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Review Article

Challenges in Implementation of Augmented Reality in Indian Dental Education: An Overview

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Abstract

Augmented reality represents transformative technology with substantial potential for enhancing dental education through interactive three-dimensional visualization and immersive learning experiences. Despite documented educational benefits globally, implementation within Indian dental institutions encounters significant barriers encompassing economic constraints, inadequate technological infrastructure, faculty preparedness deficits, steep learning curves, limited institutional support systems, curriculum integration complexities, student acceptance variations, and maintenance requirements. Understanding these multifaceted challenges is essential for developing contextually appropriate implementation strategies that can facilitate successful adoption of augmented reality technologies within resource-limited educational environments characteristic of developing countries.

Keywords: *dental education; augmented reality; dental curriculum.*

Introduction

Augmented reality technology superimposes computer-generated digital information onto real-world environments, creating enhanced interactive learning experiences that improve spatial perception and procedural understanding [1]. Conventional preclinical training faces financial, ethical, and supervisory constraints that limit effective skill development [2]. Research demonstrates that augmented reality applications in dental education offer 24-hour accessibility, objective performance evaluation, and interactive learning concepts that enhance student engagement [1]. While augmented reality presents promising solutions for addressing these limitations, Indian dental institutions encounter substantial implementation challenges requiring systematic examination and strategic planning [3]. This review provides concise summary of challenges in implementation of augmented reality in Indian dental education.

Infrastructure and Economic Barriers

High equipment costs represent the most frequently cited obstacle preventing widespread augmented reality adoption in dental education settings [4]. Initial investment requirements for augmented reality hardware, software licenses, and maintenance systems create prohibitive financial burdens, particularly for smaller dental institutions and government-funded colleges operating under budgetary constraints [5]. The expensive nature of dental implant supplies and advanced simulation equipment impedes effective training infrastructure development [6]. Inadequate digital infrastructure, including unstable internet connectivity and limited institutional investment in learning management systems, constrains

effective content delivery and platform accessibility [5]. Many Indian dental students lack personal access to high-performance computing devices required for optimal augmented reality application functionality [7]. Technical malfunctions and system failures can disrupt educational workflows, potentially compromising the consistency of student learning experiences [8].

Faculty Development and Curriculum Integration Challenges

Insufficient technical competencies among faculty members represent significant impediments to successful augmented reality implementation [9]. Training dental professionals to become proficient with sophisticated augmented reality tools requires time-intensive ongoing education programs that many institutions cannot adequately support [4]. Limited faculty training accessibility, with only 20% of public institution educators receiving digital technology instruction, exacerbates preparedness gaps [1]. Resistance from traditional sectors within dentistry can slow integration of augmented reality into both educational programs and clinical practice environments [4]. Lack of structured policies and institutional support systems creates uncertainty regarding acceptability and standardization of augmented reality methodologies [1]. Dental education requires spatial imagination to acquire theoretical knowledge, a requirement that may not be fulfilled through traditional learning environments alone [2]. However, integrating advanced simulation systems into existing curriculum frameworks presents coordination difficulties when multiple faculty members contribute using varied teaching approaches [5].

Technical Specifications and Learning Curve Limitations

Augmented reality devices must offer high-resolution graphics and seamlessly integrate digital information with real-world environments while ensuring precise alignment without causing user disorientation. Mastering augmented reality technology requires steep learning curves that demand additional training and adaptation time for both educators and students [4]. Absence of globally accepted documentation standards and challenges with incomplete recording interfaces without adequate usability features complicate system adoption [5]. Developing countries face many challenges regarding implementation of digital health technologies, including dental informatics systems essential for augmented reality integration [2]. Lack of standardization and accreditation of augmented reality systems and content limits confidence in educational outcomes and transferability across institutions [5]. Infrastructure readiness, prior-knowledge readiness, expectations, and learner attitudes must be understood comprehensively to achieve effective technology integration [3].

Student Acceptance and Digital Competency Gaps

Digital competency gaps persist among Indian dental students, with only 27.5% rating their proficiency as good or very good, indicating substantial readiness limitations [7]. Student perceptions toward augmented reality training demonstrate variable acceptance patterns influenced by prior technology exposure and educational expectations [3,6]. Faculty and student perception assessments reveal that while experienced educators and advanced students recognize significant potential benefits in teaching manual dental skills, concerns about tactile sensation authenticity and system validity persist [10]. Educational technology adoption requires addressing digital divide concerns, unequal resource access, and maintaining quality standards that remain significant challenges [7].

Conclusion

Successful augmented reality implementation in Indian dental education necessitates comprehensive strategies addressing economic constraints, infrastructure development, structured faculty training programs, curriculum standardization initiatives, and student digital competency enhancement. Prioritizing cost-effective solutions, establishing institutional support frameworks, and fostering collaborative partnerships represent essential prerequisites for meaningful technological integration within resource-constrained contexts.

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