Parsian as a Model for Employing Patient Simulation in the Learning Management System

Shirin Ayani[1], Khadijeh Moulaei[2, *], Ashraf Alimadadi[3], Mahmoud Bakhtiari[4], Rafat Bayat[5], Faezeh Sadeghi[6], Samaneh Nematolahi[7] and Mohammad Shahrabadi[7]

[1]PhD in Medical Informatics, Department of Computer Science, Faran (Mehr Danesh) Non-governmental Institute of Virtual Higher Education, Tehran, IR Iran
[2]MSc Student of Medical Informatics, Medical Informatics Group, School of Management and Medical Information, Iran University of Medical Sciences, Tehran, IR Iran
[3]MD of Endocrinology, Department of Internal Medicine, Endocrinology Branch, School of Medicine, Shahid Beheshti University of Medical Science, Tehran, IR Iran
[4]Non-communicables Diseases Research Center, Alborz University of Medical Sciences, Karaj, Iran
[5]PhD in Sociology, Department of Management, Faran (Mehr Danesh) Non-governmental Institute of Virtual Higher Education, Tehran, IR Iran
[6]MA of English Language and Literature, Department of English Language, Faran (Mehr Danesh) Non-governmental Institute of Virtual Higher Education, Tehran, IR Iran
[7]MSc of Information Technology, Faran (Mehr Danesh) Non-governmental Institute of Virtual Higher Education, Tehran, IR Iran

[*]*Corresponding author*: MSc Student of Medical Informatics, Medical Informatics Group, School of Management and Medical Information, Iran University of Medical Sciences, Tehran, IR Iran. Tel: +98-2188783115, Fax: +98-2188661654, E-mail: Moulaei.kh@tak.iums.ac.ir

Abstract

Background: E-learning is a recent approach in education, commonly appreciated for teaching students in most scientific fields, particularly in the industry. However, in medical education, this approach has difficulties that reduce its performance. Through the survey of the present models defining E-learning components, in respect to the patient simulation systems playing an important role in medical education, some deficiencies of these models have been revealed.

Objectives: In order to provide appropriate tools and techniques for implementing patient simulation within the learning management system, this research aimed at identifying the deficiencies of E-learning models and proposing a new model.

Methods: In this review article, published accredited articles or books were initially searched in order to obtain E-learning components and different types of patient simulation systems. Through a study of E-learning components in selected models, the shortcomings in implementing various kinds of patient simulation systems were determined and the "Parsian" model was subsequently introduced.

Results: According to the results of the conducted research, it was found that the group of component tools in E-learning models, which could be classified in 3 different groups, was not adequate for implementing patient simulation. In the "Parsian" model, necessary tools and techniques were introduced in 3 different groups of software, methods, and techniques and medical equipment. All these groups introduced in the "Parsian" model were applicable.

Conclusions: In the faculty of medicine, professors need patient simulation systems to provide students with E-learning. However, at the moment, there is not such patient simulation system in the existing LMS s all over the world. The LMSs are usually designed to teach courses that are mostly theoretical (rather than practical). Implementation of an LMS, exclusively applicable with high competence for teaching in all the realms of medical sciences, is provided by the means of "Parsian" tools and techniques.

Keywords: E-learning, Patient Simulation, Medical E-learning, Virtual Patient

1. Background

The development of Internet and digital technology growth have changed the web to an economic, global, and interactive media to create E-learning. E-learning is an innovative approach that facilitates availability of education and new skills in an interactive infrastructure, so that digital content could be utilized at anytime and anywhere. Adopting new educational methods based on recent technologies and the needs of communities are the 2 major features of E-learning (1-3).

During the recent decades, E-learning development has experienced many benefits and few deficiencies with respect to inclusive education. Providing a wide range of tools and components that allows teachers and students to participate in all related activities is one of these benefits; while maintaining the quality of education improves the rate of transferring theoretical and practical experiences (4, 5). Applying this method could be done by the means of different components; each of these components is used in a way that transfers the concepts to students (6). Although in different fields the combination of these com-

ponents to implement E-learning has appeared to be successful, the combination of the same components for E-learning in medical education did not ensure its best performance ([7](#)). To address the main causes of this problem, examining face-to-face training appears to be crucial. In fact, patients, students, and professors can interact in face-to-face education. Medical students are trained under direct supervision of their professors in educational hospitals so that they will improve their knowledge and experience. They will also make decisions based on observations and results of diagnosis and clinical treatments ([8](#), [9](#)). Simulating the traditional educational method, E-learning in medical education requires components to reflect the dynamism of objects, the details of an action, and the results of senses like olfactory and tactile. The combination of E-learning components, which represent these activities in the form of a simulator, games or virtual reality will lead to a successful educational approach ([10](#)-[12](#)). In medical training, it is essential to visit patients, which can be carried out through a simulation system in E-learning ([13](#)), so that medical students can practice on simulated patients in a safe environment, neither experiencing fear nor jeopardizing the patients. Patient simulation allows these students to develop and evaluate necessary diagnostic and therapeutic skills before facing real patients ([14](#)). Based on the simulation system using clinical scenarios, evaluating students' level of learning during clinical examination and also making careful and appropriate decisions is achievable ([15](#), [16](#)). While due to the lack of a patient simulation system in the existing environment of E-learning, the previously mentioned practices cannot be performed. Medical E-learning could be provided if the patient simulation system in E-learning is established. To achieve this goal, it is necessary to perform situation analysis, which was conducted in the present article.

