display but also a medium for cultural transmission. When presenting Chinese characters, ancient scripts such as oracle bone inscriptions and bronze inscriptions should be incorporated, along with historical anecdotes and cultural meanings behind the characters. Meanwhile, the design of virtual models should pursue a concise, elegant, and child-friendly aesthetic style, subtly cultivating students' aesthetic sensibilities. Third, the UGC (User-Generated Content) model should be encouraged. At higher grade levels or at the teacher level, simplified AR creation tools can be provided to encourage teachers and students to collaboratively develop personalized AR-based literacy content. For example, students may add AR interactive effects to picture books they create themselves. This approach not only deepens their understanding of Chinese characters but also significantly enhances creativity and a sense of achievement.

3.3 Instructional Models: Innovating Classroom Organization and Activity Design

(1) The "AR+" Blended Instructional Model

AR technology should not completely replace traditional instruction; rather, it should function as a powerful supplement. A blended instructional process can be adopted, consisting of "introduction (AR-based situational engagement) – exploration (AR interactive learning) – consolidation (integration of traditional exercises and AR games) – extension (AR project-based learning)." For example, when teaching the lesson *Spring, Summer, Autumn, and Winter*, teachers can first use AR to present dynamic scenes of seasonal changes along with related vocabulary to stimulate interest. Next, through AR interaction, students can drag and drop characters such as "snow" and "flowers" into corresponding seasonal images. Finally, instruction returns to the textbook for reading aloud and handwriting practice, reinforcing literacy outcomes.

(2) Designing Diverse AR-Based Learning Activities

First, character origin exploration: students scan a character to watch an animated evolution from oracle bone script to regular script. Second, component assembly: students assemble radicals and components in a virtual space, similar to building blocks, to create new characters. Third, contextual character searching: students search for hidden new characters within AR-enhanced classroom scenarios and interact with them. Fourth, story theater: students take on roles within AR-based stories and apply learned characters through dialogue and actions [4].

(3) Promoting Collaborative Learning

AR tasks that require group collaboration should be designed, such as jointly constructing a "Chinese Character Castle" containing all previously learned characters or collaboratively solving AR-based puzzles. Such activities not only cultivate social skills but also deepen understanding through peer support and cooperative learning.

3.4 Teacher Development: Enhancing Teachers' TPACK Competence

The success of technology integration ultimately depends on teachers. Therefore, efforts must focus on enhancing teachers' Technological Pedagogical Content Knowledge (TPACK).

(1) Providing targeted professional training: Workshops should be organized not only to teach teachers how to operate AR software and hardware but also to help them understand the pedagogical principles underlying AR and to design or select appropriate AR activities aligned with instructional objectives.

(2) Establishing professional learning communities: Teachers should be encouraged to form AR-focused teaching and research groups to share exemplary practices, collectively reflect on challenges encountered in implementation, and develop school-based AR

teaching resource packages and instructional strategy collections.

(3) Offering sustained technical support: Schools should appoint professional educational technology specialists to provide timely technical assistance, alleviating teachers' concerns and ensuring smooth instructional implementation.

3.5 Evaluation System: Constructing a Diversified and Process-Oriented Assessment Mechanism

AR technology provides new tools for innovating literacy assessment.

(1) Using AR for formative assessment: AR systems can automatically record students' interaction data, including task completion time, number of attempts, and types of errors. Based on these data, teachers can conduct precise learning diagnostics and offer personalized guidance.

(2) Advocating performance-based assessment: Assessment should not be limited to paper-and-pencil tests. Students can be asked to present AR-based literacy products they have created or to complete comprehensive tasks within AR contexts (e.g., designing a guide map for a virtual zoo using learned characters) to evaluate their literacy quantity, comprehension, and application abilities.

(3) Emphasizing affective and attitudinal evaluation: By observing students' engagement levels, collaboration, and inquiry enthusiasm during AR activities, teachers can comprehensively assess learners' emotions and attitudes toward learning—an essential component of core competencies emphasized in the new curriculum standards.

Conclusion

AR technology has injected strong innovative momentum into Chinese character literacy instruction in the lower grades of primary school. Through immersive experiences enabled by the integration of virtual and real elements, multimodal interactive approaches, and support for embodied cognition, AR technology precisely responds to the core demands of literacy instruction—namely, concretization, contextualization, and engagement. Its integration logic is deeply rooted in modern learning sciences. However, technology is ultimately a means rather than an end. Effective empowerment depends on a systematic implementation path: from top-level design that adheres to educational values, to carefully developed instructional resources; from flexible and innovative instructional models, to teacher professional development that enables sustainable integration; and finally, to a scientific and comprehensive evaluation system. Only through such a holistic approach can AR technology truly move from "technical spectacle" to "deep instructional integration," from a decorative supplement to a structural pillar. In doing so, it not only safeguards the cultural roots of Chinese characters but also opens a gateway to wisdom and imagination for every child, allowing the ancient and sacred journey of literacy learning to flourish with unprecedented vitality and appeal in the digital age.

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