Redefining learning in the digital era: Innovative tools shaping modern medical education

Redéfinir l'apprentissage à l'ère numérique : Des outils innovants au service de l'éducation médicale moderne

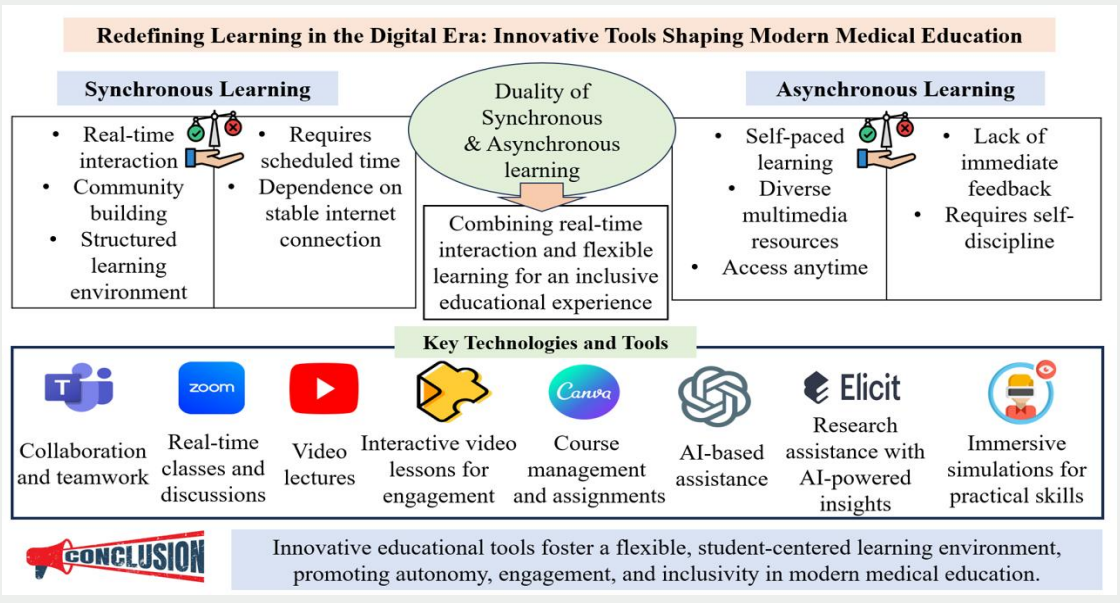
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Abstract

The rapid development of digital tools for medical education and training has expanded the possibilities for flexible and personalized learning, but it has also created challenges in choosing the best tools to meet specific learning needs. This article presents a functional framework that assists educators and learners in selecting tools based on their needs and the learning context. By categorizing tools into synchronous and asynchronous types, we aim to simplify the decision-making process and optimize educational experiences. Synchronous learning tools like YouTube Live, PathCast, Zoom and Microsoft Teams support real-time participation and promote communication, collaboration and responsiveness in the learning environment. These tools are especially useful for live streaming, Q&A, and discussions where instant feedback can support learning outcomes. Asynchronous learning tools such as YouTube, Canvas, Elicit and Quizlet, give learners the flexibility to learn material at their own pace, encouraging independent learning and memorization. Asynchronous platforms allow for pausing, reviewing and repeating material as needed, making them ideal for complex courses that require effective repetition. Hybrid models, especially the flipped classroom approach, blend these modes effectively. Tools like Edpuzzle and Nearpod make it possible to create interactive lessons and exercises in the classroom. The integration of innovative technology in medical education is not solely about adopting new tools but also about promoting adaptability and a culture of continuous learning. Blending synchronous and asynchronous tools with a human-centered approach, can build flexible, responsive learning environments that empower educators and learners to make informed choices, creating adaptive and effective learning environments that meet diverse needs.

