Hybrid models of professional training foreducational strategies in optics in the context of wartime instability

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ABSTRACT

The article examines the pedagogical foundations for implementing hybrid models of professional training under martial law conditions. The focus is on transformational processes within the educational environment, driven by the need to ensure continuity of learning amidst instability and limited physical access to educational resources, espessially for one of the actual war applications, as optical discoveries. Hybrid learning is viewed not merely as a technical combination of online and offline formats, but as a comprehensive pedagogical strategy requiring a rethinking of content, methods, formats, and tools of educational interaction.

Particular attention is given to adaptive approaches to curriculum design, modular learning, digital support for independent study, and the development of educators' digital culture. The role of artificial intelligence is emphasised, particularly that of educational chatbots, content-generation systems, and automated assistants. It is concluded that, when pedagogically grounded, hybrid learning models may serve as an effective instrument for transforming medical education in response to wartime challenges.

Keywords: medical personnel training, hybrid learning models, digital tools, digital technologies

1. INTRODUCTION

The field of education, e.g. physics and mathemetics, in Ukraine has been compelled to respond to unprecedented challenges brought about by martial law[1]. Interruptions in physical access to educational institutions, constant relocation of both learners and teaching staff, unstable connectivity, and limited resources have rendered the traditional educational model unsustainable. At the same time, the demand for high-quality training of medical professionals – particularly in light of the increased demands on the healthcare system – has only intensified[2].

Under these circumstances, hybrid learning emerges not as a temporary solution but as a viable strategy to ensure the resilience of the educational process. This refers not merely to the technical integration of online and offline formats, but to a thorough pedagogical rethinking of educational interaction, involving the adaptation of curricular content, transformation of teaching methods, and expansion of digital support tools[3].

The aim of this article is to explore and substantiate pedagogical approaches to the design of hybrid learning environments that foster students' autonomy, responsibility, and sustained motivation in the context of wartime instability. Special attention is given to modularity, digital flexibility, and the integration of intelligent technologies, which open up new opportunities for supporting learning under unstable conditions, particularly in the medical field[4].

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2. REQUIREMENTS FOR IMPLEMENTING A HYBRID LEARNING MODEL UNDER CONDITIONS OF WARTIME INSTABILITY

Wartime instability has drastically altered the conditions for the professional training of future medical personnel. In many regions of Ukraine, the educational process, especially in physics and mathematics, is disrupted by air raid alerts, power outages, the evacuation of students and staff, and limited access to laboratories, simulation centres, and clinical facilities. In such circumstances, the need arises not merely for temporary technical fixes, but for a resilient hybrid educational model that ensures continuity and meaningfulness of learning[5].

Professional training in the field of medicine requires the integration of theoretical knowledge with practical skills. Therefore, a hybrid model must take into account not only online access to learning materials, but also the organisation of practical training, simulations, and demonstration-based instruction. Key requirements include following:

– *Modularity* – structuring learning content into autonomous units that may be studied both synchronously and asynchronously, depending on internet access and the security situation;

– *Flexible scheduling of in-person components* – allowing for rescheduling or postponement of clinical placements with the option for future compensation[6];

– *Content reconfiguration* – adapting curricula to prioritise essential clinical scenarios, telemedicine cases, and pre-medical emergency care[7];

– *Expanded digital support* – providing access to recorded lectures, interactive simulators, visual aids, and video materials in lieu of traditional demonstrations[8-9];

– *Continuous academic support* – offering regular online consultations, discussion forums, and flexible forms of assessment[10].

The crucial pedagogical task is not simply to preserve the content of education in physical sciences, but to transform it in such a way that it reflects wartime realities while preparing students to act under uncertainty with professional responsibility and maintained competencies.

In this context, *hybrid learning* should be defined as a pedagogically driven model of educational delivery that combines in-person and remote formats, synchronous and asynchronous modes, and integrates digital and traditional tools to preserve the integrity, accessibility, and supportiveness of the learning process[2, 11].

3. STRATEGIES FOR IMPLEMENTING HYBRID LEARNING: DIGITAL SUPPORT, MODULARITY, AND ARTIFICIAL INTELLIGENCE

In the implementation of hybrid learning within education in physical sciences, the decisive factor lies not merely in the technical realisation of blended formats, but in their pedagogical validity and the structural organisation of educational interaction. Under wartime instability, the optimisation of curricula becomes imperative – through modular design, digital tools for supporting independent learning, and the gradual integration of artificial intelligence (AI).

A modular structure enables logical completeness of each thematic block, which is critical when access to education is disrupted. This approach allows students to master content at their own pace, even in the absence of stable internet access or the ability to attend synchronous sessions. In healthcare training, this model has proven effective in teaching core disciplines (such as anatomy, fundamentals of patient care, pharmacology), as well as short-term modules focused on pre-medical emergency assistance. These approaches align with the principles of the STEM methodology and the digital modelling of educational content[12-14].

Support for students' independent activity in hybrid learning relies on digital facilitation tools. In particular, the use of platforms such as *Google Classroom, Moodle*, and *Notion* enables the structuring of materials, assignments, and communication within a unified digital environment. Applications like *Quizlet* and *Anki* have proven effective for personalised revision of medical terminology and procedural algorithms, offering adaptive learning through visualisation and micro-repetition strategies[15].