2. Objectives

The aim of the present study was to survey E-learning components, and the strengths and weaknesses of E-learning in order to implement patient simulation and to present a new model consisting of E-learning components for implementing patient simulation in an LMS.

3. Methods

In this review article, a variety of databases and search engines, including Pubmed, Scopus, Elsevier, IEEE, Springer, Web of Science, Proquest, ACM, and Google Scholar were searched according to the below-mentioned pre-specified search strategy and the relevant Mesh terms.

The databases were looked up from April 2017 to December 2017 and published accredited scientific papers or reference books in English were initially investigated in order to obtain E-learning components and different types of patient simulation systems. Due to the fact that there was no time limit for obtaining scientific papers and finding reference books, major retrieved papers were from years 2001 to 2017.

3.1. Search Strategy

A list of search terms commonly used by E-learning components and different types of patient simulation systems was obtained from the published literature. These terms included E-learning, Medical E-learning, Digital Library, Virtual Medical Education, Blended Learning, E-learning Components, E-learning Activities, E-learning Resources, Simulation-Based Learning, Patient Simulation, and Virtual Patient and Composed Simulation.

3.1.1. Inclusion Criteria:
- The resources being in full text.
- The resources with up-to-date contents.
- The resources that define E-learning components in the "E-learning Models".
- The resources that define different types of patient simulation systems in the "patient simulation systems group".
- The resources that are defined through credible universal references.

3.1.2. Exclusion Criteria:
- There were not enough E-learning components and different types of patient simulation systems in the resources.
- Definitions were ambiguous and irrelevant to the E-learning components and different types of patient simulation systems in the resources.
- In relation to E-learning and patient simulation systems, the resources were not comprehensive.

3.1.3. Resource Extraction
Resource extraction was done using the following methods:

One hundred and one retrieved scientific papers and reference books were chosen by the researchers. Eliminating 15 duplicate references, the remaining 86 articles were classified to 2 groups named "E-learning Model" and "Patient Simulation Systems". The rest of the papers and books

in both groups were compared based on certain inclusion and exclusion criteria.

In both groups, more comprehensive papers and more suitable samples of similar models were preferred. Accordingly, 17 articles and books introducing E-learning models were selected for the study (17-34), as well as 15 articles concerning patient simulation systems chosen for the analysis (35-49). The search results are shown in Figure 1. Additionally, the 5 most usable E-learning systems among top 10 open source management systems including: 1. eFront, 2. Dokeos, 3. Moodle, 4. LRN, and 5. Canvas (50) were preferred for further analysis.

3.2. Analysis of Models and Presenting "Parsian" Model:

3.2.1. Studying and Comparing E-learning Models

Due to the vardiation of names and concepts of E-learning components and their group in different E-learning models, in order to provide further comparison, it was necessary to have a unified definition of names and concepts for each one of the E-learning components and their group. For this purpose, the following procedures were accomplished respectively:

I. First, regarding the concept, those E-learning components that appeared to be extremely similar and overlapped each other were classified in the same group.

II. Then, E-learning components in each group were studied. Based on frequently used names assigned to the components, a unified name was chosen for each component. Meanwhile, similar definitions for each component resulted in a single description for each component. Ultimately, among frequently used names of the components, an appropriate name was selected for each component group.

III. A table containing components group, the components and their descriptions were provided for analysis.

3.2.2. Studying and Classifying Patient Simulation Systems:

I. The patient simulation system was studied and then classified to 3 groups.

II. Problems of implementing patient simulation in learning management system were introduced by E-learning components.

3.2.3. Introducing the "Parsian" Model:

To resolve the existing problems in E-learning models, the "Parsian" Model encompassing essential tools and techniques was presented to implement patient simulation systems.

4. Results

4.1. E-learning and Its Components

The components are inseparable parts of E-learning systems. In fact, E-learning provides teaching and learning with different components (23). In some resources of this study (17-34), E-learning components were identified. In the present research, accomplishing the processes discussed in the method section, a classification of components was proposed.

In Table 1, demonstrating a classification of the components group, the components of each group and the concept of each component were presented. The components and their concepts are discussed below in detail.

4.2. Strategies and Activities

This group contains components, such as educational missions, educational objectives, educational strategies, educational processes, and educational roles. Strategies and activities specify how teachers and students can interact (51).

4.3. Resources

Electronic libraries hold educational materials, such as books, e-journals, databases, web pages, CDs, and other electronic formats (52). Library resources can be available in the form of e-books, films, papers, files and links in various audio, video, and multimedia or text format. It is possible to define a particular library for each course and also define a general library for all the courses in an LMS (52).

