ISSN:2790-5160 Vol 4, No.1, 2026

An Application Study of Digital Storytelling in Bilingual (Chinese-English) Numeracy Education for Kindergarten Children

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Abstract

This study aims to explore the application value, implementation paths, and practical effects of digital storytelling as an innovative teaching medium in kindergarten bilingual (Chinese-English) arithmetic education. The research first reviews the theoretical foundations of digital storytelling, early childhood bilingual education, and early arithmetic ability development, establishing the necessity and feasibility of the study. Utilizing various research methods including literature review, case study, and action research, this paper analyzes current challenges in bilingual arithmetic education and constructs a design framework and implementation strategy centered on digital storytelling. A senior class in a specific kindergarten was selected for a one-semester teaching intervention. The results indicate that digital storytelling effectively stimulates children's interest and engagement in bilingual arithmetic activities. Within immersive bilingual contexts, children showed significant improvement in number concepts, operational abilities, and mastery of mathematical vocabulary in both Chinese and English. Furthermore, their cross-cultural awareness and comprehensive language skills developed accordingly. Finally, the study summarizes the advantages and challenges of applying digital storytelling in this field and proposes educational suggestions and future outlooks.

Keywords

Digital Storytelling; Bilingual Education; Arithmetic Education; Kindergarten; Chinese-English; Teaching Strategy.

1. Introduction

Against the macro background of national emphasis on preschool and bilingual education, early arithmetic education faces practical dilemmas such as monotonous teaching forms, fragmented bilingual environments, and a lack of interest among young learners. Cognitive development and constructivism theories emphasize that the formation of early number concepts must rely on vivid contexts. Digital storytelling, as a multimodal medium integrating narrative, imagery, sound, and interaction, transforms abstract arithmetic logic into intuitive visual narratives, providing technical support and innovative opportunities to overcome the dilemmas of bilingual arithmetic education. This study focuses on its effective application models, implementation effects, and key influencing factors.

At the theoretical level, this research aims to enrich the theoretical system of early bilingual arithmetic education and expand the application boundaries of digital storytelling in preschool education. At the practical level, it intends to provide frontline teachers with a set of

operable and efficient teaching methods to improve quality through digital narratives, promoting the coordinated development of mathematical logic and bilingual proficiency. The research content covers the entire process from conceptual definition and theoretical review to status analysis, strategy construction, practical verification, and reflective summary.

In terms of methodology, this study comprehensively utilizes literature review to solidify the theoretical foundation, case studies to draw from practical experience, and multiple rounds of action research as the core. In authentic teaching scenarios, observation and interview methods are employed to collect data on children's performance and teacher feedback, ensuring the authenticity and reliability of the research results. This multi-method approach aims to achieve a deep coupling between theoretical discussion and educational practice while dynamically iterating teaching strategies.

The innovation of this study lies in the cross-disciplinary integration of digital storytelling with the two educational hotspots of "Bilingualism" and "Arithmetic." The research constructs a localized strategic framework and emphasizes the verification of effectiveness within a real educational ecosystem. By embedding abstract numbers into a multilingual narrative environment, this study attempts to build an "immersive" early education model, providing a valuable new perspective for the information transformation of preschool education.

2. Conceptual Definition and Theoretical Foundation

In terms of conceptual definition, Digital Storytelling is regarded as a digital medium integrating narrativity, multimedia, interactivity, and emotionality. In the context of kindergarten bilingual education, it serves not only as a tool for language acquisition but also as a bridge for cognitive development and cultural perception. Given the concrete-imagistic thinking characteristics of young children, Arithmetic Education covers core contents such as number, quantity, shape, time, and space. Applying digital storytelling to bilingual arithmetic education essentially involves using it as a carrier to create vivid narrative contexts that guide children to perceive and apply mathematical concepts and linguistic expressions.

Knowledge Construction and Situational Support Theory provide a profound basis for this model. Constructivism posits that learners should actively construct knowledge through exploration; digital storytelling provides cognitive "scaffolding" through multimedia elements. Situated Learning Theory further points out that knowledge acquisition should not be isolated from its practical context. The realistic bilingual situations created by digital stories provide the optimal venue for the "active use" of language and logic. In these stories, children are no longer passive recipients but active explorers who spontaneously internalize knowledge through interaction.

