

Moodle Innovation Learning Technology for Medical Education: from Theory to Practice

ABSTRACT

Background: COVID-19 pandemic has affected the medical and pharmaceutical education globally by disrupting traditional educational practices such as classroom-based teaching. This necessitated implementation of a distance learning via online platforms by medical and pharmacy schools around the world, including Ukraine.

Aims: The short review aims at studying the global experience on use of innovative e-learning platform Moodle for distant medical and pharmaceutical education, figuring out its advantages and disadvantages for teaching medical/pharmacy students and healthcare professionals, and working out some recommendations for its further implementation in Ukrainian medical schools.

Methods: For this short review, the authors relied only on accredited and peer-reviewed resources with free access articles available, such as Pubmed. The searches identified 32 full-textual content articles, of which 19 had been included in this paper and submitted to a narrative review.

Results: The Moodle platform is successfully used for distant medical and pharmaceutical education worldwide, including both high and low income countries, to provide e-learning for medical/pharmacy students and healthcare professionals of different level of education, in the form of both online only courses and blended learning. The platform is a good alternative to conventional medical education with an ability to substitute hands-on teaching for video and audio materials. The potential issues related to its use include possible technical problems, i.e. insufficient technological support or Internet failure, and necessity for proper preparation of the medical and pharmacy teachers.

Conclusion: E-learning via Moodle can be easily accommodated in the medical curriculum and offer an adequate alternative to the traditional teaching and learning activities, including both theoretical knowledge and practical skills acquisition. Its potential benefits clearly outweigh possible problems involved. The Moodle platform is recommended for further wider practical application for providing e-learning to medical and pharmacy students and healthcare professionals in Ukraine.

Keywords: medical education, pharmaceutical education, distant learning, learning management system, Moodle

14 **1. INTRODUCTION**

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16 **1.1 Research Problem**

17 The COVID-19 pandemic has affected medical and pharmaceutical education in many ways.
18 Medical and pharmacy schools appeared to be unprepared in this pandemic and as a result
19 are facing a lot of problems, including unequal opportunities in accessing educational
20 materials, inadequate course content, and delays in clinical training [1, 2]. As a result,
21 medical and pharmaceutical educators worldwide have to deal with considerable challenges
22 [3, 4]. Social distancing and other measures to stop pandemic have severely disrupted
23 traditional educational practices such as classroom-based teaching [5]. This necessitated
24 implementation of a distance learning by higher education institutions around the world [6].

25 Distance learning is a form of learning through video meetings of students and teachers,
26 which makes it possible to increase one's scientific and professional level while still learning
27 (working) [7]. The effectiveness of such an educational process depends on a number of
28 factors, including control of learning material, analysis of factors influencing the presentation
29 of material by teachers, and the work of students during distance learning. It is apparent that
30 this type of education directs the teacher to search and use new teaching aids according to
31 the presented requirements of the educational process [7]. After the UNESCO suggestion for
32 educational institutes to adopt virtual teaching in place of traditional teaching, medical
33 educators have started implementing virtual classrooms and open-source software, which
34 can facilitate in providing online courses and engage students with their educators
35 simultaneously [8]. Moreover, in order to overcome the lack of hands-on training and
36 continuing medical education online, a blended mode of learning was developed. Blended
37 learning (BL) combines the merits of both online and face-to-face learning, creating
38 significant collaboration between students, educators, and patients [9].

39 Distant learning and BL has been widely implemented in medical and pharmaceutical
40 education over the last few years with teaching-learning process being increasingly carried
41 out in online or BL environments, reducing the use of the traditional face-to-face interactions
42 [10]. This situation has increased with the crisis due to COVID-19, and these days a high
43 percentage of teaching is done through so called Learning Management Systems (LMSs)
44 [11]. Now LMSs produce a significant impact on the educational process worldwide as
45 software systems that combine different tools used to “systematically deliver content online
46 and facilitate the learning experience around that content” [12, 13].LMS provides an online
47 platform for student-teacher interaction (synchronous and asynchronous), conducting
48 assessments, keeping a record of reports, learning progress, student activities, and
49 providing learners' feedback [14]. Therefore construction of professional LMS is one of the
50 important tasks in modern medical education reform [15].

51 **1.2 Research Focus**

52 One of LMSs mostly used in educational institutions worldwide is Moodle [16, 17]. Moodle
53 (Modular Object-Oriented Dynamic Learning Environment) is a user-friendly, online LMS that
54 is being used globally in teaching online courses to undergraduates, residents and doctoral
55 students [7]. Many international universities as well as medical and pharmaceutical schools
56 have integrated Moodle in their medical education and literature supports the use and
57 importance of such tools [17]. A comprehensive guide of preparation recommendations
58 about organization of lecture handouts, image preparation (which is especially important for
59 many medicine-related disciplines), course formatting (i.e. in a modular form, which is very
60 suitable for many health-related degree courses), preparation of audio and video material,
61 etc. can be found in [18].

