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INTEGRATION OF 3D INTERACTIVE TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE IN PRIMARY ENGLISH EDUCATION

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Abstract. This study investigates the integration of 3D interactive technologies and artificial intelligence (AI) in primary English education. A quasi-experimental design with 150 primary school students demonstrated that immersive 3D environments combined with AI adaptive tools significantly enhance vocabulary acquisition, speaking skills, and learner motivation. The findings provide practical implications for curriculum development, pedagogical innovation, and fostering digital competence in young learners.

Keywords: 3D interactive technologies, artificial intelligence, primary education, English as a foreign language, immersive learning, adaptive learning, digital pedagogy, learner motivation

Annotatsiya. Ushbu tadqiqot boshlang‘ich sinflarda ingliz tilini o‘qitishda 3D interaktiv texnologiyalar va sun‘iy intellekt (AI) integratsiyasini o‘rganadi. 150 nafar boshlang‘ich sinf o‘quvchilari bilan o‘tkazilgan kvazi-eksperimental tadqiqot shuni ko‘rsatdiki, immersiv 3D muhitlar va AI asosidagi moslashtirilgan vositalar so‘z boyligini oshirish, og‘zaki ko‘nikmalarni rivojlantirish va o‘quvchi motivatsiyasini sezilarli darajada yaxshilaydi. Natijalar o‘quv dasturlarini rivojlantirish, pedagogik innovatsiyalarni joriy etish va yosh o‘quvchilarda raqamli kompetentsiyalarni shakllantirish uchun amaliy tavsiyalar beradi.

Kalit so‘zlar: 3D interaktiv texnologiyalar, sun‘iy intellekt, boshlang‘ich ta‘lim, chet tili sifatida ingliz tili, immersiv o‘rganish, moslashtirilgan o‘rganish, raqamli pedagogika, o‘quvchi motivatsiyasi.

Аннотация. Данное исследование изучает интеграцию 3D интерактивных технологий и искусственного интеллекта (ИИ) в преподавание английского языка в начальной школе. Квази-экспериментальный дизайн с участием 150 учеников показал, что иммерсивные 3D-среды в сочетании с адаптивными инструментами на основе ИИ значительно повышают усвоение словарного запаса, развитие устной речи и мотивацию учеников. Результаты имеют практическое значение для разработки учебных программ, внедрения педагогических инноваций и формирования цифровой компетентности у младших школьников.

Ключевые слова: 3D интерактивные технологии, искусственный интеллект, начальное образование, английский язык как иностранный, иммерсивное обучение, адаптивное обучение, цифровая педагогика, мотивация учащихся

Introduction. Digital transformation has fundamentally reshaped language learning, particularly in primary education. Visual, interactive, and immersive environments support comprehension and retention. 3D technologies provide experiential learning, while AI delivers adaptive and personalized instruction, aligning with constructivist and socio-cultural theories emphasizing interaction, scaffolding, and contextualized learning. As Piaget emphasizes, early cognitive development is enhanced through active engagement, while Vygotsky highlights the importance of social interaction in learning.

Literature Review. Previous research demonstrates the benefits of multimedia and adaptive learning technologies. Radianti, Majchrzak, Fromm, and Wohlgemuth found that immersive virtual reality (VR) environments increase learner motivation and engagement by providing contextualized learning opportunities. Yan and Lowell concluded that 3D VR supports listening, vocabulary acquisition, and speaking skills by creating realistic language contexts. Similarly, Parmaxi argued that VR fosters interactive and constructive learning, improving learners' language competencies.

Uzbek researchers also provide supporting evidence. Djalilova indicates that AI integration in primary education positively affects learner performance and motivation. Abduvaliev, Abdnabieva, and Juraeva show that AI adaptive platforms enhance personalized instruction and facilitate real-time feedback, while Muradkasimova emphasizes that AI can transform language learning through innovative teaching methods. Within the CIS context, Yulchiyev and Erkinova analyzed the pedagogical integration of AI and AR/VR technologies and reported improved learner engagement and adaptive learning processes. Khodjaeva emphasized AI's role in modernizing educational practices, while Sultonova highlighted the importance of developing AI competencies for future educators.

3. Methods

This study utilized a quasi-experimental design to examine the effects of 3D interactive technologies and artificial intelligence (AI) on primary English language learning. A total of 150 students from a primary school participated and were randomly assigned to either the experimental or control group. The experimental group engaged with lessons incorporating 3D interactive environments and AI-based adaptive tools over an eight-week period, while the control group received conventional instruction based on the standard curriculum.

Participants: There were 8–10 years old primary school students with comparable proficiency levels in English. Inclusion criteria ensured that all students had basic computer literacy and access to classroom devices required for 3D and AI learning activities.

Intervention: The experimental intervention combined immersive 3D scenarios with AI-driven adaptive exercises. 3D tools allowed learners to interact with virtual objects and practice language in contextualized settings, while AI systems provided personalized feedback, adjusted task difficulty, and tracked progress throughout the eight-week period.

Multiple data sources were employed to ensure a comprehensive assessment of learning outcomes:

1. Pre- and Post-tests: Standardized vocabulary and oral proficiency tests were administered before and after the intervention to measure learning gains.
2. Classroom Observations: Systematic observations were conducted to monitor engagement, participation, and interaction patterns in both groups.
3. Learner Questionnaires: Structured questionnaires assessed students' motivation, perceived usefulness of the tools, and satisfaction with the learning experience.