Multimodal Learning Theory explains effectiveness from the perspective of cognitive processing. It suggests that learning is most effective when visual, auditory, and linguistic channels work in synergy. Digital stories precisely cater to children's reliance on multi-sensory information. This multimodal interaction reduces the cognitive load of switching between languages and promotes deep understanding of abstract logic through sensory compensation, transforming dry numerical symbols into perceptible narratives.

Finally, Gamified Learning Theory emphasizes embedding educational tasks into challenging and interesting plots. Digital stories transform arithmetic practice into part of the plot through suspense and "level-clearing" tasks. This model conforms to children's natural inclination for play and stimulates intrinsic motivation. In the process of resolving narrative conflicts, children not only master arithmetic skills but also experience a sense of achievement in immersive bilingual interactions, achieving high unity between education and entertainment.

3. Review of Relevant Research at Home and Abroad

International research regarding the integration of Digital Storytelling (DST) and early childhood education commenced early, with the research focus evolving from basic language proficiency to the deep integration of social-emotional development, cross-cultural awareness, and early STEM/STEAM education. A substantial body of empirical research demonstrates that digital technology, acting as a potent auxiliary tool in early education, can effectively enhance children's logical conversion abilities in bilingual environments through multi-sensory stimulation. Particularly in the development of early mathematical skills, international scholars such as Robin and Miller have highlighted that multimedia narratives can reify abstract mathematical symbols, significantly alleviating cognitive anxiety when children encounter complex logic. However, an overview of the international research landscape reveals that while the promotion of cognitive development via digital narratives is widely demonstrated, most studies remain confined to single disciplinary applications. Specialized empirical research focusing on the synergistic evolution of "language-mathematics" logic within a bilingual context is still in its nascent, exploratory stage.

Domestic educational research on the application of digital storytelling is currently transitioning from theoretical introduction to practical innovation. At present, the achievements of domestic scholars are primarily concentrated on the digital transformation of kindergarten language education and the exploration of gamified and contextualized mathematics instruction. Research generally emphasizes that engaging digital contexts can significantly improve children's classroom participation and the efficiency of knowledge internalization. Concurrently, with the popularization of bilingual education in Chinese kindergartens, various localized teaching models, such as "immersion" or "integrated" bilingual approaches, have emerged. However, a comprehensive literature review reveals that domestic research paths remain fragmented. In many teaching scenarios, DST is still regarded as a simple visual demonstration tool or a background supplement rather than a deep-seated instructional carrier. This superficial application has resulted in a persistent lack of systematic integration models in the intersecting field of bilingual instruction and arithmetic education.

In existing practical systems, language learning and the construction of number concepts often exhibit a "disconnected" phenomenon. Specifically, when conducting bilingual mathematics teaching, instructors frequently focus on the mechanical indoctrination of English vocabulary or the pure training of mathematical calculation skills, failing to identify an effective intermediary capable of carrying both "narrative logic" and "mathematical logic" simultaneously. Although domestic research acknowledges the superiority of multimedia

technology, there is a distinct lack of specific strategic design and quantitative evaluation regarding how to utilize the multimodal medium of DST to balance the conversion of Chinese thinking and English expression within arithmetic education. This gap between theory and practice restricts the process of children building high-quality mathematical thinking within a bilingual environment, often leading to a cognitive overload where the language barrier hinders mathematical understanding.

Synthesizing the research status at home and abroad, it is evident that while the combination of digital storytelling and preschool education is a matter of broad consensus, specialized research on the specific composite scenario of "bilingualism + arithmetic" remains scarce, and systematic, localized application strategy frameworks are lacking. The entry point of this study is rooted here, positioning digital storytelling as the core bond connecting linguistic contexts and mathematical logic. This study focuses not only on the medium characteristics of DST but also on its systematic strategy construction and empirical verification in bilingual arithmetic education. By delving into authentic teaching scenarios and filling the gap in composite teaching strategy design, this research aims to provide an empirically supported interdisciplinary integration paradigm for early education. It explores a win-win path where children naturally acquire both language and mathematical logic through the immersive exploration of digital stories.

4. Analysis of Current Status and Challenges

Chapter IV: Analysis of Current Status and Challenges of Digital Storytelling in Kindergarten Bilingual Arithmetic Education

Regarding the current teaching status, this study selected several representative kindergartens to conduct a multi-dimensional perspective of frontline bilingual arithmetic instruction through questionnaires, in-depth interviews, and classroom observations. The results indicate that while teachers generally recognize the intrinsic value of bilingual arithmetic education in promoting cognitive flexibility and logical reasoning, practical implementation remains problematic. Teaching methods still lean heavily toward mechanical repetition and rote memorization, lacking an effective interdisciplinary medium to bridge the two subjects. Due to the limitations of available resources, teachers often find it arduous to manage the switch between abstract mathematical logic and English linguistic expression. Consequently, they face practical dilemmas such as monotonous content and fluctuating student engagement, which prevent teaching activities from reaching the expected depth and breadth.