4.4. Tools

E-learning tools include a wide range of various usages (53). They can be divided to 5 major components as follows:

I. Communication Tools: Synchronous and Asynchronous

II. Web Tools

III. Remote Access Tools

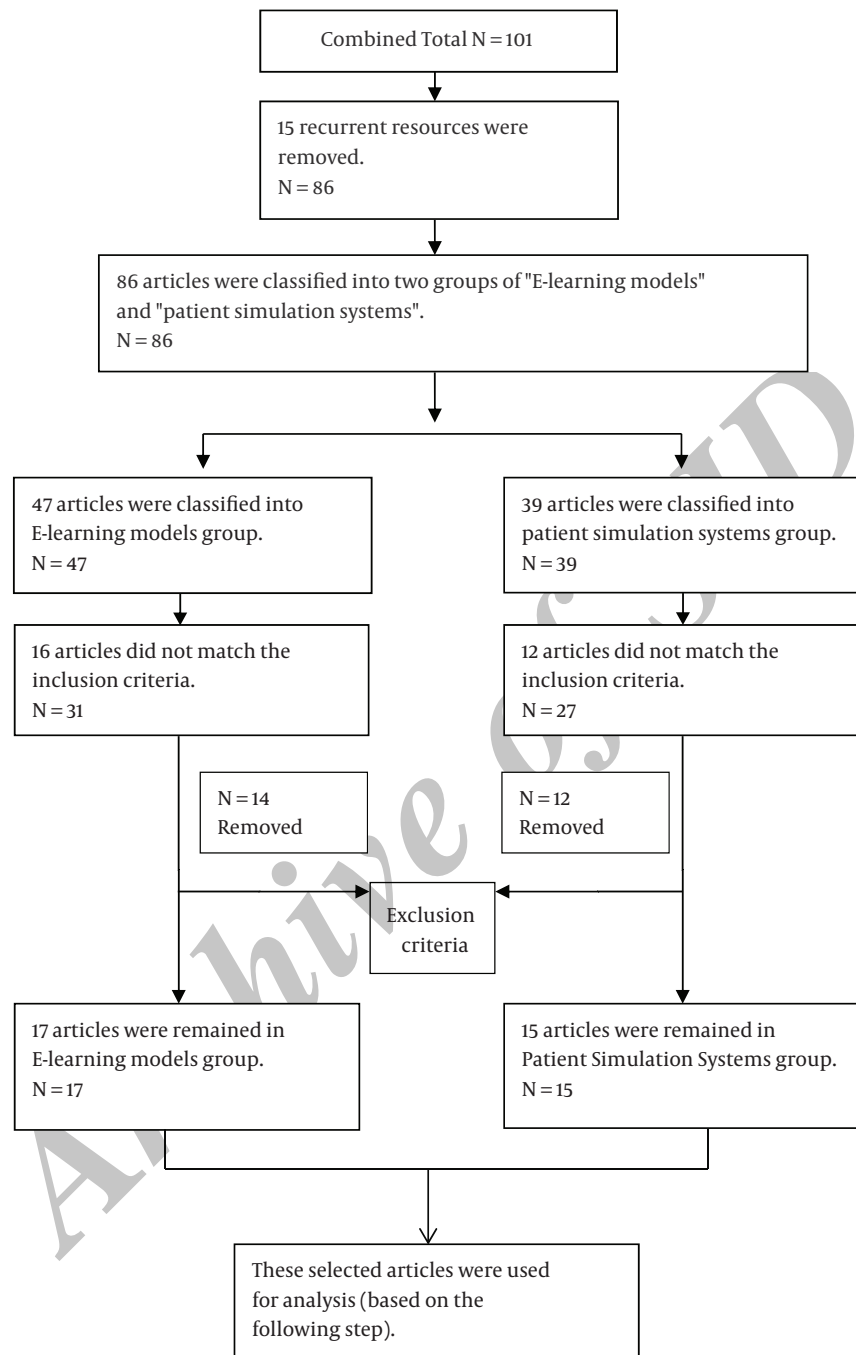IV. Monitoring Tools and Internet Navigation

V. Search Tools

Figure 1. A Scheme of the Systematic Research Processes of This Study

---

4.5. Assessment

Assessment is an essential part of education. Assessment methods can be performed between teachers and their students, between students or as self-assessments

([54](#)).

The study of the use of this components group in selected LMSs (including: 1. eFront, 2. Dokeos, 3. Moodle, 4. LRN, and 5. Canvas) clarifies that although these systems

utilize all components group, they approvingly emphasize on employing the components of Tools Group. Therefore, the systems use these components to provide high quality services.

The patient simulation system is a software for practicing and learning, which can simulate the characteristics of a real world. This kind of simulation helps the teacher represent reality, provide control, and evaluate the learning environment and receive feedback (35). The patient simulation system enhances patient safety and optimizes treatment outcomes. This system is a tool for practicing and designing a clinical decision-making. Patient simulation scenarios act like a bridge between theories and clinical experiences. Working on a patient simulator supports the students in visualizing the physiological reactions that may not be comprehensible through the study of their courses (11).

According to the resources reviewed in this study (35-49), patient simulation can be categorized to 3 general groups: 1. "Medical Equipment-based Simulation", 2. "Screen-based Simulation" and 3. "Composed Simulation". Medical equipment-based simulation can apply different mannequins or medical devices and sensors for patient simulation (55). The obtained data from this simulation equipment can be transferred to computer systems; subsequently, medical students' feedback and their decisions are controlled based on them.

In screen-based simulation, as an application, some software are used for patient simulation (56). In such simulations, there is a great deal of generated data concerning the questions, and their related answers should be previously recorded. This software can employ the data of the patient's history, physical, and para-clinical examinations (57). It can use two-dimensional or three-dimensional visual environments (55). Unlike medical equipment-based simulation, this kind of patient simulation does not require any special equipment.

In the composed simulation, medical equipment-based simulation, and screen-based simulation are used in combination. In Table 2, different types of patient simulation systems, their advantages, and disadvantages can be studied.

5. Discussion

In 2006, Issenberg introduced a patient simulation model of tools to the world. In Table 3, his model was presented to accommodate patient simulation in E-learning (58).