Integrating AI-based tools into the engineering educational process enables not only the automation of certain routine teaching tasks, but also the enhancement of personalised learning. Generative platforms – including *ChatGPT, Quillionz*, and *Curipod* – can assist in constructing clinical cases, creating variable test formats, and providing multi-style explanations of complex theoretical content adjusted to different levels of difficulty. The use of fuzzy logic in educational systems, particularly in diagnostic tasks, has likewise shown potential[15].

Special attention should be paid to the visualisation of educational content. The use of 3D models to demonstrate physiological processes or simulation system interfaces offers novel opportunities for distance-based acquisition of practical skills. Experience from engineering education in the application of three-dimensional modelling and quality control of visualisation is highly relevant to the training of future medical professionals[16].

In the long-term perspective, considerable scientific interest is devoted to research on the application of coherent optical diagnostic methods for the analysis of biological tissue morphology[17-20]. The use of high-resolution technologies makes it possible to obtain detailed information about the optical properties of biological objects, which creates the conditions for a deeper understanding of physical processes in living systems[21]. The application of such methods opens up prospects not only in the field of fundamental research but also in medical practice, particularly in the development of virtual simulators and hybrid-format clinical scenario simulations that can be integrated into the educational environment.
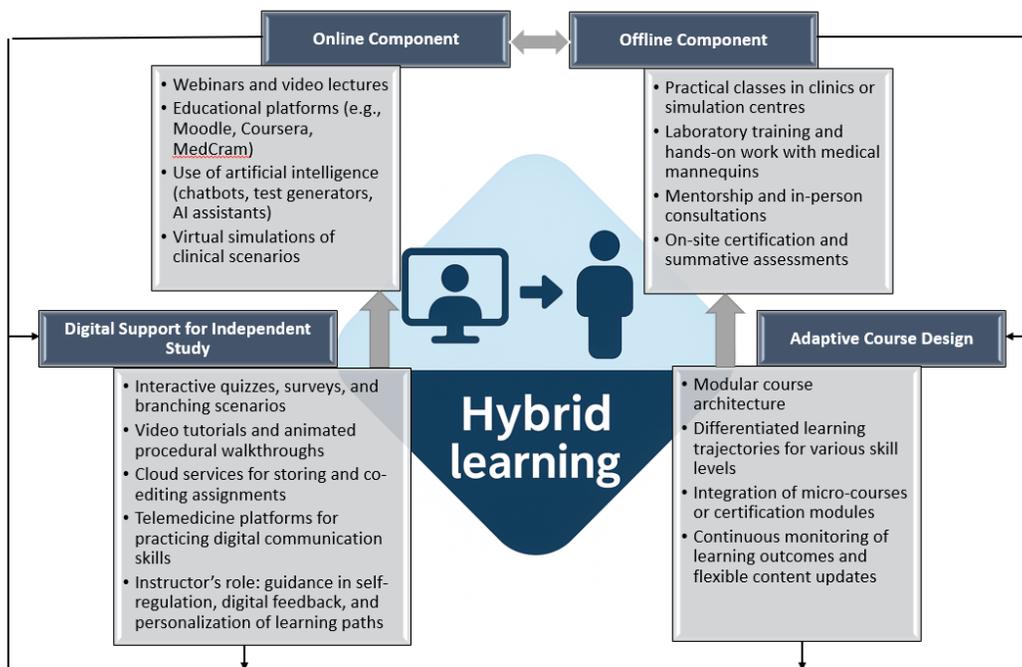

Figure 1. Conceptual framework of the hybrid model of medical education in wartime conditions

Special attention should be paid to approaches related to the restoration of the spatial phase distribution of complex optical fields in the framework of singular optics[22]. Such methodologies provide new opportunities for the visualization and modeling of optical phenomena, thereby enhancing the potential of educational programs in the field of medical and bioengineering training. In addition, interferometric and chromascopic techniques, which have proven their effectiveness in the study of phase singularities, appear to be promising and may serve as the basis for the development of educational and scientific simulation complexes[23]. These approaches can be adapted for the creation of virtual simulators and hybrid-format simulations of clinical scenarios.

4. SUMMARY

Hybrid learning models in engineering education, under conditions of wartime instability, serve not only as a means of ensuring continuity in the educational process, but also as a driver of its pedagogical transformation. Their effectiveness lies in the ability to integrate digital resources, adaptive approaches to curriculum design, and emerging technologies – particularly artificial intelligence – with pedagogically sound forms of interaction between educators and learners.

This article substantiates the value of modular curriculum structuring, the use of digital platforms to support students' independent work, and the application of generative AI tools for constructing adaptive learning environments. It also highlights the potential of visualising complex medical concepts through 3D modelling and simulations, which enable the practical component of hybrid learning in remote settings.

In view of contemporary research, the hybrid model may become the foundation of a new paradigm in engineering education (physics and mathematics) – one focused on resilience, technological adaptability, and the digital transformation of professional training. The successful implementation of such a model requires not only the modernisation of teaching tools, but also the deliberate cultivation of educators' digital culture.

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