PEDAGOGICAL AND PSYCHOLOGICAL FOUNDATIONS OF USING ARTIFICIAL INTELLIGENCE TOOLS IN MEDICAL CHEMISTRY LABORATORY CLASSES

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Abstract. The thesis analyzes the main contradictions in organizing medical chemistry laboratory classes in medical higher education institutions and reveals the pedagogical and psychological foundations for overcoming them with the help of artificial intelligence (AI) tools on the basis of the theories of A. Johnstone, J. Sweller, D. Kolb, L. S. Vygotsky, M. Chi and R. Wylie. Specific didactic implications for introducing AI tools into laboratory classes are drawn from each theory.

Keywords: medical chemistry, laboratory class, artificial intelligence, cognitive load, experiential learning cycle, zone of proximal development, ICAP theory, chemistry triangle.

Medical chemistry is the scientific foundation of the future physician's clinical thinking: without knowledge of acid–base balance, buffer systems, osmotic phenomena, electrolyte exchange and the chemical properties of drugs, it is impossible to master biochemistry, physiology and pharmacology in depth. The main form of instruction that consolidates this knowledge through practical activity is the laboratory class. The fact that the digitalization of education and the introduction of artificial intelligence technologies have become a priority of state policy in our country (Presidential Resolutions PQ-4996 and PQ-358) makes the improvement of laboratory classes on the basis of new technologies an urgent task.

In practice, however, medical chemistry laboratory classes are conducted mainly in an expository style – according to a single instruction for all students. As A. Hofstein and V. Lunetta note, in this case laboratory work turns into mechanical

"recipe-following": the student performs the experiment but does not fully understand why it is performed in exactly this way or what the obtained result means [2]. Theoretical analysis revealed four main contradictions: between competency-based requirements and the reproductive nature of classes; between differences in students' preparedness and a single instruction and a single pace; between students' everyday use of AI tools and the absence of a methodology for guiding that use pedagogically; and between the requirements of state policy and teachers' methodological support.

AI tools have the potential to overcome these contradictions, but their effectiveness is determined not by the technology itself, but by the pedagogical basis on which it is applied. A systematic review by O. Zawacki-Richter and co-authors showed that most research on AI in higher education has been conducted from a technical perspective, while pedagogical theory and the role of the teacher have not been sufficiently addressed [9]. Therefore, it is advisable to ground the introduction of AI tools into laboratory classes in the following theories.

First, according to A. Johnstone's "chemistry triangle" model, a chemical phenomenon manifests itself at the macroscopic, submicroscopic and symbolic levels [1]. In the laboratory, the student directly observes only the macroscopic level: using a pH meter, they observe that the pH barely changes when an acid is added to a buffer solution, but the reason for this – the ionic equilibrium between a weak acid and its salt – remains invisible. Molecular visualization tools and AI assistants reveal precisely these "invisible" levels to the student.

Second, according to J. Sweller's cognitive load theory, the capacity of working memory is limited [4]. In the laboratory, the student must simultaneously read the instructions, handle the equipment, follow safety rules, observe and perform calculations. If the theory and procedure have not been mastered in advance, working memory becomes overloaded. H. Agustian and M. Seery argue that pre-laboratory preparation serves precisely to reduce this load [3]. Consequently, AI-supported pre-

laboratory preparation is not an organizational but a psychological and didactic necessity.

Third, according to D. Kolb's experiential learning theory, effective learning takes place through the cycle "concrete experience – reflective observation – abstract conceptualization – active experimentation" [5]. In a traditional class, only the first stage is fully ensured, while reflection is limited to a formal report. AI tools make it possible to design the class as a complete cycle that begins before the lesson and continues after it.

Fourth, according to L. S. Vygotsky's theory of the zone of proximal development, it is the tasks a student can perform with the help of a more experienced partner that drive their development [6]. A properly configured AI assistant does not give ready-made answers but performs the function of scaffolding. For example, a student who has made an error in calculating pH is given not the correct answer, but a guiding question such as "Did you take into account the dissociation constant of the weak acid?".

Fifth, in their ICAP theory, M. Chi and R. Wylie divide learning activity into passive, active, constructive and interactive levels [7]. The didactic value of an AI tool depends on the level to which it raises the student: obtaining ready-made answers from AI makes the activity passive, whereas explaining one's own reasoning and analyzing one's errors in dialogue with AI raises it to the constructive and interactive levels.

At the same time, E. Kasneci and co-authors note that generative AI may provide incorrect information, weaken independent thinking and threaten academic integrity [8], while UNESCO emphasizes a human-centred approach and the need for teachers to critically verify AI outputs [10]. For the medical chemistry laboratory, these risks are compounded by the possibility of incorrect recommendations concerning laboratory safety. Consequently, AI tools should be selected not at random, but on the basis of well-grounded didactic criteria: scientific and chemical accuracy,

compliance with safety requirements, adaptivity, suitability for the language of instruction, safeguarding of academic integrity and the possibility of teacher control.

Conclusion. The theories considered constitute a holistic pedagogical and psychological foundation for the use of AI tools in medical chemistry laboratory classes and define the following didactic requirements: organizing pre-laboratory preparation as a mandatory stage with the help of AI; revealing the submicroscopic level of chemical processes through visualization; using the AI assistant in a guiding-question mode rather than as a source of ready-made answers; engaging the student in constructive and interactive dialogue with AI; and maintaining teacher control over the final grade and clinical interpretation. These requirements substantiate the need to design the laboratory class as a staged, continuous learning cycle.

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