

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

ABSTRACT

Background: COVID-19 pandemic has affected the medical education globally by disrupting traditional educational practices such as classroom-based teaching. This necessitated implementation of a distance learning via online platforms by medical 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 education, figuring out its advantages and disadvantages for teaching medical 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 education globally, including both high and low income countries, to provide e-learning for medical 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 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 students and healthcare professionals in Ukraine.

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

1. INTRODUCTION

1.1 Research Problem

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

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

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

1.2 Research Focus

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

Moodle platform is a popular e-learning tool used by many medical educational organizations worldwide. Although online LMSs or social networks were used by higher education institutions in the educational process prior to the COVID-19 pandemic, due to the pandemic, universities were forced to adapt the educational process for exclusively online learning, most of them opting for the integration of online learning platforms such as Moodle

[19]. Moodle has been successfully used in teaching anesthesiology and emergency medicine [20, 21], surgery [22], thoracic surgery [23], acute medicine [24], urology [25, 26], otolaryngology [27], dental radiology [28], thoracic surgery [23], blood transfusions [29], ophthalmology [30], primary health care and sexual and reproductive health services management [31], Chinese herbal medicine [32]. Via Moodle LMS courses on anatomy [33], physiology [34], medical physics [18], vaccination [35], tuberculosis [36], orthopedics [37], and even COVID-19 [38] were provided to medical students. Pharmacy [39, 40], and dental students [41] also have benefited from Moodle LMS during e-learning. This doesn't come as unexpected since "Teaching with Moodle" is a free online course designed for anybody who wants to use Moodle learning platform for teaching. Several reputed international universities are offering various courses online using the Moodle platform [17]. At the same time, medical schools in low- and middle-income countries have limited capacity to develop resources in the face of rapidly developing health emergencies [42]. This has led to the adoption of different approaches among the institutions. Some medical schools banned all patient interactions, while the others recruited students for hospital-based roles and had early graduations, so they could serve as frontline clinicians [38]. In general, in the higher education institutions of the most developed countries, e-learning is both common and widely used, while in developing countries it is still to be implemented [43].

Among LMSs suitable for providing e-learning for medical students in countries with different level of income, Moodle is the most advanced and widespread system in Ukraine and in the world [7]. Ukraine started to use Moodle for e-learning after it has been acknowledged in the EU countries. In 2020 e-learning platform Moodle was recommended by the Ministry of Education and Science of Ukraine. As of today, Ukraine takes seventh place among European countries in terms of the number of the Moodle sites registered [44].

Thanks to its availability, Moodle LMS allows medical schools in Ukraine to use innovative technologies both for education in general and for distant learning in particular. Of particular note is the platform has been translated into Ukrainian to make it even more user-friendly for local students and teachers. Starting March 2019, Dnepropetrovsk Medical Academy introduced distance learning using the Moodle LMS. Lectures, as the main form of theoretical material, and practical classes required to apply theoretical knowledge into practice are currently held on the educational platform Google Meet. Practical classes and final control are conducted with the additional involvement of e-learning system Moodle [45]. With the help of Moodle software, Bukovynian State Medical University has created various discussion forums, uploaded documents (or links to sites) with video and audio materials, textbooks, etc. These materials have educational content and contain a visual image of the disease, its clinical manifestations with practical skills for students (percussion, palpation, auscultation with changes that are characteristic of each disease), as well as diagnostic criteria, differential diagnosis [7].

1.3 Research Aim and Research Questions

Although the Moodle platform is a free, open source learning management system that is the most popular choice for higher educational institutions worldwide, the best practices of the Moodle system are still unknown to many [18]. But those who were able to benefit the advantages of this platform report promising results on its use for e-learning of medical students. Therefore it was decided to perform a short review of the published literature to determine the role of the Moodle LMS for distant medical education worldwide with an outlook for wider acceptance by in Ukraine. The short review aims at studying the global experience on use of innovation e-learning Moodle platform for medical education during COVID-19 pandemic, figuring out advantages and disadvantages of using Moodle to teach

medical students and healthcare professionals, and working out some recommendations for further wider implementation of the platform in Ukrainian medical schools.

2. METHODS

2.1 General Background

At the time of this review writing, there have been not much published data on use of Moodle e-learning platform in Ukrainian medical schools for teaching medical students and/or in Ukrainian hospitals to provide educational materials to healthcare professionals under pandemic conditions, but there have been increasing number of reports on successful use of Moodle platform in medical schools worldwide. Thus, to outline perspectives of a wide Moodle use in Ukrainian medical schools, the authors decided to evaluate more comprehensive global experience on use of Moodle-based LMSs for training medical and pharmaceutical students and professionals using published data presented in available database. The Moodle platform was selected due to its wider acceptability as compared to other open-source systems [46].

