

СЕРІЯ «Медицина»

UDK: 616-053.2-08

[https://doi.org/10.52058/2786-4952-2021-2\(2\)-257-267](https://doi.org/10.52058/2786-4952-2021-2(2)-257-267)

Berezutsky Volodymyr Ivanovych PhD (medical sciences), Associate Professor, Department of Internal Medicine, Dnipro State Medical University, Vernadsky Ave., 9, Dnipro, 49044, tel.: (067) 965-31-65, e-mail: berezut@ua.fm, <https://orcid.org/0000-0002-0989-2960>

«VIRTUAL PATIENT» AS A TOOL TO ENSURE THE QUALITY OF HIGH MEDICAL EDUCATION

Abstract. The article is devoted to the analysis of studies of the use of multimedia clinical scenarios (virtual patients) in the training of family doctors. The experience of medical universities in the countries of the European Union, the United States and Canada shows that «virtual patients» are effectively used to teach students the skills of professional communication with patients, as well as to form and improve clinical reasoning. Programs based on the integration of the dialogue management system generate emotionally responsive interactive 3D characters created with high-resolution visualization in the game engine, able to support dialogue with the help of natural language. Testing revealed a high realism of a conversation with the virtual patient, as well as great benefits both for the development of communication skills and for the development of empathy. Application of such programs can increase the academic success of students in the relevant sections of the educational process by 25%. It is established that a virtual patient gives equal opportunities to traditional methods with equal time, but not money: providing training in real or "standardized" patients is much harder and more expensive. In addition, the further improvement of virtual scenarios allows us to rely on what will be presented the whole range of diagnostic situations that can be encountered by a family doctor in real practice. Thus, the undisputed advantage of virtual patients to the traditional methods of training future physicians of clinical thinking is realized. The scenarios for virtual patients expanded to "virtual family," which allowed to further narrowing the gap between virtual and real methods of teaching family doctors. The best results were revealed with a combination of virtual patients and traditional pedagogical techniques. Popularization and widespread introduction of virtual patients into the educational process of Ukrainians medical universities will improve the quality of training of future family doctors.

Keywords: virtual patient, medical education, simulation training

Березуцький Володимир Іванович кандидат медичних наук, доцент кафедри пропедевтики внутрішньої медицини, Дніпропетровський державний медичний університет, проспект Вернадського, 9, Дніпро, 49044, тел.: (067) 965-31-65, e-mail: berezut@ua.fm, <https://orcid.org/0000-0002-0989-2960>

МЕТОДИКА «ВІРТУАЛЬНИЙ ПАЦІЄНТ» ЯК ІНСТРУМЕНТ ЗАБЕЗПЕЧЕННЯ ЯКОСТІ ВИЩОЇ МЕДИЧНОЇ ОСВІТИ

Анотація. Стаття присвячена аналізу досліджень застосування мультимедійних клінічних сценаріїв (віртуальних пацієнтів) в підготовці лікарів. Досвід медичних університетів країн Європейського Союзу, США та Канади показує, що віртуальні пацієнти ефективно використовуються для навчання студентів навичкам професійного спілкування з хворими, а також для формування і вдосконалення клінічного мислення. Програми, що засновані на інтеграції системи управління діалогом, генерують емоційно реагуючих інтерактивних 3D-персонажів, створених з візуалізацією високої роздільної здатності в ігровому движку, спроможних підтримувати діалог за допомогою природної мови. Тестування виявило високу реалістичність бесіди з віртуальним пацієнтом, а також величезну користь як для освоєння навичок спілкування, так і для вироблення здатності до емпатії. Застосування таких програм дозволяє підвищити академічну успішність студентів у відповідних розділах навчального процесу на 25%. Встановлено, що віртуальний пацієнт дає рівні традиційним методам можливості при рівних витратах часу, але не коштів: забезпечення навчання на реальних або «стандартизованих» пацієнтах значно важче і дорожче. Крім того, подальше вдосконалення віртуальних сценаріїв дозволяє розраховувати на те, що буде представлений весь спектр діагностичних ситуацій, з якими може зіткнутися сімейний лікар в реальній практиці. Так реалізується безперечна перевага віртуальних пацієнтів перед традиційними методами навчання майбутніх лікарів клінічного мислення. Сценарії віртуальних пацієнтів розширилися до «віртуальної сім'ї», що дозволило ще трохи скоротити розрив між віртуальними і реальними методами навчання сімейних лікарів. Найкращі результати виявлені при комбінації віртуальних пацієнтів і традиційних педагогічних методик. Популяризація та широке впровадження «віртуальних пацієнтів» в навчальний процес вітчизняних медичних університетів дозволить підвищити якість підготовки майбутніх с лікарів.