Keywords: innovative tools, medical education, synchronous learning, asynchronous learning



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Résumé
Le développement rapide des outils numériques pour l'enseignement et la formation médicale a élargi les possibilités d'apprentissage flexible et personnalisé, tout en posant des défis pour le choix des outils adaptés aux besoins spécifiques. Cet article propose un cadre fonctionnel pour aider les enseignants et les apprenants à sélectionner les outils en fonction de leurs besoins et du contexte d'apprentissage. En classant les outils en catégories synchrones et asynchrones, nous visons à simplifier le processus décisionnel et à optimiser les expériences éducatives.
Les outils synchrones tels que YouTube Live, PathCast, Zoom et Microsoft Teams favorisent la participation en temps réel et soutiennent la communication, la collaboration et la réactivité dans l'environnement d'apprentissage. Ils sont particulièrement utiles pour le streaming en direct, les séances de questions-réponses et les discussions, où les retours immédiats renforcent les résultats d'apprentissage.
Les outils asynchrones comme YouTube, Canvas, Elicit et Quizlet permettent aux apprenants d'étudier à leur propre rythme, favorisant l'autonomie et la mémorisation. Ces plateformes offrent la possibilité de mettre en pause, de revoir et de répéter les contenus, ce qui les rend idéales pour des cours complexes nécessitant une répétition efficace.
Les modèles hybrides, notamment l'approche de la classe inversée, intègrent efficacement ces deux modes. Des outils comme Edpuzzle et Nearpod permettent de créer des leçons interactives et des exercices en classe. L'intégration des technologies innovantes dans l'enseignement médical ne se limite pas à l'adoption de nouveaux outils, mais vise aussi à promouvoir l'adaptabilité et une culture d'apprentissage continu. Combiner outils synchrones et asynchrones avec une approche centrée sur l'humain permet de créer des environnements d'apprentissage flexibles et réactifs, où enseignants et apprenants peuvent faire des choix éclairés pour répondre à des besoins diversifiés.

Mots-clés : outils innovants, éducation médicale, apprentissage synchrone, apprentissage asynchrone

Introduction

In today's fast-moving, information-saturated world, the way we learn and teach is being profoundly transformed (1). Medical teaching and research, in particular, have been carried along by this wave of change. Traditional approaches, once centered on a hierarchical, teacher-led model, are now being redesigned. The current era places the learner, rather than the instructor, at the heart of the educational process. This shift reflects a wider trend in society, where individuals are demanding more autonomy and personalization in their learning journey (2,3).
Unlike earlier generations, who often were educated within rigid structures and fixed programs, today's medical students are part of a dynamic and interconnected global environment. They are not just receivers of knowledge, but active participants, shaping and impacting the way medical knowledge is created, shared and applied (4–6).
This huge change in human development and technology requires an equivalent revolutionary thinking in medical education. In the face of rapid advances in healthcare and the incorporation of digital tools, artificial intelligence and big data, it has become essential to embrace educational practices that are as dynamic as the field itself (7).

Synchronous and Asynchronous Learning: A New Duality in Education

In recent years, the educational environment has undergone profound changes, particularly in fields as dynamic and demanding as medical education. This evolution has been largely driven by the advent of two complementary modes of learning: synchronous and asynchronous. These two modes are playing an essential role in transforming educational experiences to meet the needs of an era in which everything is fast-paced and information is ubiquitous (8,9).

Understanding Synchronous and Asynchronous Learning

Synchronous learning implies real-time interaction between educators and students. This mode of learning provides immediate feedback and promotes a stimulating environment. Educators can ask questions, facilitate discussions and resolve misunderstandings on the spot (10).
Asynchronous learning, on the other hand, enables students to learn at their own pace. This model is particularly advantageous in medical education, where students can familiarize themselves with the content at a time that is most convenient for them (11) (table 1).

The Importance of This Duality in Medical Education

The association of synchronous and asynchronous learning creates a flexible and inclusive learning environment. It allows students to participate in both structured, instructor-led sessions and flexible, self-paced learning. This duality is important in medical education, where the complexity of the content requires both immediate interaction and time for reflection. Students benefit from synchronous sessions by actively participating, asking questions in real time and participating in interactive discussions. Asynchronous learning, on the other hand, allows them to consolidate this knowledge, review lectures and explore additional documents, which is essential for mastering complex medical concepts and procedures (9,12,13).
Teaching materials should be tailored to meet specific learning objectives at different stages of medical education. Synchronous learning is particularly effective in the first years of medical education, when basic knowledge and skills are acquired through interactive lectures and real-time feedback (14). While, asynchronous tools are more effective in supporting advanced students as they encourage independent work and allow them to work through the material at their own pace (15).