It is notable that in implementing the patient simulation system in LMS, this model or similar ones are not practical enough. According to the obtained results, it seems

that the main reason for the inefficiency of such models is the shortage of required tools and techniques, yet no precise tool has been introduced for such model; however, the introduction of the "Parsian" model helps solve this problem.

5.1. "Parsian" Model

The "Parsian" model is introduced to provide accurate tools and techniques in order to solve the mentioned problems. In this model, all the components presented in Table 1 are accepted, excluding tools group named Tools and Techniques Group. Tools and Techniques group is classified to 3 subgroups, including software, methods and techniques, and medical equipment as shown in Table 4.

In the following section, each component group of the "Parsian" model, along with their characteristics will be discussed.

5.2. Software

5.2.1. Electronic Medical Records for Patient Simulation

The Electronic Medical Record can organize, store, and retrieve patient care information. This system transfers the required data to the physician at the right time, results in proper decision-making, and prevents medical errors (59). It is possible to use this system for educating medical students in 2 ways (60, 61): according to the first approach, the students can use real data available in Electronic Medical Records while the data is associated with the diagnosis and treatment of diseases and the confidentiality of patients' information is taken into account. Based on the second approach, unreal but simulated data, related to diagnosis and treatment, should be embedded by professors in this system. Afterwards, the students can study the knowledge taken from the system's data and they can be asked to study a part of the data, make appropriate decisions, and compare them with existing responses in the system. In this way, it is possible to explore hidden knowledge established by the professors on the system.

5.2.2. Dynamic Workflow

A flowchart is a standard tool for preparing graphical documentation and logical design to create a model for a system. Furthermore, this diagram is used to design systems and conceptual model. The process flow can be modeled to various levels through this diagram (62-64). The professors can use this tool to design workflow diagrams obtained from medical books and guidelines in the educational system (65).

Various diagnostic and therapeutic scenarios, along with appropriate feedback that should be received from

Table 1. Component Groups and Their Components

Rows	Components Groups	Components	Index
1	Strategies and activities	Educational mission	Educational development in special scientific fields to achieve specific results
		Educational strategies	Problem solving simplification
			Promoting cooperation and social dialogue
			Explaining diction and ideology
			Supporting multiple perspectives
			Supporting modeling comprehension
			Defining a practical framework
			Explaining appropriate learning processes, activities and tasks
			Facilitating active roles
			Blended learning
		Educational activities	Definition of educational methods
			Content management
		Educational roles	Trainer, learner and technology
2	Resources	Digital Libraries and Electronic Resources	Including e-books, films, papers, files and links
3	Tools	Synchronous communication tools	Text-based communication, such as chat, message and etc. or audio conferencing tools such as voice and video
		Asynchronous communication tools	News groups and e-mail
		Software	Report builder, adobe connect and other systems
		Web tools	Blogs, wikis, and social networks
		Remote access tools	Telnet, file transfer protocol
			Video Teleconferencing
			Mobile
		Monitoring tools and internet navigation	Text-based browser, graphical browser, VRML browser and plugins
		Search tools	Search engines, wikipedia and encyclopedia
4	Assessment	Based on knowledge	Using multiple-choice questions
		Based on performance	Scientific structured clinical examination
		Based on behavior and attitude	Discussion and negotiation in a dialogue forum or using tools such as wikis
		Based on action	Notebooks and electronic records

Table 2. Different Types of Patient Simulations

Rows	Patient Simulation Types	Features and Advantages	Disadvantages
1	Medical equipment-based simulation	They have sensors and they are able to transfer the senses.	There is no possibility of questioning, answering or monitoring diseases. For each disease, it should be designed in particular.
2	Screen-based simulation	Observing virtual reality	There is no sensor and there is no possibility of transferring senses. For each disease, it should be designed in particular.
		Possibility of questioning and answering	
		Having massive data for decision-making	
3	Composed simulation	Including the advantages of the groups above	For each disease, it should be designed in particular.

the students, can be defined by the professors in the educational system. There is no need to change the system structure or re-program the software, yet it is the professors' task to manage this flexible educational system.

The most challenging concern of the physicians and professors is entering medical scenarios to the computer that can be solved by using this tool. Solving this problem provides the possibility of rendering medical scenarios to computerized knowledge. Thus, it is feasible to have diverse scenarios designed by a professor in order to educate and evaluate the students. Due to the variety of diseases, diagnostic and therapeutic scenarios and the complexity of medicine, an educational system that allows users to draw workflows can be regarded as a fundamental infrastructure to implement the patient simulation system in LMS.

Table 3. "Issenberg" Model and Its Components

Rows	Components Groups	Components	Explanation
1	Strategies and aActivities	Range of difficulty degree	Students have to undergo skill training according to the degree of difficulty.
		Multiple educational strategies	
		Clinical diversity	Learning strategies based on simulation include the following: Coach-centered Educational Format, Small Group Instruction, and Independent Study.
		Defined Results and Criteria	Simulation should comprise of a wide range of disease.
2	Resources	Integration and combination of resources and training programs	Using a combination of reliable multiple resources
3	Tools	Repeating exercises	Learners focus on repeating and redoing training in order to improve the skills and repeated action.
		Self-learning	For active self-learning and training experiences should be standardized and then used.
		Controlled environment	Learning will be more successful in a controlled training environment and under the supervision of simulation masters.
4	Assessment	Realism and credibility of simulator	It has been tried to approach the behavior of a simulated system to reality.
		Feedback	The feedback on the learning experience is an important feature of simulation-based training.