62 Moodle platform is a popular e-learning tool used by many medical and pharmaceutical
63 educational organizations worldwide. Although online LMSs or social networks were used by
64 higher education institutions in the educational process prior to the COVID-19 pandemic,
65 due to the pandemic, universities were forced to adapt the educational process for
66 exclusively online learning, most of them opting for the integration of online learning
67 platforms such as Moodle [19]. Moodle has been successfully used in teaching
68 anesthesiology and emergency medicine [20, 21], surgery [22], thoracic surgery [23], acute
69 medicine [24], urology [25, 26], otolaryngology [27], dental radiology [28], thoracic surgery
70 [23], blood transfusions [29], ophthalmology [30], primary health care and sexual and
71 reproductive health services management [31], Chinese herbal medicine [32]. Via Moodle
72 LMS courses on anatomy [33], physiology [34], medical physics [18], vaccination [35],
73 tuberculosis [36], orthopedics [37], and even COVID-19 [38] were provided to medical
74 students. Pharmacy [39, 40], and dental students [41] also have benefited from Moodle LMS
75 during e-learning. This doesn't come as unexpected since "Teaching with Moodle" is a free
76 online course designed for anybody who wants to use Moodle learning platform for teaching.
77 Several reputed international universities are offering various courses online using the
78 Moodle platform [17]. The Ludwig Maximilians University (Germany), to name a few, in order
79 to continue offering bedside teaching for pharmacy students during the contact restrictions
80 imposed by the authorities in 2020, digitalized the course and implemented virtual bedside
81 teaching [39]. Using Moodle, the original concept was divided into smaller sections and
82 presented, e.g. in the form of video sequences. Contact with each other was possible via
83 posting in available forums or the weekly online chat consultation. The evaluation of the
84 course by the students was very positive, with mainly technical difficulties that were criticized
85 [39]. The University of Limoges (France) uses blended learning strategy based on peer
86 evaluation for teaching drug-drug interactions to undergraduate pharmacy students using the
87 Moodle platform [40]. At the same time, medical and pharmacy schools in low- and middle-
88 income countries have limited capacity to develop resources in the face of rapidly developing
89 health emergencies [42]. This has led to the adoption of different approaches among the
90 institutions. Some medical schools banned all patient interactions, while the others recruited
91 students for hospital-based roles and had early graduations, so they could serve as frontline
92 clinicians [38]. In general, in the higher education institutions of the most developed
93 countries, e-learning is both commonly and widely used, while in developing countries it is
94 still to be implemented [43]. On the one hand, more government support and investment is
95 needed to ensure blended learning is widely used in post-pandemic times in developing
96 societies. On the other hand, higher education institutions also need to participate to improve
97 and manage existing online learning methods and expansion of Internet access and online
98 library resources [44].

99 Among LMSs suitable for providing e-learning for medical and pharmacy students in
100 countries with different level of income, Moodle is the most advanced and widespread
101 system in Ukraine and in the world [7]. Ukraine started to use Moodle for e-learning after it
102 has been acknowledged in the EU countries. In 2020 e-learning platform Moodle was
103 recommended by the Ministry of Education and Science of Ukraine. As of today, Ukraine
104 takes seventh place among European countries in terms of the number of the Moodle sites
105 registered [45].

106 Thanks to its availability, Moodle LMS allows medical and pharmaceutical schools in Ukraine
107 to use innovative technologies both for education in general and for distant learning in
108 particular. Of particular note is the platform has been translated into Ukrainian to make it
109 even more user-friendly for local students and teachers. Starting March 2019, the
110 Dnepropetrovsk Medical Academy introduced distance learning using the Moodle LMS.
111 Lectures, as the main form of theoretical material, and practical classes required to apply
112 theoretical knowledge into practice are currently held on the educational platform Google