Table 1. Understanding Synchronous and Asynchronous Learning: advantages and disadvantages

Synchronous learning		Asynchronous learning	
Advantages	Disadvantages	Advantages	Disadvantages
Immediate interaction Students can ask questions and receive answers in real time	**Time Constraints** Students must be available at specific times	**Flexibility** Students can access materials at any time	**Lack of Immediate Feedback** Students may feel isolated and miss the opportunity for real-time discussions
Community Building Synchronous classes help foster a sense of community	**Technological Issues** Dependence on technology can lead to disruptions if internet connectivity is poor or if there are technical difficulties	**Self-Paced Learning** Learners can progress through the material at their own pace	**Self-Discipline Required** Asynchronous learning requires a high level of self-motivation and time management skills
Structured Learning Regular class times provide a structured learning environment that can help students stay focused		**Diverse Learning Resources** Instructors can provide a variety of resources, such as videos, articles, and quizzes, catering to different learning styles	

Table 2. Key features and recommended use cases for innovative educational tools

Tool	Mode	Key Features	Recommended Use Cases
YouTube	Asynchronous	Video content, accessibility	Pre-recorded lectures
Zoom	Synchronous	Live interaction, breakout rooms, recording	Live discussions, webinars
Canvas	Both	LMS, assignments, grading	Course management
Microsoft Teams	Synchronous	Collaboration tools, file sharing	Facilitates teamwork and organization
Elicit	Asynchronous	Research tool, AI assistance	Evidence-based learning
ChatGPT	Asynchronous	AI responses, content generation	Instant help and clarification
Edpuzzle	Asynchronous	Interactive video lessons	Increases engagement and comprehension

Inclusivity and Accessibility

Rapid advances in technology have enabled educational institutions to prioritize inclusion and accessibility. Synchronous learning environments can be made more inclusive by creating recorded sessions for students with hearing impairments or those who are unable to attend in real time. Captioning tools, such as those offered by Zoom, can improve the experience of these learners (16,17).
In asynchronous learning, tools such as Canvas allow educators to integrate multimedia resources, making it easier for students with different learning styles to be engaged with the material (18). Functionalities such as discussion boards and forums can encourage interaction between students, favoring a sense of community, even in an asynchronous format (19).

Emerging Technologies

The incorporation of emerging technologies such as Virtual Reality (VR) and Augmented Reality (AR) into synchronous and asynchronous learning is revolutionizing the educational landscape (20). VR platforms can create immersive experiences where students are involved in simulated medical procedures, improving their practical skills in a risk-free environment. For example, platforms such as Immersive VR Education enable students to explore complex anatomical structures or practice surgical techniques (21,22). However, some studies have shown that the impact of VR on performance was not statistically significant (23).

Categorizing Educational Tools: A Functional Framework

In the evolving landscape of digital education, it is essential to classify tools according to their function in order to guide educators and learners in choosing the most appropriate resources for their needs. In this article, we will use a classification based on synchronous and asynchronous learning modes. This approach provides a clear understanding of how and when to use specific tools, maximizing the benefits of each mode in creating an interactive and effective learning environment.
By ordering tools according to their functionality in synchronous and asynchronous learning, we create a structure that improves decision-making and ease of use, enabling educators and students to adapt their approach based on real-time engagement, accessibility and versatility.

Synchronous Learning Tools

Video and Live Streaming Platforms

- **YouTube Live**: YouTube Live is a versatile platform that is suitable for educators to broadcast sessions in real time to a wide audience (24). It is especially useful for organizing live conferences or webinars, where interaction is stimulated by live commentary and Question-and-Answer segments. Benefits: With its extensive reach and user-friendly interface, YouTube Live allows educators to stream content to thousands of students simultaneously, making it one of the ideal tools for large-scale educational courses (25).

