Revisiting the Marvelous of Medical Education Machine: A Scoping Review of Metaverse Simulation in Medical Training Over the Last Two Decades

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Introduction

Two decades ago, Friedman[1] proposed a concept of the “marvelous medical education machine” while acknowledging the potential of technology and criticizing the shortcomings of medical education. Friedman's perspective that medical education had become "stuck" in three dimensions: physical space, time, and content, which was rooted in his belief that the traditional model of medical education had not adapted effectively to the changing needs of the modern world. This scoping review aimed to examine the evolution of simulation technology and the emergence of metaverse applications in medical professionals’ training through the lens of Friedman's three constraints in medical education: **physical space**, **time**, and **content**, along with an additional dimension of **assessment**.

Methodology

A protocol was developed based on recommendations of the Prisma extension for scoping reviews reporting guidelines[2]. A coding scheme was developed based on Friedman’s[1] framework with the 4 dimensions to thematically analyze included publications. All 173 papers included in the final review were analyzed and coded based on the coding scheme.

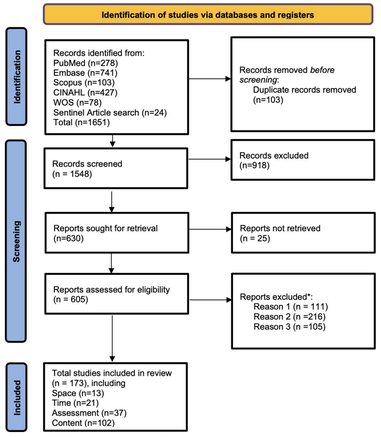

Figure 1. PRISMA flow diagram of studies on innovation in medical education, especially the idea of it being stuck in time, space, and content. *Reason 1: Studies did not include empirical data and/or outside of health professions education setting. Reason 2: Studies not related to space, time, content, and assessment based on Friedman’s operationalization. Reason 3: Participants were not medical students, nursing students, residents, other healthcare professionals.

Results

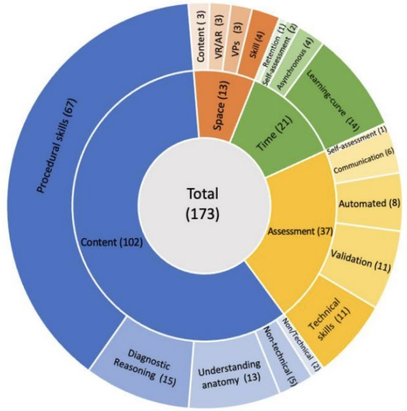

Figure 2. A summary of the selected papers in the dimensions of space, time, content, and assessment, along with their corresponding themes.

Analysis:

There has been advancement in simulation technology for developing technical skills in specialties requiring high levels of technical expertise(see Figure 2), as well as diagnostic reasoning skills and retaining knowledge across medical specialties. The number of papers focusing on the space has grown gradually over the years, although this area remains less explored compared to other aspects. The number of papers focusing on assessment is 37, indicating a steady interest. Simulation technology has also affected the “time” aspect of medical education, with 21 papers focusing on this topic.

The increasing trend in the total number of papers over the years signifies the ongoing evolution and importance of simulation technology. However, there is a clear discrepancy in the concentration of research efforts across the key themes, with the content being most heavily researched, followed by assessment, time, and finally space (Figure 3).

Discussion

Dimensions:

Space - Virtual reality, Content-based e-learning, Skills-based e-learning, and Virtual patients free students from traditional constraints of physical classrooms and clinical practice settings.

Time - Asynchronous online learning provides flexibility beyond physical/scheduling constraints. Highlighted benefits for knowledge retention, diagnostic skills, and technical proficiency, as well as online learning as an effective supplement to in-person instruction[3].

Content - Content simulation of simulation spans multiple medical specialties and relates to non-technical skills, technical skills, diagnostic reasoning, and knowledge retention, but curriculum requirements still play a major role in guiding simulation content.

Assessment - Virtual patients, learning analytics, and immersive simulations have made formative competency evaluation more practical/informative, but not yet high-stakes assessments. Reviewed papers suggest exclusively automated assessment lacks qualitative nuance, and validity evidence is still needed to integrate simulation into high-stakes testing[4].

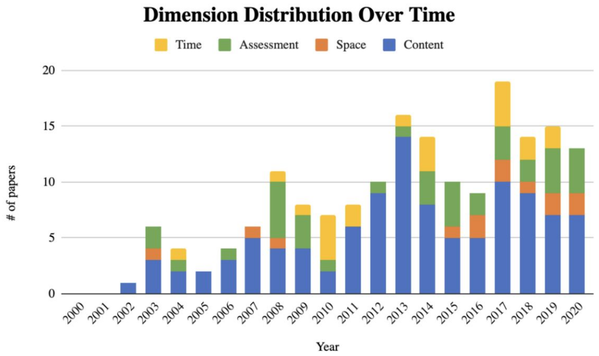

Figure 3. Number of publications in each dimension space, time, content, and assessment from 2000 to 2020.

Conclusion

The scoping review revealed that advancements in simulation technology have impacted medical education in all 4 dimensions of space, time, content, and assessment. In the original Friedman’s model[1], the dimension of space was not intersecting with the other dimensions because it was “stuck”. In the updated model, space is no longer isolated but converges with content and time, illustrating the shift towards increased independence from these dimensions (Figure 4). Assessment encompasses the other three dimensions as a learning event takes place. Realizing the full vision of the "Marvelous Medical Education Machine” proposed by Friedman[1] will require metaverse ecosystems integrating virtual patients, procedural simulators, collaborative environments, multimodal learning analytics, and competency dashboards into an accessible, personalized, flexible, and validated training ecosystem

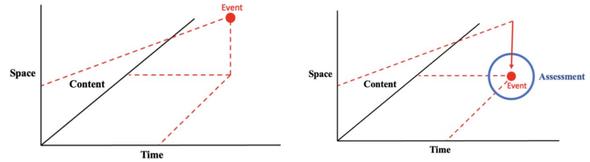

Figure 4. Original depiction by Friedman (2000) (left) and two decades later (right) of medical education as a process with events that exist in three dimensions.

References

1. Friedman, C. P. (2000). The marvelous medical education machine or how medical education can be ‘unstuck’ in time. Medical Teacher, 22(5), 496-502.
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