113 Meet. Practical classes and final control are conducted with the additional involvement of e-
114 learning system Moodle [46]. With the help of Moodle software, the Bukovynian State
115 Medical University has created various discussion forums, uploaded documents (or links to
116 sites) with video and audio materials, textbooks, etc. These materials have educational
117 content and contain a visual image of the disease, its clinical manifestations with practical
118 skills for students (percussion, palpation, auscultation with changes that are characteristic of
119 each disease), as well as diagnostic criteria, differential diagnosis [7]. Moreover, a study has
120 been conducted to evaluate the virtual reality technology and online teaching system among
121 medical students of the Bogomolets National Medical University during COVID-19 pandemic
122 with use of an extensive questionnaire to comprehensively evaluate the virtual reality
123 technology and online teaching system [47]. Data of the survey reflected that mostly
124 students adopted and agreed on virtual reality technology and online teaching and admitted
125 that these technologies are best alternatives to physical learning. Tutors/teachers also
126 enjoyed virtual reality and online learning through their experience and flexibility in time
127 management. The results showed positive reviews and encouraged virtual reality and online
128 teaching in academic continuity and stability in medical education in Ukraine [47].

129 **1.3 Research Aim and Research Questions**

130 Although the Moodle platform is a free, open source learning management system that is the
131 most popular choice for higher educational institutions worldwide, the best practices of the
132 Moodle system are still unknown to many [18]. But those who were able to benefit the
133 advantages of this platform report promising results on its use for e-learning of medical and
134 pharmacy students. Therefore it was decided to perform a short review of the published
135 literature to determine the role of the Moodle LMS for distant medical/pharmaceutical
136 education worldwide with an outlook for wider acceptance by in Ukraine. The short review
137 aims at studying the global experience on use of innovation e-learning Moodle platform for
138 medical and pharmaceutical education during COVID-19 pandemic, figuring out advantages
139 and disadvantages of using Moodle to teach medical and pharmacy students and healthcare
140 professionals, and working out some recommendations for further wider implementation of
141 the platform in Ukrainian medical and pharmacy schools.

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144 **2. METHODS**

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146 **2.1 General Background**

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148 At the time of this review writing, there have been not much published data on use of Moodle
149 e-learning platform in Ukrainian medical and pharmacy schools for teaching students and/or
150 in Ukrainian hospitals to provide educational materials to healthcare professionals under
151 pandemic conditions, but there have been increasing number of reports on successful use of
152 Moodle platform in medical and pharmacy schools worldwide. Thus, to outline perspectives
153 of a wide Moodle use in Ukrainian medical schools, the authors decided to evaluate more
154 comprehensive global experience on use of Moodle-based LMSs for training medical and
155 pharmaceutical students and professionals using published data presented in available
156 database. The Moodle platform was selected due to its wider acceptability as compared to
157 other open-source systems [48].

158 **2.2 Instrument and Procedures**

159 Pubmed is a free online resource supporting the search and retrieval of biomedical and life
160 sciences literature containing more than 33 million citations and abstracts of biomedical
161 literature, a lot of which have a full text available free of charge. First, a search in

162 Pubmeddatabase using keyword “Moodle” was performed for years 2019-2021 in order to
163 cover the COVID-19 pandemic period enforcing fast implementation of online techniques
164 ubiquitously. The database presented numerous published works, covering use of the
165 Moodle platform in different scientific fields worldwide. Only those labelled as research
166 articles, original articles, educational articles and short reports and communications were
167 submitted to further analysis. Review papers were considered not eligible. The next
168 elimination factor was if an article has a free-of-charge full text access required by the
169 authors to be able to conduct a detailed review of the topic. Finally, only papers describing
170 use of Moodle in medicine or pharmacy were selected for subsequent review. This resulted in
171 32 publications addressing application of Moodle software for medical and pharmaceutical
172 purposes. Among them, only reports describing use of Moodle software within educational
173 process, specifically for blended or distant learning of under- and postgraduate medical and
174 pharmaceutical students as well as healthcare professionals and medical academic staff
175 were considered relevant. E-learning of pharmacy students was within the scope of the
176 review since pharmacology is an integral part of undergraduate education in medical
177 universities and colleges in Ukraine.

178 **2.3 Sample**

179 As a result 19 papers were selected for the review, including 11 original articles, 5 research
180 articles, one educational article and two short reports representing results obtained from
181 universities and other medical and pharmaceutical educational settings of Europe, USA,
182 Asia, Africa, Middle East, etc. The main themes evaluated and discussed included e-learning
183 with use of the Moodle platform in medicine and pharmacy worldwide, types of knowledge
184 provided with a particular focus on courses and trainings in specialties requiring manual
185 skills, quantitative (if any) or qualitative assessments of Moodle-based educational courses
186 given by the attendee and the teachers, general satisfaction, and possible issues involved.

187 **2.4 Data Analysis**

188 The general scientific method used to perform this review is the method of a narrative
189 review, which is defined as a synthesis of a certain topic or branch of knowledge wherein the
190 researcher seeks to establish theoretical frameworks and draw conclusions [49]. This
191 allowed us to select, group, and analyse the collected database of papers, to evaluate
192 general experience, and to outline recommendations for further implementation in Ukraine.