• **PathCast**: In 2016, the authors founded pathCast, a platform that uses Facebook Live and YouTube to broadcast pathology lectures to the international medical community (26). An interactive pathology curriculum was developed covering complex topics across all disciplines. Experienced pathologists were invited to deliver 60-minute lectures using digital slides, slide packs, or traditional slide sets. Remote (online) participants interact with the lecturer in real-time using a demo chat interface. Facebook's and YouTube's analytics were evaluated to assess the performance of all lectures. From June 2016 to December 4, 2019, 53 speakers delivered 87 lectures representing 18 pathology subspecialties in 9 different languages and from various geographic regions. The lectures hosted on the Facebook channel have garnered 8,333 followers and 52,171 views for a total of 386,200 minutes of watch time, and the lectures hosted on the YouTube channel have accumulated 5,891 subscribers and 292,735 views for a total of 50,674 hours of watch time. The lectures have been viewed by users from 1,093 unique cities across 124 countries (26).

Collaboration and Interactive Platforms

• **Zoom and Microsoft Teams**: These tools offer many opportunities for live interaction, including screen sharing, meeting rooms for group discussions and real-time polling. Medical educators can use these platforms to lead interactive case discussions, lab demonstrations and participatory learning exercises. Zoom and Microsoft Teams encourage dynamic interactions and allow students to work collectively in a digital environment that closely resembles face-to-face learning (27,28). A study (29) found that Zoom was effective in facilitating e-learning, offering a variety of teaching methods and easy access to learning resources. However, the challenges are limited interaction and difficulties in remaining focused during sessions. Useful tips for avoiding 'zoom fatigue' and enhancing student engagement include the use of pre-tests, post-tests and interactive elements (27). Although online platforms cannot completely replace hands-on surgical training, they have proven effective in conducting lectures, case discussions and even viva voce examinations in postgraduate surgical training (28). Since virtual teaching is becoming a permanent component of medical education, creative use of these tools can enhance learning experiences.

• **Classroom Response Systems (e.g., Poll Everywhere):** The use of polls and quizzes in lessons increases student engagement and provides instant feedback. Educators can use these tools to evaluate understanding and clarify complex concepts on the spot (30,31). Poll Everywhere, a public response system, has proved to have promising results in enhancing medical education. Studies have shown its potential to improve learner satisfaction, participation and involvement in a number of educational contexts. In internal medicine courses, Poll Everywhere improved satisfaction scores and self-perceived attention (32). During the COVID-19 pandemic, its use in an online practical histology course resulted in significantly higher exam scores and improved student engagement and knowledge retention as compared to traditional methods (33). In largescale groups, combining Poll Everywhere with a flipped classroom approach fostered active learning and enabled instructors to concentrate on challenging areas based on immediate student feedback (34).

Asynchronous Learning Tools

Content Creation and Sharing Platforms

• **YouTube (Pre-recorded Content)**: YouTube videos have emerged as a growing educational resource. Teachers can download pre-recorded lessons, instructional videos and demonstration materials, allowing students to access content on demand. This function is particularly useful for complex subjects that require repeated watching for better understanding. There are a number of advantages to using this tool, such as the ability to pause, rewind or record videos on demand. This helps learners to process and retain information at their own pace. Studies have shown that a high percentage of medical students use YouTube for educational purposes, with 83.9% using it as a learning tool in medical university (35). A review (36) included 31 studies focusing on the use of YouTube in medical education. Among these studies, only 6 (19.4%) reported evaluative outcomes related to the use of YouTube for instructional purposes.

• **Canvas:** Canvas has gained increasing prominence in medical education and is used as a comprehensive Learning Management System (LMS) that centralizes resources, course assignments and feedback. Medical educators can organize course materials, publish announcements and monitor student progress, thus creating a structured environment for asynchronous learning. Canvas offers a highly organized space that facilitates a continuous and structured learning experience, encouraging independent study and ongoing engagement (37,38).