2.2 Instrument and Procedures

Pubmed is a free online resource supporting the search and retrieval of biomedical and life sciences literature containing more than 33 million citations and abstracts of biomedical literature, a lot of which have a full text available free of charge. First, a search in Pubmed database using keyword "Moodle" was performed for years 2019-2021 in order to cover the COVID-19 pandemic period enforcing fast implementation of online techniques ubiquitously. The database presented numerous published works, covering use of the Moodle platform in different scientific fields worldwide. Only those labelled as research articles, original articles, educational articles and short reports and communications were submitted to further analysis. Review papers were considered not eligible. The next elimination factor was if an article has a free-of-charge full text access required by the authors to be able to conduct a detailed review of the topic. Finally, only papers describing use of Moodle in medicine or pharmacy were selected for subsequent review. This resulted in 32 publications addressing application of Moodle software for medical and pharmaceutical purposes. Among them, only reports describing use of Moodle software within educational process, specifically for blended or distant learning of under- and postgraduate medical and pharmaceutical students as well as healthcare professionals and medical academic staff were considered relevant. E-learning of pharmacy students was within the scope of the review since pharmacology is an integral part of undergraduate education in medical universities and colleges in Ukraine.

2.3 Sample

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

2.4 Data Analysis

The general scientific method used to perform this review is the method of a narrative review, which is defined as a synthesis of a certain topic or branch of knowledge wherein the researcher seeks to establish theoretical frameworks and draw conclusions [47]. This allowed us to select, group, and analyse the collected database of papers, to evaluate general experience, and to outline recommendations for further implementation in Ukraine.

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

3. RESULTS

In the 21st century medical under- and postgraduate education and pedagogy have undergone massive changes and faced many challenges [17]. Since face-to-face interactions in large group environments (e.g., lecture and tutoring sessions) have high potential in spreading the COVID-19 infection [48], the clerkship phase of medical education, which requires active presence in the clinics, is considered as high risk for students [38]. Thus education in medical colleges and postgraduate training institutes has been drastically affected [22].

On the other hand, this has provided an opportunity for medical educational settings to utilize online teaching and learning tools to fill in the gap created by the disruption of traditional teaching due to the COVID-19 pandemic [49]. Indeed, medical education is improving rapidly, both in complexity and advancement opportunities. Nowadays, active forms of continuing medical education are considered more effective than passive forms while internet-based distance learning practices, such as webinars or online modules, are successful at improving clinicians' performance [50].

3.1 Moodle LMS Global Use and Types of Medical Trainees

Among the variety of platforms providing tools for e-learning, Moodle is one of the most popular LMSs in the world with 226 countries applying them for educational purposes [44]. Not initially designed for teaching medicine-related subjects, Moodle, however, is globally used in this field, adding to improvement of a pandemic-related disruption in educational processes. The review shows that use of the Moodle LMS is widely adopted among medical universities worldwide in order to provide a non-stop educational process to undergraduate medical [35, 20, 33, 25, 51, 32, 30, 21, 52, 38, 15] and pharmacy [40, 39] students under pandemic conditions. During 2019-2021 a number of online courses were provided to medical students in Universities of Austria [35, 21], Germany [20, 25, 30, 52], Italy [51], Turkey [38], China [32, 15], and Nicaragua [33]. The courses included training in hygiene, human and dental medicine, anatomy, urology, ophthalmology, anesthesiology, resuscitation, etc. There are reports from some European universities established online training of pharmacy undergraduates in drug-drug interactions [40] and bedside teaching [39]. Among others is the Peking Union Medical College, where Moodle LMS helped to create an autonomous learning environment to provide orderly, abundant and various learning resources for 46 medicine related courses. As a result it was concluded that modern Moodle-based teaching methods could be effectively and efficiently applied in medical education [15].

Besides undergraduate medical education, Moodle LMS has been used to provide online courses for medical postgraduates in Cleveland Clinic Lerner College of Medicine [53], University of Birmingham [54], and Karachi University of Health Sciences [22], whereas offline teaching activities of postgraduates, including ward rounds, elective theatres, and case-based learning, all have been interrupted globally [55].