Table 4. Components Groups of the "Parsian" Model

Rows	Components	Components	Explanation
1	Software	Electronic medical records	Including medical history, physical examination and para-clinical examination based on patient visits
		Dynamic workflow	In this way, scenarios based on clinical guidelines are fed in the simulator software and accurate feedback that was supposed to be received from the students is defined.
		Virtual reality	Showing the real world through E-learning
		Picture archiving and communication system (PACS)	Picture Archiving and communication System used for storing and retrieving medical images
2	Methods and techniques	Artificial intelligence	Providing the possibility of simulating in the absence of knowledge, based on certain volume of data
3	Medical equipment	Sensors	Reflecting the patient's condition

5.2.3. Virtual Reality

Virtual Reality (VR) is a computer-based software capable of simulating objects in a multi-dimensional environment. It utilizes various tools, such as glasses, or creates hologram images, stereo sound, and other things to create a sense of the real environment (66, 67). Formerly, large volumes of VR files and Internet bandwidth limitations would cause disruption in the use of this type of tool. However, today, because of the increasing bandwidth and improvement of compressed image algorithms to reduce the size of VR files, the virtual reality simulator is used as a valuable educational tool (68). Virtual Reality can represent an actual environment and also allows the students to feel the real elements. For example, medical students can observe virtual patients or virtual operating rooms and examine necessary equipment before performing practical exercises (69).

5.2.4. Picture Archiving and Communication System

Picture Archiving and Communication System (PACS) is an advanced technology, which is capable of storing, retrieving, and showing images with the use of special devices (70-72). This system stores pictures and videos received by medical equipment, and documents related to the diagnosis.

Since old pictures and videos of the patients are used for educating medical students, in a virtual learning environment, the system should provide high-quality images and pictures in full color. Physicians can give the students selected pictures and videos and once the educational phase is accomplished, they can assess the students' knowledge.

5.3. Methods and Techniques

5.3.1. Artificial Intelligence

An approach, encompassing various techniques, is used to detect repeating patterns in order to predict the op-

timal diagnosis and treatments (73). In some cases, there is no accurate or specified rule to define the process flow by "dynamic workflow". Artificial intelligence techniques can simulate a real environment. When there is no explicit knowledge, based on a certain volume of data, the AI approach can be used to simulate a disease. Representing complex conditions and having them under control can be provided by an AI technique.

5.4. Medical Equipment

5.4.1. Sensors

Sensors can reflect a wide range of physical or environmental conditions, such as temperature, humidity, vibration, pressure, sound, smell, and movement (74, 75). The internal memory, processing power, and wireless functionality of sensor devices provide a situation for integrating sensors in LMS in order to enhance the performance of education (74).

Medical sciences rely on the 5 senses of physicians to obtain signs and new findings. The absence of reflection to the 5 senses is considered as a major deficiency in simulation systems and sensors contribute to solve this problem.

5.5. Conclusion

In this study, in addition to evaluating component groups related to E-learning models, a patient simulation system was also surveyed and classified. Comparing the most practical models of E-learning, it was specified that all the models strongly emphasized on the tools components group. However, these tools were not adequate enough for patient simulation.

The main cause of the failure of patient simulation systems in E-learning was the absence of precise methods and techniques to achieve the desired results. As a solution to this problem, the "Parsian" model, holding the necessary tools and techniques for creating an infrastructure was proposed. The real and obtainable tools mentioned in the "Parsian" model can lead to all 3 types of patient simulation systems, including medical equipment-based simulation, screen-based simulation, and composed simulation.

In the "Parsian" model, all the objects introduced in tools and techniques group are available and can be used by medical informatics specialists. The simulation systems utilizing tools and techniques presented by the "Parsian" model can meet the needs of researchers and professors to develop E-learning in medicine.

Acknowledgments

Footnotes

References

1. Al-Shboul M. Roadmap to advance E-learning management system at The University of Jordan. *J American Sci*. 2013;**9**(1):531–45.
2. Frank Rennie RM. *E-learning and Social Networking Handbook: Resources for Higher Education*. New York: Routlege; 2013.
3. Andreicheva L, Latypov R. Design of E-learning System: M-learning Component. Procedia. *Social Behav Sci*. 2015;**191**:628–33.
4. Borotis S, Poulymenakou A, editors. E-learning readiness components: Key issues to consider before adopting e-learning interventions. *E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education*. 2004. Association for the Advancement of Computing in Education (AACE); 2004. p. 1622–9.
5. Arora R, Chhabra I. *Extracting components and factors for quality evaluation of E-learning applications. 2014 Recent Advances in Engineering and Computational Sciences (RAECS);*. India: Chandigarh; 2014. p. 6–8.
6. Khan BH, Ally M. *International handbook of E-learning volume 1: Theoretical perspectives and research*. **2**. Routledge; 2015.
7. Back DA, Behringer F, Haberstroh N, Ehlers JP, Sostmann K, Peters H. Learning management system and e-learning tools: an experience of medical students' usage and expectations. *Int J Med Educ*. 2016;**7**:267–73. doi: 10.5116/ijme.57a5.f0f5. [PubMed: 27544782].
8. Wylie A, Leedham-Green K. Health promotion in medical education: lessons from a major undergraduate curriculum implementation. *Educ Prim Care*. 2017;**28**(6):325–33. doi: 10.1080/14739879.2017.1311776. [PubMed: 28395588].
9. Frank JR, Snell L, Englander R, Holmboe ES, Icbme Collaborators . Implementing competency-based medical education: Moving forward. *Med Teach*. 2017;**39**(6):568–73. doi: 10.1080/0142159X.2017.1315069. [PubMed: 28598743].
10. Ellaway R, Masters K. AMEE Guide 32: e-Learning in medical education Part 1: Learning, teaching and assessment. *Med Teach*. 2008;**30**(5):455–73. doi: 10.1080/01421590802108331. [PubMed: 18576185].
11. Kim S. The future of E-Learning in medical education: current trend and future opportunity. *J Educ Eval Health Prof*. 2006;**3**:3. doi: 10.3352/jeehp.2006.3.3. [PubMed: 19223995].
12. Stojic R, Djokic A, Sabo I. On the teaching and development of games and virtual reality educational system. *Fourth Int Conferenc E-learning (eLearning-2013)*. 2013;**4**:20–5.