193 As the authors describe the papers already written, there was no need to get the formal
194 ethical clearance from the authority.

195 **3. RESULTS**

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198 In the 21st century medical under- and postgraduate education and pedagogy have
199 undergone massive changes and faced many challenges [17]. Since face-to-face
200 interactions in large group environments (e.g., lecture and tutoring sessions) have high
201 potential in spreading the COVID-19 infection [50], the clerkship phase of medical education,
202 which requires active presence in the clinics, is considered as high risk for students [38].
203 Thus education in medical colleges and postgraduate training institutes has been drastically
204 affected [22].

205 On the other hand, this has provided an opportunity for medical educational settings to utilize
206 online teaching and learning tools to fill in the gap created by the disruption of traditional
207 teaching due to the COVID-19 pandemic [51]. Indeed, medical education is improving

208 rapidly, both in complexity and advancement opportunities. Nowadays, active forms of
209 continuing medical education are considered more effective than passive forms while
210 internet-based distance learning practices, such as webinars or online modules, are
211 successful at improving clinicians' performance [52].

212 **3.1 Moodle LMS Global Use and Types of Medical Trainees**

213 Among the variety of platforms providing tools for e-learning, Moodle is one of the most
214 popular LMSs in the world with 226 countries applying them for educational purposes [45].
215 Not initially designed for teaching medicine-related subjects, Moodle, however, is globally
216 used in this field, adding to improvement of a pandemic-related disruption in educational
217 processes. The review shows that use of the Moodle LMS is widely adopted among medical
218 universities worldwide in order to provide a non-stop educational process to undergraduate
219 medical [35, 20, 33, 25, 53, 32, 30, 21, 54, 38, 15] and pharmacy [40, 39] students under
220 pandemic conditions. During 2019-2021 a number of online courses were provided to
221 medical students in Universities of Austria [35, 21], Germany [20, 25, 30, 54], Italy [53],
222 Turkey [38], China [32, 15], and Nicaragua [33]. The courses included training in hygiene,
223 human and dental medicine, anatomy, urology, ophthalmology, anesthesiology,
224 resuscitation, etc. There are reports from some European universities established online
225 training of pharmacy undergraduates in drug-drug interactions [40] and bedside teaching
226 [39]. Among others is the Peking Union Medical College, where Moodle LMS helped to
227 create an autonomous learning environment to provide orderly, abundant and various
228 learning resources for 46 medicine related courses. As a result it was concluded that modern
229 Moodle-based teaching methods could be effectively and efficiently applied in medical
230 education [15].

231 Besides undergraduate medical education, Moodle LMS has been used to provide online
232 courses for medical postgraduates in Cleveland Clinic Lerner College of Medicine [55],
233 University of Birmingham [56], and Karachi University of Health Sciences [22], whereas
234 offline teaching activities of postgraduates, including ward rounds, elective theatres, and
235 case-based learning, all have been interrupted globally [57].

236 Moreover, there are reports how Moodle platform helps to deliver medicine-related
237 information and trainings to healthcare professionals [31, 29] and academic staff [58] under
238 circumstances of enforced distancing and face-to-face contacts limitation. Table 1
239 demonstrates the Moodle platform can be used not only for teaching medical/pharmacy
240 students, but for further improvement of healthcare professionals' knowledge and skills. Two
241 blended courses for post-Ebola capacity strengthening of health professionals were
242 successfully developed and implemented in Guinea, one in primary health care and the
243 other in sexual and reproductive health services management, with a total of 282 health
244 professionals enrolled [31]. Both courses were offered online via the Moodle platform,
245 followed by a face-to-face capacity-building workshop. The completion rate was 69.5%, the
246 success rate for learners who completed the courses was 80%, and the overall success rate
247 for enrollees was 55%. It is notable that the success rate of medical doctors enrolled was
248 higher than for other health professionals, in particular nurses and midwives [31]. We think
249 this fact should be considered while preparing online courses for different educational levels
250 of medical trainees to achieve the best results of education.

251 Detailed characteristics of the articles included in the short review are presented in Table 1.
252 The reviewed articles show that Moodle LMS has been widely used for teaching medical
253 students and healthcare professional globally thus presenting a useful tool to fill in the gap
254 created by the disruption of traditional teaching due to the COVID-19 pandemic. It is notable
255 that the platform is appreciated by both high- and low-income countries, not least due to its
256 availability free of charge and in local languages.