An analysis of the application of digital storytelling (DST) reveals that despite the high penetration rate of digital tools in kindergartens, their deep integration into the field of bilingual arithmetic is still in its infancy. Currently, teacher proficiency exhibits significant polarization: while some teachers possess basic multimedia playback skills, many show a distinct lack of competence in the independent design and creative production of digital stories. Existing applications often fall into the trap of "prioritizing technology over education," characterized by an over-reliance on flashy visual effects while neglecting the precise alignment between narrative content and instructional objectives. Furthermore, the selection of content is predominantly restricted to generic materials, lacking specialized

designs tailored to Chinese-English switching logic or specific arithmetic concepts such as number sequencing, one-to-one correspondence, and conservation. This misalignment often results in teaching effects that are merely superficial.

The application of digital storytelling faces severe multi-dimensional challenges. At the teacher level, instructors are confronted not only with a lack of digital narrative design skills but also the immense pressure of balancing bilingual proficiency with mathematical guidance. From a resource perspective, high-quality, ready-made digital stories that incorporate complete bilingual arithmetic logic are extremely scarce on the market. This scarcity forces frontline teachers to undertake the heavy burden of secondary resource development, which is often beyond their time and technical capacity. Additionally, significant individual differences in children's cognitive development and linguistic foundations mean that a single, rigid story model struggles to balance universality with personalized needs. Coupled with hardware limitations and a lack of real-time technical support in some kindergartens, the pace of digital transformation remains heavy and slow in actual implementation.

Moreover, the "disconnected" nature of current bilingual arithmetic lessons often leads to cognitive overload for young learners. Observations suggest that without a cohesive narrative thread, children struggle to process mathematical operations while simultaneously deciphering a second language. This fragmentation not only hinders the acquisition of number concepts but also diminishes the natural flow of language acquisition. The lack of a systematic framework for integrating these two domains means that technology is often used as a "digital blackboard" rather than a transformative pedagogical tool. Teachers reported that without high-quality digital "scaffolding," it is difficult to maintain a balance where neither the language nor the mathematics is sacrificed for the sake of the other.

However, within these challenges lie significant opportunities for development. The deep promotion of national educational informatization policies provides solid institutional support for the legitimacy and popularization of digital teaching methods. As the overall level of teacher education improves, the internal drive for professional growth through the mastery of new technologies is steadily increasing. Meanwhile, there is a strong expectation among parents for high-quality, innovative, and internationalized education, creating a favorable social atmosphere for the introduction of digital storytelling as a new medium. The synergy of policy dividends, professional self-reflection, and market demand is pushing digital storytelling from a "supplementary tool" toward a "core carrier" in bilingual arithmetic education. This shift provides a vast space for the construction of the application strategies explored in the following chapters, turning a technological challenge into a catalyst for pedagogical evolution.

5. Strategy Construction and Practice

The construction of application strategies must follow five principles: interest, contextuality, bilingual emphasis, interactivity, and development. This study established a closed-loop framework covering "resource screening/creation → instructional design → activity implementation → evaluation/reflection." This framework emphasizes the continuity of teaching activities, transforming digital stories from visual tools into dynamic carriers that drive children to actively construct mathematical experiences.

In the creation phase, strict quality standards should be established. Themes should be closely linked to life experiences, such as "supermarket shopping," to provide a sense of reality. The narrative structure should adopt a "climax" logic where mathematical challenges resolve the plot. In bilingual integration, core vocabulary (e.g., add, subtract) should be embedded naturally and frequently, with visual cues aiding comprehension. Multimedia elements should follow the "non-interference" principle, ensuring animations reinforce concepts rather than distracting the learner.

Instructional implementation focuses on the evolution of "Context Introduction — Interactive Exploration — Experience Transfer." Before the activity, suspense and vocabulary warming create a psychological scaffold. During the activity, teachers drive thinking through guided questions and use physical props to "materialize" virtual problems. Here, the teacher is a "narrative guide," reinforcing bilingual expression through demonstration. After the activity, extended tasks like drawing or building transfer logic to real life, with results shared via home-school platforms.