Ayani S et al.

13. McConnell H, Pardy A. Virtual patient simulation for prevention of medical error: beyond just technical upskilling. *World Hosp Health Serv*. 2008;**44**(3):36–9. [PubMed: 19181024].

14. Merzouk A, Kurosinski P, Kostikas K. E-learning for the medical team: the present and future of ERS Learning Resources. *Breath*. 2014;**10**(4):296–304.

15. Botezatu M, Hult H, Tessma MK, Fors UG. Virtual patient simulation for learning and assessment: Superior results in comparison with regular course exams. *Med Teach*. 2010;**32**(10):845–50. doi: 10.3109/01421591003695287. [PubMed: 20854161].

16. Marshall DA, Burgos-Liz L, I. Jzerman MJ , Osgood ND, Padula WV, Higashi MK, et al. Applying dynamic simulation modeling methods in health care delivery research-the SIMULATE checklist: report of the ISPOR simulation modeling emerging good practices task force. *Value Health*. 2015;**18**(1):5–16. doi: 10.1016/j.jval.2014.12.001. [PubMed: 25595229].

17. Henry P. E-learning Technology, Content and Services. *Educat Train*. 2001;**43**(4):249.

18. Buzzetto-More NA. Student Perceptions of Various E-learning Components. Interdisciplinary. *J E-learn Learn Object*. 2008;**4**(1):113–35.

19. Frehywot S, Vovides Y, Talib Z, Mikhail N, Ross H, Wohltjen H, et al. E-learning in medical education in resource constrained low- and middle-income countries. *Hum Resour Health*. 2013;**11**:4. doi: 10.1186/1478-4491-11-4. [PubMed: 23379467].

20. Manuela A, Fernando B, Oliveira T . An E-learning Theoretical Framework. *E-learn Theoretical Framework Educat Technol Socie*. 2016;**19**(1):292–307.

21. Abu-Shawar B. Evaluating AOU E-learning Platform Based on Khan's Framework. The Sixth International Conference on Advanced Cognitive Technologies and Applications; ABU- Shawar-bayan. *IARIA*. 2014:99–103.

22. Siavash O, Maslin M, Selamat H. Review of E-learning and ICT Infrastructure in Developing Countries (Case Study of Iran). *American J Economic Business Administ*. 2011;**3**(1):120–5.

23. Oscar Martin-Rodrigueza JCFM, Miguel GA. The main components of satisfaction with E-learning. *Technol, Pedagog Educat*. 2014;**24**(2):267–77.

24. Atsumbe BN, Raymond E, Enoch EB, Patrick D. Availability and utilization of e-learning infrastructures in Federal University of Technology, Minna. *J Educat Practic*. 2012;**3**(13):56–65.

25. Izkair AS, Sulaiman H. ICT infrastructure service elements for E-learning implementation. The 3rd National Graduate Conference (NatGrad2015), Universiti Tenaga Nasional. *Putrajaya Campus*. 2015;**10**(7):278–83.

26. Beder DM, Silva AC, Otsuka JL, Silva CG, Rocha HV, editors. A case study of the development of e-learning systems following a component-based layered architecture. *Advanced Learning Technologies, 2007. ICALT 2007. Seventh IEEE International Conference on*. 2007. IEEE; 2007. p. 21–5.

27. Gautam SS, Tiwari MK. Components and benefits of E-learning system. *Comput Scie (IRJCS)*. 2016;**1**(3):14–7.

28. Othman MS, Mohamad N, Yusuf LM, Yusof N, Suhaimi SM. An Analysis of E-learning System Features in Supporting the True E-learning 2.0. *Procedia Soc Behav Sci*. 2012;**56**(8):454–60.

29. Veeramanickam MR, Mohanapriya M, editors. Research paper on E-learning application design features: Using cloud computing & software engineering approach. *2016 International Conference on Information Communication and Embedded Systems (ICICES)*. 2016. 2016. p. 25–6.

30. Chellatamilan T, Suresh RM, editors. Automatic classification of learning objects through dimensionality reduction and feature subset selections in an e-learning system. *Technology Enhanced Education (ICTEE), 2012 IEEE International Conference on*. 2012. IEEE; 2012. p. 1–6.

31. Bobalo Y, Stakhiv P, Shakhovska N, editors. Features of an eLearning software for teaching and self-studying of electrical engineering. *Computational Problems of Electrical Engineering (CPEE), 2015 16th International Conference on*. 2015. IEEE; 2015. p. 7–9.