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258 **3.2 Moodle LMS Use for Blended vs Online Only Learning**

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In the majority of the reviewed cases describing use of Moodle LMS for the purposes of a non-stop delivery of a medical knowledge under pandemic conditions, the platform was used to provide online courses only (Table 1), whereas only 6 authors of 19 report that participants, including medical and pharmacy students [15, 33, 40, 54], postgraduates [22], and healthcare professionals [31] had an access to BL, which combines the merits of both online and face-to-face learning, creating significant collaboration between students, educators, and patients [59]. This is of particular importance, since clinical teaching is at least partially dependent on face-to-face-learning environments as medical education includes both theoretical and practical learning objectives [60]. During emergency mode teaching caused by COVID-19 pandemic in the summer semester of 2020, a pilot project on practical classroom teaching was undertaken in the Inter-Professional Medical Training Centre of Dresden [54]. An “inverted classroom model” was implemented as a teaching concept during emergency operation with preparation through digital learning and classroom teaching. 1012 students completed their training with the majority of students found the communication of information via Moodle to be sufficient and did not experience any technical problems. Moreover, an analysis of the students’ evaluation revealed a high level of overall satisfaction with the adapted teaching concept. As a result, the medical school will once again use the “inverted classroom model” concept should there be renewed or continued emergency operation and will establish it as an integral part of regular teaching [54]. As it is seen from the review, during BL the teachers could combine the virtual learning environment with classroom teaching closely, and develop more innovative and exploratory teaching activities.

Under current pandemic conditions BL seems to be the best case scenario for medical schools worldwide. But Table 1 demonstrates that for the majority of the educational institutions the only available solution was online teaching only, even when the courses were including some clinical skills or procedures to be learned. In order to achieve sustained improvement in routine procedures and anchor patient safety in the undergraduate medical curriculum, the Medical University of Vienna developed online instructional videos on clinical skills and hygiene procedures permanently available as preparation for the first clinical clerkship [35]. Short films explaining how to insert urinary catheters in women and men were produced and provided online. These videos were shown to medical students shortly before the practical examination. A total of 647 students viewed one of the two videos on urinary catheters, 623 responded to the online Moodle questionnaire completely. 85.2% reported being better able to recall individual steps and procedures, 96.7% positively rated the fact that instructional videos were available on the Medical University of Vienna’s website, more than half were better able to remember critical hygiene practices, which is very important prior to the first clerkship to ensure the highest level of patient safety possible [35]. The Bielefeld University has built a multimedia eLearning environment for fourth year medical students covering the medical school curriculum “anesthesiology and emergency medicine” [20]. For this purpose they have chosen Moodle as a platform since “it is widely used by Anglo-American educational institutions to support and conduct academic and nonacademic teaching”. Of 157 participants, 85.4% rated the course as “very good”, 12.1% as “good” and 1.9% as “OK”. Lower ratings were not given. The free-text answers revealed that accessibility and multimedia self-controlled learning were highly valued; however, it was felt that hands-on training cannot be replaced by eLearning [20]. Indeed, the main and biggest drawback of e-learning is the lack of practice, since practice in the medical field is a crucial step in the analysis of the material and its understanding [7]. Although e-learning is highly valued by medical students and healthcare professionals and helps to reduce the need for classroom teaching, no doubt that for teaching practical skills on-hand teaching is still a preferable form of education.

312 Students seem to mainly benefit from combining online and offline training, as demonstrated
313 by adding an online learning course in anatomy to the regular academic anatomy course
314 using the MOODLE platform [33]. Before the pandemic, second-year medical students at the
315 National Autonomous University of Nicaragua were randomly allocated to an experimental
316 and control group. Only the experimental group had access to the online learning module. Of
317 students in the experimental group 94.1% and 81.6% of students in the control group took
318 the objective structured practical exam, and the experimental group significantly
319 outperformed the control group on the results. The addition of an online course to the regular
320 course was considered beneficial [33]. As the lockdown was implemented, the Karachi Dow
321 University of Health Sciences employed BL to provide uninterrupted learning for surgical
322 trainees [22]. They authors of the article aimed at evaluating the perception of postgraduate
323 trainees of general surgery regarding the benefits and limitations of BL, particularly its online
324 component, Moodle LMS, for surgical education during the COVID-19 pandemic. The
325 approach of blended learning was positively received by the participants. Nearly half of the
326 participants found Moodle LMS user-friendly, practical and a good platform for learning. BL
327 was found to be beneficial in the training process of surgical postgraduates in the current
328 COVID-19 pandemic situation and recommended for the training of doctors for optimized
329 learning [22].As it is seen from the review, during BL the teachers could combine the virtual
330 learning environment with classroom teaching closely, and develop more innovative and
331 exploratory teaching activities.

