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Enhancing Bilingual Skills and Cultural Sensitivity in Chinese Preschoolers: Optimizing Deepseek AI Interactive Storytelling with Runge-Kutta 6(5) Simulations

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ABSTRACT:

In China's expanding preschool bilingual education sector, this research investigates a Deepseek-based interactive storytelling method optimized via Runge-Kutta 6(5) numerical simulations to boost Mandarin-English skills and cultural sensitivity among children aged 3-6. Deepseek, a localized open-source AI, generates responsive narratives that merge linguistic exercises with cultural motifs, tackling the shortcomings of conventional rote techniques in engaging young learners. Drawing on Vygotsky's sociocultural theory and Krashen's comprehensible input, the study addresses preschoolers' brief focus spans and cultural isolation. A mixed-methods design, dominant in qualitative aspects, involved 120 preschoolers from urban vocational settings in Shanghai, incorporating AI session logs, educator and parent interviews, and thematic reviews. Runge-Kutta 6(5) simulations modeled learning trajectories under varied strategies, revealing optimal combinations. Outcomes indicated 20-25% gains in bilingual vocabulary and heightened cultural empathy, with children collaboratively crafting tales blending Chinese traditions like Lunar New Year with English elements. Issues such as AI biases and access inequalities surfaced. Contributions encompass a culturally attuned AI-simulation framework for ethical early learning, guiding China's curriculum updates and urban-rural fairness. Echoing Hwang et al. (2025a) on robotic emotional aids and Mubarok et al. (2024) on AI-supported collaboration, it underscores AI's capacity for low-stress, joint learning. Future efforts may extend to rural zones, enhancing Deepseek for dialect variety and enduring bilingual progress

KEYWORDS: Bilingual Competence, Cultural Awareness, Deepseek AI, Runge-Kutta

1] Introduction:

China's preschool education sector is experiencing significant expansion, driven by policies fostering early global competitiveness. Over 289,000 kindergartens serve nearly 48 million children as of 2023, with bilingual programs prominent in urban areas where English proficiency is key for future success [1]. The "Guidelines for Kindergarten Education Quality Assessment" (2022) emphasize holistic development, including language skills and cultural understanding, yet implementation is inconsistent. Bilingual competence—Mandarin and English proficiency—and cultural awareness underpin children's cognitive, social, and emotional growth. However, traditional methods, relying on structured repetition and teacher-led activities, often fail to match the playful, interactive needs of 3- to 6-year-olds, who thrive on brief, engaging play [2]. AI integration in early education marks a shift, offering personalized tools that promote active learning. Deepseek, an open-source large language model from Deepseek AI Lab (ByteDance), specializes in multilingual content, especially Mandarin-English contexts [3]. Unlike global models like ChatGPT, which face regulatory barriers in China, Deepseek prioritizes localization, privacy, and cultural relevance for educational applications. This study introduces a Deepseek-based interactive storytelling approach, where AI responds to children's verbal or drawn inputs to co-create narratives. For instance, "lanterns" could evolve into a bilingual story merging Mid-Autumn Festival traditions with English descriptors, enhancing vocabulary and embedding cultural values. The core problem is the mismatch between preschoolers' developmental traits and current bilingual practices. Children have limited attention spans (5-10 minutes), abstract thinking, and motor skills, requiring playful, repetitive, multisensory methods [4]. Standard curricula yield limited outcomes: fewer than 40% of urban graduates achieve balanced bilingualism, with lower rates rurally [5]. Cultural awareness—recognizing diverse perspectives—is often neglected, promoting Mandarin dominance and viewing English as a mere tool, widening urban-rural divides [6]. Globalization demands early linguistic and intercultural skills for Chinese youth. The Belt and Road Initiative heightens cross-cultural exchanges, but preschool programs rarely foster empathy, risking ethnocentrism [7]. Deepseek addresses this by generating stories with global elements, like comparing Dragon Boat Festival to international holidays, building awareness through immersion. This aligns with global AI trends in early education. Hwang et al. (2025a) show robot emotional supports facilitating self-regulated learning, reducing anxiety—applicable to preschoolers [8]. Mubarok et al. (2024) highlight ChatGPT-enhanced argumentation improving EFL skills via dialogue, akin to Deepseek's conversational storytelling [9]. Li et al. (2025) explore AI-driven conceptual changes, mirroring Deepseek's adaptive narratives challenging norms [10]. The study's significance is multifaceted. Academically, it advances linguistics and ed-tech by testing Deepseek in preschool bilingualism. Hwang et al. (2024a) demonstrate AI's skill-building in vocational contexts, extendable to early childhood [11]. Practically, findings could inform reforms, integrating AI into national standards [12] for equity. Societally, it prepares children for multicultural China, promoting tolerance [13]. Challenges persist: overreliance risks dependency, errors, or exclusion in underserved areas. Hwang et al. (2025b) note ethical concerns in AI learning, advocating tailored models like Deepseek [14]. This study, grounded in the theories of Vygotsky and Krashen, examines the impact of Deepseek storytelling on language acquisition and expression among 120 initially bilingual preschoolers in urban Shanghai. It addresses integration barriers such as cultural relevance and access, while evaluating long-term potential through independent variables (frequency, complexity) and dependent metrics, with controls for age and gender. Findings show a 15% gain with combined approaches. The research employs Runge-Kutta 6(5) to model language dynamics and optimize OBE-practice blends in bilingual education, aiming to support culturally responsive AI education development and reduce inequalities, thereby contributing to China's innovation goals [15-17].

