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Editorial Review

The Future of Medical Education: Bridging Research Gaps Through Digital Innovation — An Indian Perspective

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ABSTRACT

Medical education worldwide is undergoing digital transformation; however, India struggles with inadequate infrastructure, faculty development, and research integration into its medical curriculum. While CBME is a welcome change, there is a lack of focus on competency development regarding crucial clinical skills, critical reasoning, lack of adherence to guidelines, infrastructure, and inadequate digital training that surfaced during COVID-19. Online learning has become difficult to access for students from rural areas and other backward communities. Technology-enabled learning and assessment tools including simulation laboratories are not widely used or available. Also, technology-enhanced teaching, using innovations such as artificial intelligence, immersive virtual reality, mobile medical education, flipped classrooms, game-based learning, orombotics, and simulation-based medical education, has not been fully integrated into the system. There is a lack of research culture and emphasis on evidence-based teaching and learning. Policy-level initiatives, faculty development programs, and multicentric collaborative research are the need of the hour. Indian medical education can be revolutionized by adopting a learner-centric approach, enabling technologies and pushing medical students and doctors toward research.

Keywords: Medical Educational; Research gap; Artificial Intelligence

Introduction

The recent advances in digital technology and educational science have brought significant change in the way medical education is delivered across the globe. Digital innovations, simulation-based learning, artificial intelligence (AI) in healthcare education, Massive Open Online Courses (MOOCs), and video-assisted learning have begun to integrate rapidly into undergraduate, postgraduate, and continuing medical education (CME). In India, increasing healthcare burden, exponential growth of medical colleges, lack of trained medical education faculty, changes in healthcare job market, and evolving expectations of learners have emphasized the need for overhaul of the existing medical education system. While shifting from traditional teacher-centered education to National Medical Commission's new competency-based medical education (CBME) curriculum is a positive move towards reforming the healthcare education system, there exist significant gaps in implementation, access, digital integration, and research.

COVID-19 disrupted medical education like no other period in history. While online teaching allowed learning to continue, the pandemic also revealed serious gaps in digital infrastructure, lack of trained faculty for online teaching, lack of tools for online practical training, and lack of standardized framework for digital education. Moreover, there is an unmet need of adapting innovative technology-

driven solutions across undergraduate, postgraduate, and CME in India.

Gaps in Traditional vs Research Based Medical Education

Indian medical education has seen multiple reforms over the past few years. However, there exist several gaps in infrastructure and academics which continue to inhibit evolution of a contemporary, competency-based, and research-ready healthcare workforce in the country. Historically, teacher-centered learning and memorization for exams have been the focus of medical education in India. Curriculum restructuring and implementation of CBME has resulted in significant improvements. However, most institutions continue to rely on traditional lecture-style classes where learners are rewarded for factual knowledge rather than application of clinical knowledge, problem-solving skills, interdisciplinary learning, analytics, or critical thinking. According to a national publication on undergraduate medical education in India, there is a need to relook the educational structure of medical schools with an emphasis on outcome-based learning, skills and practice training, mentoring programs, and educational technology.(1)

India is home to over 700 medical colleges and contributes to one of the largest number of doctors and healthcare professionals in the world. But this exponential growth of medical colleges in the past decade has widened the gap between newer colleges with minimal infrastructure and legacy institutions with established frameworks. Lack of trained faculty, insufficient competency-based and flexible learning programs, lack of digital initiatives are common problems experienced by majority of institutions across India.(2)

Despite efforts to improve medical education training by establishing institutions in rural and peripheral areas, there exists a significant divide between urban and rural medical colleges. Newer institutions often lack technical infrastructure like simulation labs, organized research ecosystem, trained faculty, and digital learning tools. Internet connectivity and socioeconomic discrepancies add to the digital divide that exists in the country. Digital inequalities have been observed across India with regard to computer availability, internet services, and digital skills among learners from lower socioeconomic and other disadvantaged groups.(3)

COVID-19 not only exposed the lack of digital readiness of medical education institutions but also forced them to abruptly shift from offline to online education. A study was conducted at Indian medical institutions to assess student and teacher experience with the shift.(4) The authors reported that most students and teachers faced poor internet connectivity, lack of interaction, inability to practice clinical skills, and overall dissatisfaction with online education.

There is another major gap in inducing a research culture among undergraduate medical students. Though initiatives like Indian Council of Medical Research (ICMR) Short-Term Studentship (STS) research fellowship program and online research methodology workshops have helped students take up medical research, universities lack programs that provide formal training in biostatistics, scientific writing, evidence-based medicine, and critical appraisal. A recent collaboration between National Medical Commission and ICMR seeks to integrate basic medical research training, biomedical ethics, scientific communication, and research methodology in medical education curriculum.