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333 **3.3 Moodle LMS Use for Acquisition of Practical Skills**

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335 It's an obvious point that the face-to-face component of BL is critical for teaching doctors
336 since it is important for acquiring psychomotor skills. But when online medical education is
337 the only option perforce, if there is an alternative way for medical students and healthcare
338 professionals to master their practical skills? Regular training in the blood transfusion
339 process is crucial for transfusion safety therefore hospital transfusion committees have an
340 obligation to provide this education to hospital employees through training activities [29].
341 Members of Almeria Poniente hospital who are involved in the transfusion process, including
342 technicians, nurses, and doctors received a training course on blood transfusion. The course
343 used Moodle as the e-learning platform, which was evaluated using a satisfaction survey
344 along with a knowledge-transfer and impact survey a year after taking the course. The level
345 of general course satisfaction was 9.27 (an average out of 10) with more than 90% of the
346 students stated that they were able to apply the acquired knowledge in the workplace after a
347 year. E-learning has demonstrated itself as an affordable solution with the advantage that it
348 includes general knowledge and particular skills in local transfusion medical practice [29]. To
349 provide an alternative to hands-on training during the COVID-19 lockdown, Technical
350 University of Munich created a virtual curriculum to teach practical skills using videos
351 combined with online exams on a virtual e-learning platform with the goal to convey different
352 theoretical and practical aspects of urology [25]. The students had access to the virtual
353 curriculum via the university's Moodle e-learning platform. A total of 164 participants took
354 part in the virtual curriculum. The overall evaluation and feedback was very positive and the
355 acceptance of the virtual alternative to hands-on teaching was high. The authors of the
356 research concluded that the virtual curriculum offered a fast and contactless alternative to
357 the regular hands-on teaching [25]. Thus, regardless apparent disadvantages of distant
358 learning for medical purposes such as lack of clinical practice and potential for technical
359 problems, i.e.lack of Internet access, it is still considered a good alternative to conventional
360 medical education with an ability to substitute hands-on teaching for video and audio
361 materials. This is supported by the fact that it is not always possible to demonstrate the
362 specific pathology to the medical students during regular classes at medical schools.
363 Accordingly, video materials previously uploaded by the teacher to the Moodle system and
364 describing the pathology under consideration may be of some help, especially in case of rare

365 clinical cases. Also it may be more cost and time effective as compared to the conventional
366 offline teaching. Additionally, a meta-analysis performed in 2017 on online learning in the
367 health professions found little difference between the effectiveness of online and face-to-face
368 formats [61].

370 **3.4 Moodle LMS Related Potential Issues**

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372 By being doctors, we cannot help paying attention to the fact that in ongoing Covid-19
373 scenario, since there is an increased use of laptops and mobile phones facilitating virtual
374 learning for students, there has been increased prevalence of non-specific neck pain among
375 the people due to prolonged fixed flexion posture [62]. Besides that, implementation of e-
376 learning has met some criticism for the failure to solve problems such as low engagement,
377 low discipline, high drop-out rates, student under-performance, etc. [18]. Nevertheless, the
378 results of this short review demonstrate sufficiently high level of the trainees' satisfaction.
379 E.g. a total of 70 pharmacy students successfully completed the course of bedside teaching
380 using virtual learning environment [39]. In medicine, bedside teaching is an important part of
381 university education since it is considered a fundamental method for learning clinical and
382 communication skills. And even though for pharmacy students bedside teaching is the
383 exception rather than the normal part of their regular teaching, at the LudwigMaximilians
384 University visits to hospitals by pharmacy students have been taking place since 2005. To
385 provide bedside teaching for pharmacy students even during existing pandemic conditions,
386 the teaching concept for the seminar in clinical pharmacy and practical bedside teaching has
387 been digitalized using Moodle LMS. The overall evaluation of the e-learning process by the
388 pharmacy students was very positive, with mainly technical difficulties that were criticized
389 [39]. The possible problems involved, i.e. insufficient technological support and technical
390 failures of Internet suppliers, usually are temporary with a potential for their fixing [7]. The last
391 but not the least to consider is preparation of medical or pharmacy teacher responsible for
392 providing education via Moodle LMS, since the assumption that if one can teach in the
393 classroom this skill is easily transferrable to online courses, is wrong [18]. Whereas e-
394 learning is based on the ability to use different software technologies, not every
395 medical/pharmacy teacher can properly use them. But from a different angle, this provides
396 an opportunity for educators to take advantage of the technology for medical and
397 pharmaceutical education. While online lectures have been already used in medical
398 education [50], the COVID-19 pandemic required prompt education and preparation for a
399 wider audience [38]. Therefore our understanding is that proper and timely preparation of
400 medical and pharmaceutical educators is the key to success when starting using LMS such
401 as Moodle to provide BL for medical students and healthcare professionals. If this step is
402 adequately regarded, e-learning via Moodle will not only allow for teachers self-development
403 but also for improvement of the higher medical and pharmaceutical education quality in a
404 holistic way.