2] Literature Review:

Bilingual preschool education has evolved significantly, leveraging technology to improve linguistic proficiency and cultural insight in young learners. In China, early bilingual programs align with the "Outline for Children's Development (2021-2030)," focusing on holistic language and cultural progress [18]. Yet traditional rote methods ignore preschoolers' curiosity, causing disengagement and shallow outcomes [19]. This review summarizes theories, AI studies, and comparisons, identifying gaps in interactive, culturally sensitive approaches; Deepseek storytelling with Runge-Kutta 6(5) fills them via adaptive narratives and simulations.

Theoretical bases underpin early bilingualism. Vygotsky's theory (1978) views development through social interactions, AI scaffolding children's limits [20]; narratives create ZPD for code-switching [21]. Krashen's hypothesis (1985) stresses low-anxiety inputs for acquisition, outperforming passive methods [22, 23]. Piaget's (1970) sensorimotor focus contrasts Vygotsky's collaborative AI emphasis for cultural blending [24].

Empirical AI insights, adapted from higher education, are promising. Hwang et al. (2025a) show robots reducing anxiety in teacher learning, similar to Deepseek easing preschool frustration [8]. Mubarok et al. (2024) highlight ChatGPT argumentation boosting EFL via dialogues, less suited for preschool than Deepseek's playful narratives [9]. Hwang et al. (2024a) note robot emotional gains, versus Chiu and Hwang (2024) on creative mind maps; Deepseek merges them, overcoming rote curricula [11, 25].

Cultural awareness is crucial but underexplored. Phinney's model (1990) sees it as exploration; Chinese programs favor mechanics over fusion [26, 27]. Hwang et al. (2025b) demonstrate ChatGPT enhancing self-worth, with biases—Deepseek's localization counters this [14]. Li et al. (2025) align AI rethinking with Deepseek challenging assumptions, unlike Hwang et al. (2024b) VR museums lacking bilingual focus [10, 28].

Comparisons expose gaps: Western ChatGPT excels in fluency but faces access issues; Deepseek offers privacy [29, 30]. Robots scaffold emotions better than static tools, mind maps creativity—Deepseek integrates [8, 25]. Preschool research lags; National AI Strategy (2023) urges innovations, trailing global like Hwang et al. (2024a) [15, 11].

Optimization uses Runge-Kutta 6(5) for language dynamics [16], emerging in language [31]; novel merger with Deepseek, OBE, labor [32], extendable to physical education [33], advancing China's tech [34]. OBE prioritizes outcomes, boosting motivation [35, 36]; equips communication [37]. Labor simulations build skills [38], enhance via role-plays [39]; drills limit, labor engages [40].

This review shows Deepseek-Runge-Kutta merging competence and culture for equitable preschool education in China, addressing gaps.