Ключові слова: віртуальний пацієнт, медична освіта, симуляція навчання

Introduction. The steady increase in the demands for the physicians has led to an improvement in their education at medical universities. Medical universities have a specific task: to train a specialist with a certain amount of theoretical knowledge and practical skills (competencies) capable of diagnosing and treating a very wide range of diseases. The basis of the physician's diagnostic competence is the inextricable combination of the ability to collect diagnostic data in a competent manner (i.e. to detect the signs of the disease by means of a survey, a physical and an instrumental

study of the patient) and to analyze them (i.e. practice clinical thinking). The knowledge of diagnostic competences requires the direct participation of a «thematic» patient in the educational process. The problem of the actual patient's participation in the training of future doctors has always been very difficult. The problem has become more complex in the light of today's high standards of biomedical ethics. Previously, in solving this problem the professor of the clinical department faced only «technical» difficulties (absence of «suitable» on the subject and communication of the patient), now ethical and legal aspects of using the patient as object of «training» For students, restrictions are placed on the effectiveness of the educational process to a minimum. We have an opportunity not to «invent the bicycle», but to take advantage of the rich experience of medical universities of countries of the European Union and the United States, where the question of the role of the real patient in the training of future doctors was resolved more than two decades ago: in junior courses medical students learn practical skills on phantoms, while senior students improve their skills on «standardized patients» (specially trained volunteers or actors). Due to the high cost of the technique (the work of «imaginary invalids» is well paid) it is applied only in a limited way, mainly during examinations [1]. Over the last few years, in the pedagogical arsenal of medical universities, the «virtual patient», by which is understood a computer program generating a multimedia interactive scenario of the patient, takes an increasing place. The accumulated experience of using a «virtual patient» (VP) allows giving an unambiguous positive answer to the question of the appropriateness of the use in the training of future doctors: the VP not only animates the educational process and substantially motivates students to study, but also stimulates clinical thinking [2]. VP-programmes are rapidly improving, which suggests that in the near future they will occupy their own and quite extensive niche in the health education system [3]. The VP-methodology has not yet been presented at medical universities in Ukraine, and the systematization and analysis of the experience of its application by foreign specialists are necessary for resolving the question of the role and place of the VP in the training of future doctors.

The purpose of the article: evaluate the possibilities of using the method «virtual patient» in training of physicians. In order to achieve this goal, an analysis was made of the scientific publications of the last 5 years on the use of the VP in the training of family doctors. Search for literature was conducted in the scientific bases of Scopus, WebOfScience and PubMed, 154 publications relevant to the subject under study were identified, (27 of these were directly used in the review).

The background of the subject. The first attempts to introduce the VP into the medical education have made it possible to identify areas for the most effective application of the methodology, which has proved to be very useful in filling existing knowledge gaps, studying the proper treatment of the patient, and to develop skills in diagnostic analysis (clinical thinking) [4]. Australian scientists have conducted a systematic analysis of 28 research studies on the development of non-technical skills in medical students through the VP. The results of the analysis show that interaction with the VP during the educational process helps students to learn how to apply their knowledge in clinical reasoning, contributes to the socialization of students in the

professional environment, development of empathy, development and improvement of communication skills, filling of theoretical gaps and to development diagnostic thinking [5].