Moreover, there are reports how Moodle platform helps to deliver medicine-related information and trainings to healthcare professionals [31, 29] and academic staff [56] under circumstances of enforced distancing and face-to-face contacts limitation. Table 1 demonstrates the Moodle platform can be used not only for teaching medical/pharmacy students, but for further improvement of healthcare professionals' knowledge and skills. Two blended courses for post-Ebola capacity strengthening of health professionals were successfully developed and implemented in Guinea, one in primary health care and the other in sexual and reproductive health services management, with a total of 282 health professionals enrolled [31]. Both courses were offered online via the Moodle platform, followed by a face-to-face capacity-building workshop. The completion rate was 69.5%, the success rate for learners who completed the courses was 80%, and the overall success rate for enrollees was 55%. It is notable that the success rate of medical doctors enrolled was higher than for other health professionals, in particular nurses and midwives [31]. We think this fact should be considered while preparing online courses for different educational levels of medical trainees to achieve the best results of education.

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

3.2 Moodle LMS Use for Blended vs Online Only Learning

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, 52], 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 [57]. 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 [58]. 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 [52]. 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 [52]. 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. Students seem to mainly benefit from combining online and offline training, as demonstrated by adding an online learning course in anatomy to the regular academic anatomy course using the MOODLE platform [33]. Before the pandemic, second-year medical students at the National Autonomous University of Nicaragua were randomly allocated to an experimental and control group. Only the experimental group had access to the online learning module. Of students in the experimental group 94.1% and 81.6% of students in the control group took the objective structured practical exam, and the experimental group significantly outperformed the control group on the results. The addition of an online course to the regular course was considered beneficial [33]. As the lockdown was implemented, the Karachi Dow University of Health Sciences employed BL to provide uninterrupted learning for surgical trainees [22]. The authors of the article aimed at evaluating the perception of postgraduate trainees of general surgery regarding the benefits and limitations of BL, particularly its online component, Moodle LMS, for surgical education during the COVID-19 pandemic. The approach of blended learning was positively received by the participants. Nearly half of the participants found Moodle LMS user-friendly, practical and a good platform for learning. BL was found to be beneficial in the training process of surgical postgraduates in the current COVID-19 pandemic situation and recommended for the training of doctors for optimized learning [22]. 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.

3.3 Moodle LMS Use for Acquisition of Practical Skills

It's an obvious point that the face-to-face component of BL is critical for teaching doctors since it is important for acquiring psychomotor skills. But when online medical education is the only option perforce, if there is an alternative way for medical students and healthcare professionals to master their practical skills? Regular training in the blood transfusion process is crucial for transfusion safety therefore hospital transfusion committees have an obligation to provide this education to hospital employees through training activities [29]. Members of Almeria Poniente hospital who are involved in the transfusion process, including technicians, nurses, and doctors received a training course on blood transfusion. The course used Moodle as the e-learning platform, which was evaluated using a satisfaction survey along with a knowledge-transfer and impact survey a year after taking the course. The level of general course satisfaction was 9.27 (an average out of 10) with more than 90% of the

students stated that they were able to apply the acquired knowledge in the workplace after a year. E-learning has demonstrated itself as an affordable solution with the advantage that it includes general knowledge and particular skills in local transfusion medical practice [29]. To provide an alternative to hands-on training during the COVID-19 lockdown, Technical University of Munich created a virtual curriculum to teach practical skills using videos combined with online exams on a virtual e-learning platform with the goal to convey different theoretical and practical aspects of urology [25]. The students had access to the virtual curriculum via the university's Moodle e-learning platform. A total of 164 participants took part in the virtual curriculum. The overall evaluation and feedback was very positive and the acceptance of the virtual alternative to hands-on teaching was high. The authors of the research concluded that the virtual curriculum offered a fast and contactless alternative to the regular hands-on teaching [25]. Thus, regardless apparent disadvantages of distant learning for medical purposes such as lack of clinical practice and potential for technical problems, i.e. lack of Internet access, it is still considered a good alternative to conventional medical education with an ability to substitute hands-on teaching for video and audio materials. This is supported by the fact that it is not always possible to demonstrate the specific pathology to the medical students during regular classes at medical schools. Accordingly, video materials previously uploaded by the teacher to the Moodle system and describing the pathology under consideration may be of some help, especially in case of rare clinical cases. Also it may be more cost and time effective as compared to the conventional offline teaching. Additionally, a meta-analysis performed in 2017 on online learning in the health professions found little difference between the effectiveness of online and face-to-face formats [59].