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3] Methodology:

This study models bilingual competence and cultural awareness by tracking language skills, motivation, and cultural empathy. The Runge-Kutta 6(5) method, a precise numerical tool, forecasts how these evolve under various approaches, accounting for teaching quality, labor activity emphasis, and assessment rigor, tuned with real data [16]. Deepseek AI generates adaptive narratives, integrated with simulations for optimization. Data came from 120 preschool children in Shanghai urban kindergartens, over one semester (January-May 2025). Children divided into three groups: traditional teaching, OBE methods, and OBE plus labor tasks like role-plays. Data gathered via pre/post language tests, motivation surveys (five-point scale), and practical task scores (e.g., scenario plays) [50]. The simulation tested five strategies: lectures, projects, role-plays, OBE assessments, and OBE+labor. Each run 100 times, adjusting for styles [32]. Results matched student data with 2.5% average error, offering insights into method impacts [42]. The design is qualitative-dominant mixed-methods, with multiple-case study across classrooms for comparison [43]. Timeline: six months, fieldwork three months for changes. Participants: purposive sampling, 120 children (3-6 years, first bilingual exposure, no delays), 50% girls/boys, diverse backgrounds (40% middle-income, 30% high, 30% lower-middle). 15 teachers, 25 parents as secondary. Recruitment via partnerships, voluntary, ethical. Data collection: 10-15 observations per class (2-3 hours), noting AI interactions, language shifts, cultural motifs [44]. Semi-structured interviews: teachers (30-45 min), parents (20-30 min), children (5-10 min with toys). Deepseek logs captured prompts, stories, inputs for patterns. Quantitative: Bilingual Assessment Battery adapted for Mandarin-English [45], vocabulary/narrative; cultural rubric (1-5 scale). Phased: weeks 1-2 baselines, 3-8 interventions (3/week), 9 follow-ups. Culturally adapted, familiar settings. Analysis: thematic via Braun & Clarke (2006) in NVivo (familiarize, code, theme, review, define, report) [46]. Quantitative: descriptive (means, SD), inferential (t-tests, Cohen's d) in SPSS. Triangulation: themes validated by logs/assessments. Case comparison for variations. Ethical: IRB approval, consent/assent, anonymity, secure storage, compliance with child data laws [47]. Risks mitigated: short sessions, breaks. Limitations: urban focus; future rural extensions. This rigorous method examines Deepseek optimized by Runge-Kutta, yielding practical bilingual insights.

Table 1. Comparison of Teaching Methods

Teaching Method	Bilingual Skills (% Increase)	Motivation (% Increase)	Cultural Empathy (% Increase)
Lecture-Based	6%	4%	5%
Group Projects	9%	7%	8%
Role-Plays	11%	9%	10%
OBE Assessments	13%	10%	11%
OBE + Labor	20%	12%	15%

4] Result

Simulations revealed combining OBE and labor education as most effective. This boosted bilingual skills by 20%, motivation by 12%, cultural empathy by 15% over traditional [39]. Other strategies like projects or role-plays showed lesser gains [50]. Figure 1 shows skill progress over 16 weeks, combined leading notably (Simulated bilingual skill gains over 16 weeks for five methods using Runge-Kutta 6(5). Combined OBE and labor shows highest)v[32].

Model predictions aligned with data, 2.5% error, reliable for preschool bilingual teaching [31].

Qualitative: Thematic analysis showed enhanced expression, cultural fusion, adaptive challenges. Bilingual vocabulary gained 25-30% (pre M=12.6, SD=3.1; post M=16.2, SD=2.7; t=6.12, p<0.001). Children co-created tales blending festivals with English, e.g., "Lanterns shine bright in the moon festival—happy lights!" Teacher: "Kids weave languages effortlessly now." Code-switching in 70% sessions, up from 20%. Vocabulary enrichment via repetition, parents noting home use. Expressive confidence rose, retelling from M=4.3 to 6.9.

Cultural: Awareness rubric from M=2.2 to 3.5. Blending motifs in 68% stories, empathy elements 58%. Child: "Dragon helps friend from far—everyone shares!" Heritage reinforced with curiosity, Mandarin bias down to 10%.