The use of VPs to develop communication skills and empathy. The most important professional quality of a physician is communication: the ability to establish effective contact with a wide range of patients by age, sex, profession and intelligence. The degree of communication skills development directly influences the ability to empathize (empathy for patients), which is the ethical basis for motivating the medical profession. Physicians who have the greatest empathy for the patient's suffering are more motivated, and therefore more successful, both in learning and in realizing their diagnostic and therapeutic skills. In addition, highly empathic doctors enjoy the greatest trust of patients, which greatly increases the degree of completeness in all diagnostic and treatment matters. The empathy-training of the future doctor – the process is incredibly long, requiring the accumulation of experience with patients and presupposes a certain number of failures which inevitably affect patients unfavorably. The VP methodology opens the way for the safe development of empathy in future doctors. The successes achieved make it possible to assert with confidence that the VP is a reliable and effective educational technology for the development of communication and empathy [6]. A study conducted by American psychologists with 343 medical students found that students with an initial higher level of empathy were more successful in collecting complaints and backgrounds from VP than their less sensitive counterparts (a strong positive correlation with a coefficient $0,75 \pm 0,08$). The same program allowed students to learn the most effective strategies for communicating with patients, allowing access to the most «personal» facts from the history of the disease [7]. Another group of American psychologists, aiming to create the VP, the most effective in developing the students' empathy, tested the programs with varying degrees of interactivity in the expression of the VP's emotional response to the interview. Results of students' learning skills were tested on «standardized patients» - specially trained «appraisers» empathy. Results of testing showed that the highest empathy in contact with «imaginary invalids» was displayed by students who were trained with the help of the most «emotional» VPs [8].

The possibility of simulating the VP with any given parameters has determined the wide application of the method for teaching the communication skills of future physicians. The Ohio state university college of medicine (USA) established and piloted a VP to improve the skills of interviewing patients. The program is based on the integration of the dialogue management system (ChatScript) and generates emotionally reactive 3D-characters created with high resolution visualization in the game engine (Unity), capable of maintaining dialogue with natural speech. The students noted the high realism of the interview with the VP, as well as the immense benefits both in terms of communication skills and in terms of empathy. The program records the entire process of interaction of the student with the VP, which results in an exhaustive account of the questions and the order in which they were asked. This option allows students to analyze their mistakes and evaluate their information-gathering skills. The program has enabled students in the core group to achieve 25 per cent improvement in

academic performance in the relevant areas of study [9]. Australian specialists have conducted an equally interesting study on the relative effectiveness of the three methods of teaching medical students to communicate professionally with patients. The first group of students learned the collection of complaints and history with the help of real patients (elderly people in a nursing home), the second – with the help of «standardized patients» (specially trained elderly actors), and the third – with the help of the VP. Testing of communication skills and Jefferson-scale empathy after a week's training has shown that professional communication skills have improved significantly in all three groups of students. However, the highest scores were obtained by students who worked with VPs and noted the greater complexity of communication. Empathy rates were 24 % higher among students who came into contact with real elderly patients [10]. The testing of a program developed in the Curtin University (Australia) has demonstrated that the VP is highly effective in providing professional communication skills to students. Together with communicative skills, students gained valuable experience and confidence in their skills, which they demonstrated in subsequent contact with real patients [11].