Case Study 1: "Little Bear's Birthday Party" focused on "Addition within 5." Children count gifts in both languages (one to five) and solve tasks like "1 apple plus 2 oranges." Teachers used interactive "hotspots" on the screen for children to click and count, reinforcing "How many?" and "plus." Results showed that the vivid setting significantly reduced children's resistance to addition, allowing them to internalize concepts in a joyful atmosphere.

Case Study 2: "Adventure in Shape Kingdom" focused on "Basic Shape Recognition." The protagonist identifies shapes (circle, square, triangle) as "secret codes" to pass levels. Teachers guided children to "find shapes around them" using physical blocks while watching. This model gave life to geometric attributes; children not only mastered English terms but also deepened their spatial understanding through comparison and assembly.

6. Research Results and Analysis

The findings of this study, derived from a comparative analysis of observation records and interview data, demonstrate that digital storytelling significantly enhances both learning interest and classroom engagement among preschool children. Following the introduction of digital storytelling, the duration of children ' s sustained attention during lessons was markedly extended compared to traditional teaching models. There was a substantial increase in the frequency of proactive questioning and spontaneous interaction. Analysis of children's work further reveals that vivid, plot-based narratives effectively dissolve the inherent tediousness of arithmetic learning. Students displayed a pronounced preference for "level-clearing" arithmetic tasks embedded within stories. Interview results confirm that children not only developed a profound memory of the arithmetic logic within the narratives but also experienced a heightened desire for exploration due to emotional projection, successfully transitioning from "passive reception" to "active immersion."

In terms of competency outcomes, a comparison of pre-test and post-test data indicates significant improvements across several dimensions, including number concepts, basic addition and subtraction operations, and spatial perception. The tracking of specific cases reveals that digital storytelling provides an effective cognitive scaffold for children, enabling

them to acquire mathematical vocabulary more efficiently within a bilingual environment. The willingness and quality of bilingual communication — using both Chinese and English to discuss mathematical problems — showed a notable upward trend. By anchoring abstract numbers to concrete narrative events, children were able to bypass the cognitive barrier of language switching, demonstrating a more fluid integration of bilingual expression and logical reasoning.

Furthermore, the implementation of this pedagogical approach facilitated profound professional growth among the participating teachers. There was a definitive shift in teaching philosophy, moving from the role of a "knowledge transmitter" to that of a "context creator and facilitator." Teachers not only mastered the technical skills required for creating digital stories but also significantly enhanced their abilities in bilingual instructional organization, classroom observation, and reflective practice. This evolution allowed teachers to better identify the "Zone of Proximal Development" for individual children, providing timely and personalized feedback. The transition underscored the importance of pedagogical content knowledge (PCK) in the digital age, where the teacher's role is to mediate the relationship between technology and the learner.

The study ultimately illustrates the construction of a high-quality educational ecosystem characterized by the mutual growth of teachers and students. The synergistic effect of "narrative + bilingual + arithmetic" creates a multi-dimensional learning space that respects children's natural inclination toward play while maintaining academic rigor. The digital story serves as a shared cognitive territory where children develop mathematical literacy and linguistic fluency simultaneously. This ecological approach to teaching ensures that the information transformation of the classroom is not merely a change in tools, but a fundamental optimization of the learning experience, fostering a sustainable interest in both language and mathematics that extends beyond the classroom environment.

7. Conclusion and Outlook

This study concludes that digital storytelling significantly enhances the interest and effectiveness of kindergarten bilingual arithmetic education, resolving the problems of fragmented environments and monotonous content. The constructed "Creation — Implementation — Reflection" framework is highly operable and demonstrates the great potential of digital storytelling in promoting the coordinated development of "arithmetic logic" and "bilingual expression." Therefore, the study recommends that teachers embrace integrated education and digital literacy; managers should strengthen hardware support and resource-sharing platforms; and policymakers should focus on the fusion of emerging technologies with early education.

Despite these results, the study is limited by a small sample size and short duration; the long-term cognitive effects require further validation. Future research will focus on developing systematic bilingual arithmetic resource packages to reduce teacher workload. Furthermore, as Generative AI (AIGC) matures, exploring how to use AI for personalized, adaptive digital storytelling and conducting larger-scale evidence-based research will become core tasks for the information transformation of early bilingual arithmetic education.

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