32. Salmon G. Flying not flapping: a strategic framework for eLearning and pedagogical innovation in higher education institutions. *ALT-J Res Learn Technol*. 2005;**13**(3):201–18.

33. Jafari SM, Salem SF, Moaddab MS, Salem SO, editors. Learning Management System (LMS) success: An investigation among the university students. *e-Learning, e-Management and e-Services (IC3e), 2015 IEEE Conference on*. 2015. IEEE; 2015. p. 64–9.

34. Krämer NC, Bente G. Personalizing e-learning. The social effects of pedagogical agents. *Educat Psychol Rev*. 2010;**22**(1):71–87.

35. Benedict N, Schonder K. Patient simulation software to augment an advanced pharmaceutics course. *American J Pharmaceut Educat*. 2011;**75**(2):21–30.

36. Huang G, Reynolds R, Candler C. Virtual patient simulation at US and Canadian medical schools. *Acad Med*. 2007;**82**(5):446–51. doi: 10.1097/ACM.0b013e31803e8a0a. [PubMed: 17457063].

37. Shahbazi B, Edalat-nejad M, Edalat-nejad N, Edalatnejad M. Introduction of Clinical, Simulation-Based Software for Medical Sciences Teachings. *Procedia Engineer*. 2012;**29**:43–7.

38. Kleinheksel AJ. Transformative learning through virtual patient simulations: predicting critical student reflections. *Clinical Simulat Nurs*. 2014;**10**(6):e301–e8.

39. Douglass MA, Casale JP, Skirvin JA, DiVall MV. A virtual patient software program to improve pharmacy student learning in a comprehensive disease management course. *Am J Pharm Educ*. 2013;**77**(8):172. doi: 10.5688/ajpe778172. [PubMed: 24159213].

40. Battaglia JN, Kieser MA, Bruskiewitz RH, Pitterle ME, Thorpe JM. An online virtual-patient program to teach pharmacists and pharmacy students how to provide diabetes-specific medication therapy management. *Am J Pharm Educ*. 2012;**76**(7):131. doi: 10.5688/ajpe767131. [PubMed: 23049103].

41. Freeman KM, Thompson SF, Allely EB, Sobel AL, Stansfield SA, Pugh WM. A virtual reality patient simulation system for teaching emergency response skills to US Navy medical providers. *Prehospital Disaster Med*. 2001;**16**(1):3–8.

42. Torbjörn A, Jens A, Ohlsson K. Simulator-based humanmachine interaction design. *Vehicl Sys Model Test*. 2009;**4**(1):1–16.

43. Musacchio MJ, Smith AP, McNeal CA, Munoz L, Rothenberg DM, von Roenn KA, et al. Neuro-critical care skills training using a human patient simulator. *Neurocrit Care*. 2010;**13**(2):169–75. doi: 10.1007/s12028-010-9405-7. [PubMed: 20625852].

44. Mateusz Pus´lecki MK, Marcin L, Sebastian S, Lukasz, G , Siorowski, M. D , Agata, D , et al. Customization of a patient simulator for ECMO training. *Qatar Med J*. 2017;(80):1–3.

45. DeVita MA, Schaefer J, Lutz J, Wang H, Dongilli T. Improving medical emergency team (MET) performance using a novel curriculum and a computerized human patient simulator. *Qual Saf Health Care*. 2005;**14**(5):326–31. doi: 10.1136/qshc.2004.011148. [PubMed: 16195564].

46. Deutsch ES. High-fidelity patient simulation mannequins to facilitate aerodigestive endoscopy training. *Arch Otolaryngol Head Neck Surg*. 2008;**134**(6):625–9. doi: 10.1001/archotol.134.6.625. [PubMed: 18559730].

47. Kleinert R, Heiermann N, Wahba R, Chang DH, Holscher AH, Stippel DL. Design, Realization, and First Validation of an Immersive Web-Based Virtual Patient Simulator for Training Clinical Decisions in Surgery. *J Surg Educ*. 2015;**72**(6):1131–8. doi: 10.1016/j.jsurg.2015.05.009. [PubMed: 26094909].

48. Klein S, Whyne CM, Rush R, Ginsberg HJ. CT-based patient-specific simulation software for pedicle screw insertion. *J Spinal Disord Tech*. 2009;**22**(7):502–6. doi: 10.1097/BSD.0b013e31819877fd. [PubMed: 20075813].

49. Takeuchi A, Kobayashi T, Hirose M, Masuda T, Sato T, Ikeda N. Arterial pulsation on a human patient simulator improved students pulse assessment. *J Biomed Scie Eng*. 2012;**5**(5):285–9.

50. Elabnody MR. A Survey Of Top 10 Open Source Learning Management Systems. *Int J Scient Technol Res*. 2015;**4**(8):7–11.

51. Kisanga D, Ireson G. Barriers and strategies on adoption of e-learning in Tanzanian higher learning institutions: Lessons for adopters. *Int J Educat Develop Use Infor Communicat Technol*. 2015;**11**(2):126–37.

52. Leeder C, Lonn S. Faculty usage of library tools in a learning management system. *Colleg Res Lib*. 2014;**75**(5):641–63.

53. Oye ND, Sallah M, Iahad NA. E-Learning methodologies and tools. *Int J Advanc Comput Scie Applicat (IJACSA)*. 2012;**3**(2):48–52.