Research and Knowledge Discovery

• Elicit: Elicit is a research assistant with artificial intelligence, developed to simplify the process of discovering and organizing research documents. (39). Both students and educators can use Elicit to rapidly locate and filter academic papers, which is invaluable in evidence-based medical education. Elicit accelerates the research process, enabling users to focus on analyzing and applying information rather than spending excessive time on search. A recent study presented at the 2024 International Conference on Scientific Researches (40) explored the effectiveness of Elicit, an AI-powered tool, in conducting systematic literature reviews. The research found that Elicit significantly improves efficiency by automating data synthesis and quickly identifying relevant sources, making it easier for researchers to manage academic content. The study highlights the reliability of Elicit's outputs, with minimal errors in the generated summaries and sources, underscoring its potential to streamline research processes across various academic disciplines.

Personalized Assistance and Study Aids

• **ChatGPT:** This AI-based tool can respond to questions, provide complex explanations and produce content, making it a valuable companion for students navigating difficult medical topics. ChatGPT provides personalized and on-demand assistance, empowering students to both clarify doubts and boost their knowledge. A systematic review (41) analyzing 12 studies on ChatGPT's integration in education, highlighted that ChatGPT enhances the learning experience by providing personalized feedback and immediate assistance. However, it underscores the importance of proper training for educators to ensure the tool is used effectively, minimizing risks like misinformation and plagiarism.

Another rapid literature review (42) examines the potential benefits and challenges of ChatGPT across subject areas. The research emphasizes that while ChatGPT can facilitate student engagement and collaborative tasks, it also introduces risks such as academic dishonesty. It calls for updated academic policies to ensure responsible usage and stresses the need for instructor training and student education to manage these challenges.

A recent study published in JMIR Medical Education (43) explored the perceptions and experiences of medical students regarding ChatGPT. This research, conducted through a web-based survey, revealed that while most students had limited exposure to ChatGPT during medical school, they expressed interest in leveraging it more during their residency for tasks like exam preparation and research. Notably, students were optimistic about the potential of AI to enhance diagnostic accuracy and reduce medical errors, emphasizing a generally positive outlook toward integrating AI tools into their education and clinical practice.

Additionally, another study (44) examined the performance of GPT models on medical licensing exams, comparing different versions of the model. GPT-4 significantly outperformed GPT-3.5 and even medical students, achieving a remarkable 96% accuracy on unique exam questions. This underscores the evolving role of AI in supporting medical education, suggesting it could serve as an advanced tool for training and assessment, especially when paired with traditional teaching methods.

• **Quizlet:** Quizlet enables students to create flashcards, practice tests, and memory games. This tool is excellent for reinforcing terminology, memorizing key concepts, and preparing for exams. A number of recent studies have underlined the usefulness of quizzes and flashcards in medical education. Quizzes, traditionally used for assessment, are now being recognized as valuable pedagogical tools that favor active learning, peer interaction and improved memory retention (45). Electronic flashcard applications such as Quizlet have grown in popularity among medical students as they offer distance learning and self-testing abilities that improve the educational experience (46). Flash cards have been shown to be especially efficient for visual learning in subjects such as histology, with students consistently preferring them to other study devices (47). Using smartphones to enable these evidence-based educational methods can significantly improve the acquisition of evidence-based knowledge in medical education (48).

Matching Educational Tools to Learning Outcomes at Different Stages of Medical Education

Educational tools should not only be categorized by their mode of delivery (synchronous vs. asynchronous) but also by the specific learning outcomes and competencies expected at various stages of medical education (49). Each phase of medical training, undergraduate, graduate, and continuing medical education, has unique objectives that require specific pedagogical approaches.