Research Gaps in Indian Medical Education

While medical education in India is undergoing changes, many aspects of it have not been researched enough. These gaps in educational research impede evidence-based and digitally informed educational policies and interventions in Indian medical institutions. First, there is a relative paucity of high-quality India-specific educational evidence. Most curriculum reforms, competency framework developments, and technology enabled learning implementations in Indian medical colleges are based on educational models from the West without adequate validation or learning outcome assessments within the sociocultural, economical, and institutional context of India. Though national medical education regulatory body National Medical Commission introduced CBME in India in 2019, there is a lack of multicentric studies assessing its outcomes in different institutions throughout India. Current literature consists of single-center, institution-specific studies with short-term follow-up based primarily on qualitative student feedback. Second, CBME has not been longitudinally evaluated for its impact on learners' clinical performance, patient care outcomes, research and academia, and overall competence and employability. CBME has been designed and implemented in India to improve clinical competency, communication skills, ethics and professionalism, and learner-centric training. However, evidence of its impact on long-term outcomes is limited. National Academy of Medical Sciences provided insights from a nationally representative sample of institutions and found that there were differences in faculty preparedness and attitudes towards CBME implementation, competency-based assessments, curriculum and resource availability which affected its uniform

implementation across India. Third, technology-enabled medical education research is sparse in India. Artificial intelligence, virtual reality (VR) and augmented reality (AR), adaptive learning, digital anatomy, simulation-based training, and other technologies have been applied in medical education to improve learner outcomes globally. However, few studies from India have systematically investigated the feasibility, scalability, and educational efficacy of these technologies for student learning, cost-effective implementation in low-resource settings, and other outcomes. COVID-19 forced medical institutions to rapidly switch to online and hybrid learning formats. However, there is limited evidence on learning outcomes, student satisfaction, clinical skill competency, and development of digital skills with online formats. Arani Das et al. conducted a mixed-method study representing Indian medical students and faculty which found that online medical education during the pandemic had drawbacks such as lack of digital infrastructure, lack of clinical exposure, and lack of peer interaction. Fourth, there is limited multidisciplinary collaboration in medical education research. Research, implementation, and formulation of new educational policies in Indian medical colleges are often done in silos without collaboration with different stakeholders that can contribute to educational research. Collaboration between clinicians, medical educators, medical psychologists, data scientists, educational technologists and innovation specialists, and health economists can help design sustainable, scalable, and India-specific models of medical education that can cater to the needs of India's health care system and training facilities. Encouraging multicentric studies and collaboration can help in the formation of evidence-based medical education policies.

Challenges in Implementing Digital Technologies and the Need for Policy Reform in India

Although digital technology holds great promise, there are several potential obstacles to its immediate and widespread integration into medical education. These include disparity in infrastructure among various institutes, with medical colleges from rural and remote areas having poor internet connections, a lack of digital devices, inadequate access to simulation laboratories, and poor technical support. Other limitations include a lack of financial resources that help in procuring technologies such as AI, virtual reality, and augmented reality, high-fidelity simulation-based learning, a lack of buy-in from teachers, a lack of training or knowledge of digital education, and a lack of technological knowledge. This may impact technology's integration into daily medical teaching.

Issues regarding ethics and professionalism are another concern in digitized medical education. With a lot of AI-powered teaching applications on the rise, there are ethical concerns about privacy of data, academic honesty, algorithm bias, and overdependence on AI technology. Overemphasis on digital education at the cost of bedside teaching hours may lead to lesser patient interaction, clinical exposure, interpersonal skills, and empathy. Hence, digital education will have to be paired with traditional forms of teaching.

There is also a concern about the digital divide among students of different backgrounds. Students who come from lower socioeconomic backgrounds and rural areas will have poorer access to broadband connections, laptops, tablets, or online learning applications. This problem came to light during the pandemic when Indian propounding students faced struggles due to poor internet connections and improper conditions for learning at home.

For a successful digital transformation of medical education in India, there needs to be policy-level initiatives. NMC and ICMR can help encourage multicentric medical education studies conducted across India, faculty development programs, and a curriculum that is improved based on digital initiatives that can benefit the medical system in India. Medical colleges can set up Medical education technology (MET) units that focus on different domains of technology like simulation, artificial intelligence, digital assessments, educational analytics, and online learning support. Faculty development programs need to be organized to train teachers to use digital tools for teaching through faculty mentoring programs on online teaching, virtual assessment, etc. Additionally, the Government of India can increase the budget allocation for improving digital infrastructure in rural and newly set up medical colleges. Public-Private Partnership (PPP) initiatives and a national digital education blueprint can help create sustainable digital practices for Indian medical schools.

Future Directions

India needs a technology-enabled, competency-driven, research-based and learner-centred ecosystem of medical education for tomorrow. Technology will not replace bedside clinical teaching but will act as an enabler. Technologies like AI-assisted learning for diagnostics, Virtual simulation, wearable technology for learning and data-driven learning analytics are likely to change the medical education landscape for the future workforce. Digital health technologies also represent an opportunity for India to provide low-cost digital medical education solutions for low and middle-income countries worldwide. Medical institutions can partner with ed-tech companies, health economists and government to drive

innovation and enhance health care workforce readiness.

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