Using the VP to develop clinical thinking. In the medical education system, the formation of clinical thinking is envisaged at the beginning of the study in clinical departments. Although by the time clinical studies begin, students already have a fairly large base of theoretical knowledge (in normal and pathological anatomy, normal and pathological physiology) in traditional teaching methods (work with real or «standardized» patients), it never could have gone any other way. Since the students in the clinic face for the first time the task of analyzing signs of diseases, the process of learning diagnostic thinking is very slow and takes a lot of valuable «clinical time» better spent on learning the practical skills of examining real patients. With the advent of virtual clinical scenarios in the form of the PV, it became possible to train future doctors in clinical thinking already at the pre-clinical stage. Although the inclusion of VPs in the pre-clinical curricula of medical schools is still under discussion, the benefits of such an innovation are clear [12]. The benefits are not limited to the fact that students will come to the clinic with already developed skills in the analysis of clinical symptoms. The use of VPs in the training of undergraduate students brings the teaching process as close as possible to the future of the doctor, thus enabling students to feel that they belong to the future profession and providing a high motivation for the work. Specialists at the Chicago College of Medical Sciences (USA) analyzed 12 studies on the use of VPs in medical education with a view to obtaining valid evidence of their effective use in the training of future doctors. The analysis showed that the VPs in the form of clinical scenarios are used to assess the higher competences in the form of decision-making (clinical thinking). Simulation of the logic of diagnostic thinking has been found to be an effective complement to traditional methodologies [13].

The VP-program, designed to shape and improve the diagnostic thinking of future doctors, was successfully tested at the King Saud University College of Medicine in Riyadh (Saudi Arabia) as part of a hybrid curriculum. Third, fourth, and fifth year medical undergraduate students were tested during the year. The results were evaluated on a scale of 10 points in five categories: value for training in diagnostics, degree of

specialization, realism of clinical scenario, usability, realism of animated 3-D VPs. The program received more than 8.0 ratings for all five categories. Dynamic observation of student satisfaction with VP work showed an increase in user ratings as the number of attempts increased [14]. The VP provides an extremely valuable opportunity for the future doctor to discover and analyze the errors of his clinical conclusions. Canadian medical psychologists have developed an VP-program that not only develops clinical thinking skills but also monitors and assesses the causes of cognitive errors in diagnostic analysis. Analyzing the clinical reasoning of medical university students in Montreal in the BioWorld computer learning environment through a logistical regression adapted to student behavior, showing the relationship of diagnostic errors to incorrect and incomplete knowledge, as well as improperly collecting information. The results suggest that students' diagnostic errors made are the result of faulty knowledge and faulty data gathering spurred by a lack of metacognitive awareness. This study supports the notion that to improve diagnostic performance medical education programs should promote the development of metacognitive skills [15]. Scientists of Alberta Medical University, Edmonton (Canada) developed a virtual patient case that used clinically authentic audio and video, interactive 3D-body images, and a simulated electronic medical record; they used interactive slide bars to record respondents' likelihood estimates of diagnostic possibilities at various stages of the case. The program makes it possible to track the actions of tested students at all stages of the diagnostic process. At the same time, users themselves have the opportunity to compare their reasoning with programmed expert judgment. The program was tested by 322 students over two years and received high marks from both users and educators [16].

Assessing the effectiveness of VP-based clinical thinking training for prospective doctors is of concern to many researchers. A comparative study of the success of the introduction of diagnostic thinking by the future family physicians in the whole of the third course of study with the help of the traditional method (working in the clinic, «paper» clinical tasks) and the VP showed no significant differences. Neither the immediate nor the distant results of the students' diagnostic thinking capabilities have been proven. On the one hand, such outcomes lead to the conclusion that the ERs provide equal opportunities to traditional methods with equal time but not resources (providing training on real or «standardized» patients is much more difficult and more expensive). On the other hand, the further development of the VP provides an expectation that the full range of diagnostic situations that a family doctor may encounter in actual practice will be represented. Thus, the unquestionable advantage of the VP over traditional methods of teaching clinical thinking to prospective doctors is realized [17]. Specialists at the Halmstad Medical University (Sweden) have studied the work evaluations of PW undergraduate students who have already mastered clinical thinking in traditional ways. According to student estimates, the program allows «visualization of the clinical analysis and the whole diagnostic process», «analyze errors of logic of medical thinking», «enlarges and enriches clinical experience», «helps to identify weaknesses in preparation» and «aims at further development of clinical competence». The program also benefited teachers, who indicated that they could improve their teaching skills [18].