3.4 Moodle LMS Related Potential Issues

Although implementation of e-learning has met some criticism for the failure to solve problems such as low engagement, low discipline, high drop-out rates, student under-performance, etc. [18], the results of this short review demonstrate sufficiently high level of the trainees' satisfaction. The possible problems involved, i.e. insufficient technological support and technical failures of Internet suppliers, usually are temporary with a potential for their fixing [7]. The last but not the least to consider is preparation of medical teacher responsible for providing education via Moodle LMS, since the assumption that if one can teach in the classroom this skill is easily transferrable to online courses, is wrong [18]. Whereas e-learning is based on the ability to use different software technologies, not every medical teacher can properly use them. But from a different angle, this provides an opportunity for educators to take advantage of the technology for medical education. While online lectures have been already used in medical education [48], the COVID-19 pandemic required prompt education and preparation for a wider audience [38]. Therefore our understanding is that proper and timely preparation of medical educators is the key to success when starting using LMS such as Moodle to provide BL for medical students and healthcare professionals. If this step is adequately regarded, e-learning via Moodle will not only allow for teachers self-development but also for improvement of the higher medical education quality in a holistic way.

4. DISCUSSION

In summary, COVID-19 pandemic has placed a massive challenge in front of educators and educational facilities of over the world due to inability to sustain conventional face-to-face mode of teaching. But at the same time this has provided an opportunity for them to utilize online teaching and learning tools such as Moodle LMS to deliver courses online. Although nothing can replace a person-to-person educational experience, especially in case of practical skills acquisition, the overall trainees' satisfaction and end-of-course test results

demonstrate that e-learning via Moodle LMS can be easily accommodated in the curriculum and offer an adequate substitute or useful adjunct to the traditional teaching and learning activities. We demonstrated that the Moodle LMS is widely used among medical schools and healthcare facilities globally, including countries with different level of income, yet this powerful tool of training medical students and healthcare professionals is not used in Ukraine as widely as it should be, possibly due to the generally poor integration of e-learning resources such as laptops, tablet PCs, and smartphones into teaching practices of Ukrainian medical schools. We consider that there is much potential for implementation of Moodle-based e-learning into medical educational system in Ukraine, since the platform is freely available, user-friendly, has customized translated interface, and has proved its ability to meet the needs of medical teaching, including both theoretical and practical courses for medical under-, postgraduates, and healthcare professionals. Also, based on the brief review of the Moodle LMS use among medical schools in Ukraine, we think it may be more cost and time effective as compared to the conventional offline teaching. Considering the abovementioned, we recommend that Ukrainian medical educational institutions should consider wider use of the Moodle LMS as an e-learning platform for teaching medical students and healthcare professionals in order to improve their standards in line with the good international practice. Upon that, proper preparation of educational staff responsible for using the Moodle platform should not be left out of consideration in order to prevent or promptly fix potential software- and/or hardware-related problems, with a particular focus on a multi-speed approach to medical trainees of different educational levels. We strongly believe that this will improve higher medical education in Ukraine during the pandemic and not only. The conducted short review demonstrated the geographical dispersion of the Moodle LMS users covering countries of different income, which is of particular importance for giving recommendations on its use for developing countries. Also we were able to represent different types of medical trainees and medicine-related courses and prove the Moodle system to be multipurpose in terms of students' educational level and type of medical knowledge provided. However there was no possibility for a side-by-side comparison of the reviewed data since all the studies included used different types of qualitative and/or quantitative subjective and/or objective assessments. More uniform data needed to conduct a larger systematic review on worldwide use of the Moodle LMS as a substitute for or an adjunct to a conventional medical education, especially in disciplines requiring acquisition of practical skills.

5. CONCLUSION

The short narrative review results demonstrated that that the Moodle LMS has been widely used for teaching medical students and healthcare professional globally to replace traditional teaching affected by the COVID-19 pandemic. It was emphasized that the software is customized and free-of-charge, therefore countries of different income are able to use it. The review showed its suitability for providing e-learning to medical undergraduates, postgraduates, and healthcare professionals in different areas of medicine.

The results of personal and impersonal assessments of the trainees demonstrated that e-learning via Moodle LMS can be easily accommodated in the medical curriculum and offer an adequate alternative to the traditional teaching and learning activities. It was proved that the Moodle LMS can be successfully used for both theoretical knowledge and practical skills acquisition.

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

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

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

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APPENDIX

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. [56]	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. [53]	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. [54]	RA	OO	Surgery	PMS	Our online learning program will include a Moodle-based virtual learning environment
Kidess et al. []	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. [25]	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. [52]	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

AS = Academic Staff at medical schools

BL = Blended Learning

EA = Educational Article

HP = Health-care Professionals

HS = Hospital Staff including technicians, nurses, and doctors

OA = Original Article

OO = Online Only

PMS = Postgraduate Medical Students

RA = Research Article

SR = Short Report

UMS = Undergraduate Medical Students

UPS = Undergraduate Pharmacy Students