54. Azimi HM, Rahmani AR. Importance of Needs Assessment for Implementation of E-learning in Colleges of Education. *Int J Inform Comput Technol*. 2103;**3**(5):377–82.

55. Lapkin S, Levett-Jones T, Bellchambers H, Fernandez R. Effectiveness of patient simulation manikins in teaching clinical reasoning skills to undergraduate nursing students: A systematic review. *Clinic SimulatNurs*. 2010;**6**(6):e207–e22.

56. Philip JH. Using screen-based simulation of inhaled anaesthetic delivery to improve patient care. *Br J Anaesth*. 2015;**115 Suppl 2**:ii89–94. doi: 10.1093/bja/aev370. [PubMed: 26658205].

57. Rosen KR. The history of medical simulation. *J Crit Care*. 2008;**23**(2):157–66. doi: 10.1016/j.jcrc.2007.12.004. [PubMed: 18538206].

58. Issenberg SB. The scope of simulation-based healthcare education. *Simul Healthc*. 2006;**1**(4):203–8. doi: 10.1097/01.SIH.0000246607.36504.5a. [PubMed: 19088590].

59. Zhao C, Jiang J, Xu Z, Guan Y. A study of EMR-based medical knowledge network and its applications. *Comput Methods Programs Biomed*. 2017;**143**:13–23. doi: 10.1016/j.cmpb.2017.02.016. [PubMed: 28391811].

60. Solarte I, Konings KD. Discrepancies between perceptions of students and deans regarding the consequences of restricting students' use of electronic medical records on quality of medical education. *BMC Med Educ*. 2017;**17**(1):55. doi: 10.1186/s12909-017-0887-2. [PubMed: 28288618].

61. Tierney MJ, Pageler NM, Kahana M, Pantaleoni JL, Longhurst CA. Medical education in the electronic medical record (EMR) era: benefits, challenges, and future directions. *Acad Med*. 2013;**88**(6):748–52. doi: 10.1097/ACM.0b013e3182905ceb. [PubMed: 23619078].

62. Ensmenger N. The Multiple Meanings of a Flowchart. *Lib Cultur Rec*. 2016;**143**(51):13–23.

63. Asplin BR, Magid DJ, Rhodes KV, Solberg LI, Lurie N, Camargo CJ. A conceptual model of emergency department crowding. *Ann Emerg Med*. 2003;**42**(2):173–80. doi: 10.1067/mem.2003.302. [PubMed: 12883504].

64. Paulson JA, Ramadesigan V, Subramanian VR, Braatz RD. *Control systems analysis and design of multiscale simulation models. 2016 American Control Conference (ACC)*. USA: Boston, MA; 2016.

65. Shiow-yang W, Kuo-Chang L. *Cross enterprise business modeling with AC diagrams and workflow patterns. Seventh IEEE International Conference on E-Commerce Technology (CEC'05)*. Germany: Munich; 2005. p. 19–22.

66. Kizony R, Zeilig G, Krasovsky T, Bondi M, Weiss PL, Kodesh E, et al. Using virtual reality simulation to study navigation in a complex environment as a functional-cognitive task; A pilot study. *J Vestib Res*. 2017;**27**(1):39–47. doi: 10.3233/VES-170605. [PubMed: 28387691].

67. Jenson CE, Forsyth DM. Virtual reality simulation: using three-dimensional technology to teach nursing students. *Comput Inform Nurs*. 2012;**30**(6):312–8. quiz 319-20. doi: 10.1097/NXN.0b013e31824af6ae. [PubMed: 22411409].

68. Stansfield S, Shawver D, Sobel A, Prasad M, Tapia L. Design and implementation of a virtual reality system and its application to training medical first responders. *Presence Teleoperat Virtual Environ*. 2000;**9**(6):524–56.

69. Rothbaum BO, Rizzo AS, McDaniel DD, Zanov MV. *Virtual reality exposure therapy a2 - friedman, howard s. Encyclopedia of mental health*. second edition ed. Oxford: Academic Press; 2016. p. 370–4.

70. Al-Hajeri M, Clarke M. Future trends in Picture Archiving and Communication System (PACS). *Conf Proc IEEE Eng Med Biol Soc*. 2015;**2015**:6844–7. doi: 10.1109/EMBC.2015.7319965. [PubMed: 26737865].

71. Mildenberger P, Bruggemann K, Rosner F, Koch K, Ahlers C. PACS infrastructure supporting e-learning. *Eur J Radiol*. 2011;**78**(2):234–8. doi: 10.1016/j.ejrad.2010.05.006. [PubMed: 20619986].

72. Yarmohammadi Z, Hosseiny R. 210:Utilzation of medical images of PACS for evidence based training. *BMJ Open*. 2017;**7**(Suppl 1). A1–A78.

73. Hamet P, Tremblay J. Artificial intelligence in medicine. *Metabolism*. 2017;**69S**:S36–40. doi: 10.1016/j.metabol.2017.01.011. [PubMed: 28126242].

74. Mwinyi AK, Al-Haddad S, Hashim SB, Abdullah RBH. Review on multi-agent system collaboration in learning management system domain by deploying wireless sensor networks for student location detection. *J Comput Sci*. 2014;**10**(6):995.

75. Fager SK, Sorenson T, Butte S, Nelson A, Banerjee N, Robucci R. Integrating end-user feedback in the concept stage of development of a novel sensor access system for environmental control. *Disabil Rehabil Assist Technol*. 2017:1–7.