Undergraduate Medical Education: Knowledge Acquisition and Foundational Skills

Innovative tools, such as VR, AR, virtual patients, and human patient simulators, are changing the way undergraduate medical education is being delivered. These tools offer interactive, individualized, and efficient learning experiences, that support the educational objectives of medical programs (50). Calvez et al reported that VR can be used effectively in the teaching of anatomical concepts that cannot easily be learned from cadavers (51). Additionally, asynchronous learning tools like Canvas and pre-recorded YouTube lectures are also useful in supporting students (52). The learners are therefore able to go back to complex topics for example, physiology or biochemistry at their own pace and with the aim of developing critical thinking skills and to build a good fundamental biomedical knowledge (52).

Graduate Medical Education: Skill Development and Clinical Application

Graduate medical education increasingly incorporates innovative tools to improve clinical reasoning and practical skills, aligning with competency-based medical education objectives (53). As with undergraduate medical students, VR and AR provide interactive learning experiences and offer trainees a safe environment to practice. VR platforms simulate surgical procedures and patient management scenarios, while AR contributes to improving diagnostic and procedural accuracy by maintaining digital information through real-world settings (50), In addition asynchronous tools like Elicit, that simplifies access to relevant literature, further engage residents to stay updated (39). Synchronous approaches, such as discussions on platforms like Zoom offer an opportinity for group discussion and allow a real-time decision-making for more efficient practice and better outcomes (54,55). Jones et al (56) found that students were satisfied with Live interactive webcasting for providing an international postgraduate module in eHealth,

Continuing Medical Education: Lifelong Learning and Adaptation to Advances

Continuing Medical Education includes various educational activities designed to maintain and improve physicians' clinical skills and competencies, through both asynchronous tools like online courses, YouTube and synchronous tools such as live webinars and workshops (57,58).

Cross-Phase Tools for Professional Competencies
For all stages, tools such as Chat GPT can improve medical education by providing immediate clarification on concepts, supporting exam preparation and generating case-based scenarios for practice (59). Similarly, plateforms like Quizlet improve memorization through interactive and engaging methods, improving learning outcomes at all levels of medical education (60).

Hybrid and flipped classroom models

Flipped Classroom Approach

The flipped classroom model inverts traditional teaching by allowing students to study theoretical content at home and reserving in-class time for practical application and discussion (61). This model is particularly effective in medical education, where hands-on experience is essential. By leveraging tools like Canvas and YouTube for at-home learning, educators can use synchronous sessions for problem-solving, case studies, and skills practice. The flipped classroom approach to medical education has shown significant advantages when compared to conventional teaching methods. Studies have reported an improvement in knowledge acquisition and retention among medical students and residents (62,63). The flipped classroom model entails students acquiring their knowledge in an independent manner prior to the course, and then participating in active discussions and problem solving in face-to-face sessions (64). This approach promotes critical thinking skills, active participation and greater depth of understanding (65). A meta-analysis found a substantial improvement in student learning outcomes with flipped classroom in comparison to the conventional classroom in health professions education. The implementation of quizzes at the start of classroom sessions further enhanced the efficacy of flipped classroom (63). Although there are some difficulties such as technical issues and the increased workload of teachers, this approach does offer a promising avenue for curriculum reform in medical education (64). Tools such as Edpuzzle or Nearpod can facilitate flipped classroom models by enabling students to follow pre-recorded lessons at home and attend interactive sessions in class (66–69).

Hybrid Platforms (e.g., Google Classroom)

Google Classroom is emerging as a desirable learning management system for medical education, particularly in resource-limited settings. Findings showed that medical students and residents in Nigeria were familiar with the system but made limited use of it (70). In India, both medical and dental students described favorable experiences with Google Classroom for learning anatomy, citing advantages such as the improvement in access to additional materials and resources (71,72). The platform has been utilized successfully to teach physiology and biochemistry, with students valuing its accessibility on mobile devices and its suitability for clinical application (72). However, challenges persist, including internet connectivity issues, homework submission struggles and the requirement for more interactive features (70). Despite these challenges, Google Classroom offers a potentially promising and cost-effective way to improve medical education, particularly in low- and middle-income countries (72).