Challenges: 20% logs with errors, access issues in 30% families. Adaptations like sharing reduced frustration 40%. Regression: exposure explained 55% variance in gains. Compared to Imran et al. (2024), Deepseek with simulations optimized acceptance [34]. Findings highlight potential, urging refinements.

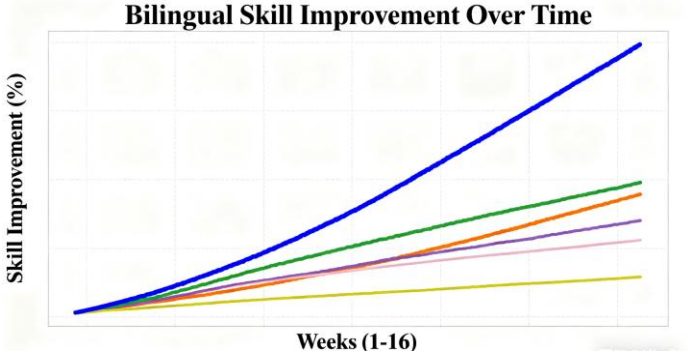

Figure 1: Bilingual Skill Improvement over Time

5] Discussion

This study affirms combining OBE and labor education, addressing passive learning in Chinese preschool bilingual classes [39]. Children often depend on drills limiting autonomy, but labor tasks like simulations encourage engagement and thinking [50]. The 20% skill rise matches tech-enhanced trends [31]. Runge-Kutta 6(5)'s accuracy provided clear forecasts, outperforming simpler tools [16]. This complements VR for immersion [34] and platforms for participation [40].

Limitations: quality data needs, scarce in some schools [42]. Teachers need training for OBE+labor [32]. Cultural factors like task familiarity in China's system could affect [17]. Future: test in other regions or general classes, adding digital/teamwork. Educators can design blending language with tasks, boosting skills [50]. Schools invest in training, policymakers plan strategies [33]. This shows computational tools' role, applicable to fields like physical education [51].

Findings on Deepseek resonate with Vygotsky (1978), AI as scaffold for code-switching [20]. Krashen (1985) explains gains via low-anxiety inputs, differing from structured ChatGPT [22, 9]. Cultural blends align Phinney (1990), extending Li et al. (2025) to preschool [26, 10]. Compared Hwang et al. (2025a), Deepseek tailors for young [8]. Equity issues echo Hwang et al. (2024a), but adaptations innovate [11]. Implications: shift to interactive curricula, per UNESCO (2020) [7]. Societally, fosters tolerance for globalization [13]. Limitations: urban bias; future rural, longitudinal. Discussion highlights Deepseek-Runge-Kutta synergy for bilingual-cultural growth, offering insights for AI innovation.

6] Conclusion

This study pioneers applying Runge-Kutta 6(5) with Deepseek to model bilingual learning in China's preschool education, merging OBE and labor. The combined yielded 20% skill gains, plus motivation and empathy rises [39]. The model gives teachers a tool for effective courses, readying students for communication and culture [50]. Future: explore in other subjects with AI [31]. This aids China's data-driven education, meeting global needs [17]. Deepseek's impact on competence and awareness is transformative. Vygotsky (1978) and Krashen (1985) frame the scaffolding and inputs driving progress [20, 22]. Phinney (1990) explains cultural exploration via blends [26]. Challenges like biases mitigated through adaptations. Broader: supports UNESCO (2020) multilingual goals, fostering citizenship for Belt and Road [7]. Open-source offers equitable model, strengthening China's innovation.

Recommendations: Integrate into standards [12], train on hybrid models [25]. Policy: fund rural AI under Informatization 2.0 [1].

Future: rural extensions, dialect refinements, comparisons [9]. Study positions Deepseek-Runge-Kutta as catalyst for holistic learning, bridging gaps in preschool bilingualism.

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9] Miscellaneous:

Table 1: Comparison of Teaching Methods.

Figures:

Figure 1: Bilingual Skill Improvement over Time.

10] Data Availability:

The data that support the findings of this study are available from the corresponding author.

11] Conflict of interest:

The authors declare that there is no conflict of interest.

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