406 **4. DISCUSSION**

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408 In summary, COVID-19 pandemic has placed a massive challenge in front of educators and
409 educational facilities of over the world due to inability to sustain conventional face-to-face
410 mode of teaching. But at the same time this has provided an opportunity for them to utilize
411 online teaching and learning tools such as Moodle LMS to deliver courses online. Although
412 nothing can replace a person-to-person educational experience, especially in case of
413 practical skills acquisition, the overall trainees' satisfaction and end-of-course test results
414 demonstrate that e-learning via Moodle LMS can be easily accommodated in the curriculum
415 and offer an adequate substitute or useful adjunct to the traditional medical and
416 pharmaceutical teaching and learning activities.

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418 We demonstrated that the Moodle LMS is widely used among medical and pharmacy
419 schools and healthcare facilities globally, including countries with different level of income,
420 yet this powerful tool of training medical/pharmacy students and healthcare professionals is
421 not used in Ukraine as widely as it should be, possibly due to the generally poor integration
422 of e-learning resources such as laptops, tablet PCs, and smartphones into teaching
423 practices of Ukrainian medical schools. We consider that there is much potential for
424 implementation of Moodle-based e-learning into medical educational system in Ukraine,
425 since the platform is freely available, user-friendly, has customized translated interface, and
426 has proved its ability to meet the needs of medical and pharmaceutical teaching, including
427 both theoretical and practical courses for medical/pharmacy under- and postgraduates and
428 healthcare professionals. Also, based on the brief review of the Moodle LMS use among
429 medical schools in Ukraine, we think it may be more cost and time effective as compared to
430 the conventional offline teaching. Considering the abovementioned, we recommend that
431 Ukrainian medical educational institutions should consider wider use of the Moodle LMS as
432 an e-learning platform for teaching medical students and healthcare professionals in order to
433 improve their standards in line with the good international practice. Upon that, proper
434 preparation of educational staff responsible for using the Moodle platform should not be left
435 out of consideration in order to prevent or promptly fix potential software- and/or hardware-
436 related problems, with a particular focus on a multi-speed approach to
437 medical/pharmaceutical trainees of different educational levels. We strongly believe that this
438 will improve higher medical education in Ukraine during the pandemic and not only.

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440 The conducted short review demonstrated the geographical dispersion of the Moodle LMS
441 users covering countries of different income, which is of particular importance for giving
442 recommendations on its use for developing countries. Also we were able to represent
443 different types of medical/pharmacy trainees and medicine-related courses and prove the
444 Moodle system to be multipurpose in terms of students' educational level and type of
445 medical and/or pharmaceutical knowledge provided. However there was no possibility for a
446 side-by-side comparison of the reviewed data since all the studies included used different
447 types of qualitative and/or quantitative subjective and/or objective assessments. More
448 uniform data needed to conduct a larger systematic review on worldwide use of the Moodle
449 LMS as a substitute for or an adjunct to a conventional medical education, especially in
450 disciplines requiring acquisition of practical skills.

451

452 **5. CONCLUSION**

453

454 The short narrative review results demonstrated that that the Moodle LMS has been widely
455 used for teaching medical and pharmacy students and healthcare professional globally to
456 replace traditional teaching affected by the COVID-19 pandemic. It was emphasized that the
457 software is customized and free-of-charge, therefore countries of different income are able to
458 use it. The review showed its suitability for providing e-learning to medical and pharmacy
459 undergraduates, postgraduates, and healthcare professionals in different areas of medicine.
460 The results of personal and impersonal assessments of the trainees demonstrated that e-
461 learning via Moodle LMS can be easily accommodated in the medical curriculum and offer
462 an adequate alternative to the traditional teaching and learning activities. It was proved that
463 the Moodle LMS can be successfully used for both theoretical knowledge and practical skills
464 acquisition.

465 The analysis of the experience on global Moodle use showed that potential benefits of its
466 use clearly overweigh the possible temporary problems involved.