The human element in innovative pedagogy

The role of educators

• **Facilitators of Learning**: In the era of fast-paced information exchange, educators are moving from being traditional lecturers to facilitators who guide students through extensive resources. They may use a variety of methods, such as group discussions, problem-based projects, and technology-based learning, to increase student involvement (73). By exploiting tools such as ChatGPT and Elicit, teachers can help students formulate questions and build their critical thinking skills (74). As traditional lecture-based methods give way to more interactive and collaborative approaches, there is a greater emphasis on student participation (50,73). Such approaches, on one hand, require educators to demonstrate strong communication skills and empathy (2006-Article Text-6069-1-10-20240722.pdf), for a humanist teaching approach to have a more inclusive and engaging classroom environment (73). On the other hand, educators should be supported in their use of technology and in designing student-centered online learning (4).
• **Personalization of learning**: can use data analysis from platforms such as Canvas to identify students' needs (75) and adapt their approach by providing individualized feedback and support, improving learning experiences and promote a more inclusive environment (76).The ability to identify individual student needs is critical for implementing inclusive and adaptive teaching methodologies (50,73). To accommodate various learning styles, educators should adopt diverse teaching methods (69,73), such as group discussions, problem-based projects, and technology-based learning, which make the learning process more engaging and effective. These methods also facilitate the development of critical and creative thinking skills (73). Furthermore, inclusion must be an important element of the learning environment, ensuring that all students feel connected, safe, and included, regardless of their abilities and differences in learning style and cultural background (69).This inclusive approach ensures that each student has the opportunity to work in a supportive and equitable environment. In this context, technology plays a significant role in personalizing education, with tools like Nearpod enabling interactive presentations that engage students (69). Google Forms further streamline assessments by automatically scoring responses in real-time, allowing educators to offer more individualized instruction and efficiently monitor student progress (50).
• **Mentorship and support**: The role of educators is not only to transmit content for students but also to serve as mentors and provide emotional support (77), concerning

both academic and non-academic aspects, addressing students' cognitive, emotional, and social needs (78). By providing a safe environment for open discussion (79), they enable students to express their concerns and engage with the material. This support is particularly important in asynchronous environments, where students can feel isolated (80).Additionally, online interventions for developing positive thinking have potential bebefits for the mental health of medical students, particularly in terms of self-compassion, stress perception and coping mechanisms (81). However evidence is limited, most studies having methodological limitations such as small sample sizes and short follow-up periods, indicating the need further researchs (82,83).

The Role of Learners

• **Active Participants**: In the modern learning world, students are no longer simply passive receptors of information (84). They are active participants in their learning, using innovative learning resources. Recent studies highlight the potential role of active learning and AI in education (85). Active learning approaches have been shown to enhance academic performance, critical thinking, and clinical competencies, and incorporating ChatGPT into classrooms can further support these benefits by increasing student engagement and fostering interactive learning (86,87). However, concerns exist regarding source reliability and accurate citation (88,89). To address these issues, educators can help with guidelines for ethical use and encourage verification with reliable sources (88,89).

• **Self-directed Learning**: The wide availability of asynchronous resources makes it possible for learners to take control of their education (90). The availability of asynchronous materials allows students to learn at their own pace and convenience (91). These resources include platforms such as Canvas that facilitate self-paced learning, empowering students to pursue in-depth topics depending on their interests and needs (75). Additionally, YouTube has emerged as a valuable educational resource in medical education, providing accessible, on-demand contents that students can review repeatedly at their own pace (92,93) . The platform supports flipped classroom models, allowing instructors to create and share videos for pre-class viewing (94). To maximize its potential, medical institutions should endorse and regulate YouTube content (92), and educators should consider incorporating it into their teaching methods (93,94).

• **Collaboration and Community Building**: With synchronous tools like Zoom, students are able to collaborate on projects, exchange ideas and develop a sense of community. This interactivity enhances their social skills and prepares them for teamwork in professional environments (95). These tools are more effective than asynchronous tools for developing collaborative learning skills in online group activities (96). Anderi et al (97) reported that one of the biggest disadvantages for medical students was the inability to find peers and the loss of a sense of community. To address this issue during the COVID-19 pandemic, the Wayne State University School of Medicine Learning Community plans to use the Zoom platform to expand its offerings and enhance students' sense of belonging (97). Michelle et al (98) reported that virtual café sessions facilitated strengthened social bonds and trust among students, so they subsequently felt less isolated, but rather gained a sense of belonging, which motivated their learning.