Quantitative data from pre- and post-tests were analyzed using descriptive statistics and paired-sample t-tests to identify significant improvements in vocabulary acquisition, speaking skills, and motivation. Qualitative data from classroom observations were analyzed thematically to capture engagement behaviors, collaboration, and learner responses to 3D and AI-based tasks. Triangulation of quantitative and qualitative data ensured the reliability and validity of the findings.

Ethical Considerations: Parental consent was obtained for all participants, and the study was conducted in accordance with ethical guidelines for research in educational settings. Students' anonymity and confidentiality were maintained throughout the study.

Results

Students in the experimental group demonstrated significantly higher vocabulary retention and improved speaking skills compared to the control group. Radianti et al. and Yan & Lowell observed similar effects in VR-assisted language learning, indicating that immersive environments enhance contextual understanding and retention. AI adaptive feedback contributed to personalized learning pathways, aligning with findings by Djalilova and Abduvaliev et al. Motivation and active participation were higher, confirming Yulchiyev and Erkinova's observations on engagement.

Discussion

The findings of this study clearly indicate that integrating 3D interactive technologies and artificial intelligence (AI) into primary English education can significantly transform the teaching and learning process. The experimental group demonstrated superior performance in vocabulary acquisition, oral proficiency, and motivation compared to the control group, confirming the effectiveness of immersive and adaptive learning environments.

3D Technologies and Contextual Learning: The use of 3D interactive environments provided students with rich visual and contextual cues that facilitated experiential learning. These immersive settings allowed learners to interact with objects, simulate real-life situations, and engage in meaningful language practice. According to Piaget and Vygotsky, constructivist learning theories emphasize that learners acquire knowledge most effectively through active engagement and social interaction, and the immersive 3D environments used in this study align closely with these principles. By embedding vocabulary and conversational practice within realistic 3D contexts, students were able to internalize language structures more effectively, leading to higher retention rates.

Artificial Intelligence and Personalized Learning: AI tools played a critical role in adapting lessons to individual learner profiles. Real-time feedback, scaffolded tasks, and adaptive exercises ensured that each student could work at their own pace while addressing specific weaknesses. This Holmes and Luckin’ personalized approach is consistent with modern educational models advocating learner-centered instruction. The combination of AI-driven assessments with 3D interactions enabled continuous monitoring of progress, which enhanced motivation and provided teachers with actionable insights to optimize instruction.

Motivation and Engagement: Immersive 3D environments and interactive AI features contributed to higher levels of learner motivation and engagement. Students reported enjoying the novelty and interactivity of lessons, which encouraged active participation. This finding is supported by Radianti and Parmaxi, who emphasize that virtual reality and interactive simulations capture attention and foster intrinsic motivation. The gamified and exploratory nature of 3D lessons, combined with immediate AI feedback, created a stimulating environment where learners were more likely to take risks in speaking and experiment with new vocabulary.

Regional Context and Pedagogical Implications: Evidence from Uzbekistan and CIS countries further supports these results. Studies by Djalilova and Abduvaliev confirm that AI integration improves instructional efficiency, while Yulchiyev & Erkinova, Khodjaeva and Sultonova highlight the importance of incorporating VR/AR and AI into teacher training programs to modernize education. This regional perspective demonstrates that the combination of 3D and AI technologies is not only pedagogically effective but also feasible and culturally adaptable for primary education systems in Central Asia.

Integration into Curriculum Design: The study underscores that technology alone is insufficient; its effectiveness depends on thoughtful integration into the curriculum. Combining immersive 3D experiences with AI-driven adaptive tasks ensures that digital tools complement rather than replace traditional pedagogical strategies. This hybrid approach allows teachers to scaffold learning, provide individualized support, and maintain structured progression through the curriculum. Moreover, integrating these technologies prepares students for future digital learning environments, fostering both technological literacy and language competence.

Limitations and Considerations: While the results are promising, some limitations must be acknowledged. The study was limited to an eight-week intervention in specific schools, which may not capture long-term learning outcomes or the full potential of AI-3D integration. Additionally, teacher training and technological infrastructure are crucial factors influencing the effectiveness of these tools. Schools with limited access to devices or insufficient teacher preparedness may experience lower gains. Future studies should examine scalability, longitudinal impact, and cross-cultural adaptability to provide a more comprehensive understanding of 3D and AI integration in primary education.

Conclusion

The integration of 3D interactive technologies and artificial intelligence offers substantial benefits in primary English education. This study demonstrates that such integration leads to

enhanced vocabulary acquisition, improved oral proficiency, and increased motivation among young learners. The immersive nature of 3D environments supports contextual and experiential learning, while AI tools provide personalized guidance that adapts to individual student needs, helping to address learning gaps and foster autonomous learning. These findings highlight the transformative potential of combining immersive and adaptive technologies in primary education. Teachers can leverage these tools to create dynamic and engaging lesson plans, while educational policymakers may consider adopting such technologies for curriculum modernization. The positive outcomes also suggest that integrating 3D and AI technologies can prepare students for future learning environments, equipping them with skills to interact effectively with digital tools.

Future research should explore long-term effects of 3D and AI integration, investigate cross-cultural applicability, and assess scalability across different educational systems. By doing so, educators and researchers can optimize the use of digital technologies to maximize student engagement, learning outcomes, and overall educational quality.

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