467 Recommendations on further wider practical application of the Moodle LMS for providing e-
468 learning to medical and pharmacy students and healthcare professionals in Ukraine:

- 469 - Wider implementation and use the Moodle LMS as a useful tool to educate medical
470 and pharmacy students and healthcare professionals of different experience, level of training
471 and qualification;
472 - Considerably larger utilisation of its numerous advantages, such as free access,
473 user friendliness, customised translated interface, ability to meet the demands of teaching
474 medicine including theoretical and practical courses, which will contribute to efficacy of
475 medical education even when conventional face-to-face learning is available again, to
476 provide fast transition from offline mode of teaching to the online one and vice versa;
477 - Providing ability for teaching clinicians to improve their skills in the methods of online
478 education, online counselling, online teaching, which is both currently required for their
479 professional education and useful for professors combining clinical practice with teaching to
480 save time;
481 - Developing new contributions of the Moodle platform to medical and pharmaceutical
482 education together with IT specialists able to update the software with an emphasis on
483 medicine and pharmacy needs and teaching medical/pharmacy students in schools of
484 different level of education and specialisation.
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Table 1. Detailed characteristics of articles included in the short review

Author	Type of paper	Teaching model	Type of courses	Participants	Inference
Abdalla et al. [58]	EA	OO	Social accountability of medical schools	AS	The Moodle-based online course provides a flexible way to conduct faculty development programmes
Bäwert et al. [35]	OA	OO	Clinical skills and hygiene procedures	UMS	The combination of learning formats, such as videos on online platforms as Moodle with textbooks or lecture notes, is well suited to increase effectiveness and efficiency in learning
Bergmans et al. [20]	OA	OO	Anesthesiology and emergency medicine	UMS	Technology enhanced learning via Moodle was highly valued by students and helped to reduce the need for classroom teaching
Brateanu et al. [55]	OA	OO	Internal medicine	PMS	An online module as Moodle can offer a simple and effective method to increase the medical knowledge
Chan et al. [33]	OA	BL	Anatomy	UMS	An addition of an online Moodle-based course to the regular course was beneficial
Elledge et al. [56]	RA	OO	Surgery	PMS	Our online learning program will include a Moodle-based virtual learning environment
Kidess et al. [25]	OA	OO	Urology practical skills	UMS	The virtual curriculum via Moodle offered a fast and contactless alternative to the regular hands-on teaching
La Torre et al. [53]	OA	OO	Smoking and smoking cessation	UMS	Students appreciated contents and structure of online courses delivered through Moodle
Li et al. [32]	RA	OO	Chinese herbal medicine	UMS	A specially designed Moodle module may be effective in Chinese herbal medicine education
Lawson et al. [40]	RA	BL	Drug-drug interactions	UPS	Our Moodle-based teaching approach was qualified as being a positive and stimulating learning tool by students
Millimouno et al. [31]	RA	BL	Post-Ebola capacity strengthening	HP	Two blended courses for health professionals were successfully developed and implemented with use of Moodle
Mohi et al. [30]	OA	OO	Ophthalmology	UMS	Students assessed the digital training through Moodle in most parts to be a good and an

					equivalent option compared to classroom teaching
Molina-Arrebola et al. [29]	OA	OO	Blood transfusion	HS	E-learning has demonstrated itself as an affordable solution that could help in the training of hospital staff
Mueller et al. [21]	RA	OO	Resuscitation	UMS	Although sufficient skill training could not be imparted under pandemic circumstances, we could provide sufficient theoretical knowledge to allow students to continue studies
Pudritz[39]	SR	OO	Bedside teaching	UPS	The evaluation of the Moodle-based course was very positive, with mainly technical difficulties that were criticized
Rimsha et al. [22]	OA	BL	General surgery	PMS	Blended learning was found to be beneficial in the current pandemic situation. We recommend it for the training of doctors for optimized learning
Röhle et al. [54]	SR	BL	Human and dental medicine	UMS	The inverted classroom model using Moodle will be established as an integral part of regular teaching
Yilmaz et al. [38]	RA	OO	COVID-19	UMS	Online courses could play a vital role in the dissemination of accurate information to medical students in future public health emergencies
Zhang et al. [15]	OA	BL	Medicine related courses	UMS	Through Moodle, modern teaching methods could be applied in the medical education effectively and efficiently

711 AS = Academic Staff at medical schools

712 BL = Blended Learning

713 EA = Educational Article

714 HP = Health-care Professionals

715 HS = Hospital Staff including technicians, nurses, and doctors

716 OA = Original Article

717 OO = Online Only

718 PMS = Postgraduate Medical Students

719 RA = Research Article

720 SR = Short Report

721 UMS = Undergraduate Medical Students

722 UPS = Undergraduate Pharmacy Students

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