The Symbiotic Relationship

• **Interdependence of Roles**: The dynamic relationship between educators and learners is key to the effectiveness of innovative pedagogy (73). While educators adjust their teaching style to integrate technology, learners should take ownership of these tools to optimize their educational experience.

• **Feedback Loops**: Continuous feedback between educators and learners is essential to refine teaching approaches and enhance learning results (99). This iterative approach favors an environment of constant growth and improvement (Figure 1).

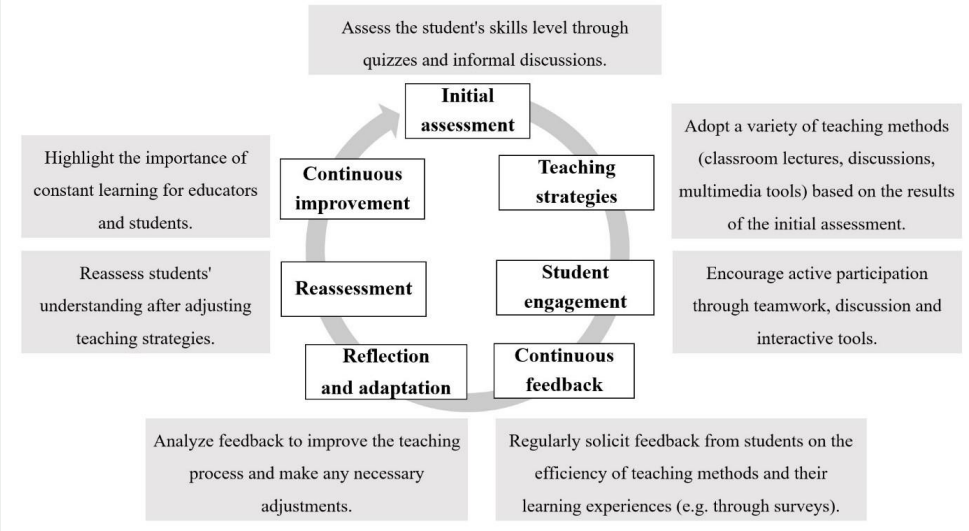


Figure 1. A continuous improvement cycle in education, involving assessment, diverse teaching strategies, active engagement, feedback, reflection, and reassessment to enhance student learning.

Perspectives on Innovation Tools in Medical Education: Challenges and Issues

The integration of innovation tools in medical education represents a major opportunity to improve learning outcomes and prepare students for a constantly evolving world. However, their effective implementation raises several limitations, especially resources availablity, teacher engagement, and personalization of learning methods. Combining synchronous and asynchronous tools appears to be a promising solution to meet the diverse needs of learners. Further studies should be carried out to determine the best combination to suit the characteristics of different disciplines and the specific needs according student profiles to garentee a more inclusive strategy. However, several challenges could be faced. Fist, implementing these strategies requires significant investment in educators training to enable them to master these tools and to overcome difficulties in establishing human connections with students in a digital environment. Second, problemes like limited resources and rigid pedagogical practices may not respect equitable access to technology for all students. If not addressed, these obstacles may hinder the positive impact of educational innovation. Ultimately, the adoption of these innovative tools must be guided by a learner-centered approach, considering both pedagogical and technological realities.

Conclusion

Medical education has undergone a important change, embracing innovative tools and a more collaborative, learner-centred approach. Yet, despite these advancements, challenges remain. Ensuring equal access to digital resources and guaranteeing the reliability of educational content are key issues to be adressed. Moreover, while progress has been made in adapting teaching methods, truly individualised learning that meets the needs of each student is still an ambitious goal.Thus, the continuous refinement of pedagogical strategies and innovative tools is essential to bridge these gaps and create a more inclusive learning environment.

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