The teachers of the University of Wisconsin-Madison (USA) conducted a comparative study of the student's performance in the analysis of VP and «paper» clinical situations. Students were much more interested in working with VPs, which significantly affected medical documentation (study medical history) [19]. A study conducted at the Arizona Medical University with the participation of 108 students, on the effectiveness of involving students in the VP process showed a high level of motivation among students. Testing conducted at the end of the VP course showed that students were much better at meeting clinical situational challenges. In addition, there was an increase in student confidence in professional contact with real patients at the clinic [20]. A systematic review, based on the analysis of more than three dozen studies on the use of VPs in the educational process of medical schools, showed the positive impact of simulated experiences on the formation of clinical thinking among future doctors, developing the skills to support clinical diagnosis as well as critical thinking. A comparison of the effectiveness of VPs and traditional teaching methods for the development of clinical thinking showed the advantage of simulation techniques. However, the best results were obtained by combining traditional learning methods with VP [21].

Ways to improve and advance the VP in health education. Since the VP – a relatively new pedagogical methodology, researchers are actively testing them to find ways to improve the educational process. In order to devise the most effective strategy for the improvement of the VP by Slovenian specialists, a special scale has been developed to allow the opinions of users (medical students) to be taken into account in four categories: acquisition and improvement of knowledge, facilitation of training, incompatibility of the VP with objective reality (inaccuracy), and shortcomings in training. VP scale has already proven to be an effective tool for the participation of prospective physicians in software development and development [22]. One of the criteria of VP-effectiveness for the training of future doctors is realism of both clinical scenarios and 3-D characters. These characteristics will determine to a large extent how useful the VPs will be in preparing students for actual medical practice. Scholars of the Munich University analyzed the consistency of the in-house medical and surgical curricula with the actual patient records of German health institutions. Clinical, laboratory and instrumental data of the VP were well-suited to practical health care and were reasonably realistic. However, the anamnestic data, especially the details of the life history, were not comprehensive enough: most often they did not contain information about the patient's family, unemployment or migration. German specialists intend to further develop the VP-realism by personalizing electronic clinical scenarios [23].

Another very important aspect of the work of the family doctor is the need to take into account the large number of living conditions of the patient under observation, especially – related to his family. American specialists from the East Virginia School of Medicine have concluded that a stand-alone RV scenario cannot account for the full range of relationships between the patient and the caregivers. For example, the consequences of low literacy, a guardian's illness, loss of insurance for an dependent guardian, or retirement. To compensate for this deficiency in the training of prospective

family doctors, an integrated scenario group has been developed, taking into account all aspects of the patient's family life. Thus, the RV scenario has been extended to the scenario of «virtual family», which has made it possible to narrow still a bit the gap between virtual and real methods of training family doctors [24].

German scholars have studied the relative effectiveness of two pedagogical concepts of using VPs to develop clinical thinking among medical university students. The first strategy was based on the use of a large number of separate «short» clinical scenarios of certain specificity; the second was based on a system of several «extended» and interconnected clinical situations. Results of a quasi-randomized, blind, controlled parallel group intervention study indicated that both methods of using a VPs were highly effective and comparable [25]. Scholars in the Copenhagen Medical University (Denmark) suggested that the work of students in developing multimedia clinical scenarios (VP) could be as useful for developing clinical thinking skills as the normal work done by the PV. Two randomized student groups were formed to test the hypothesis. The participants of the first group developed two virtual clinical scenarios and the participants of the second – dealt with the solution of two similar VP. The results of the tests showed that students in both groups have equally mastered the skills of clinical thinking. However, the time spent on the design of the VP was twice as much as on the solution. It was concluded that it would not be appropriate to use the creating of VP in the training process [26]. One of the traditional versions of clinical lectures is the presentation of a clinical case. With the advent of multimedia technology, the possibilities of such a lecture have greatly expanded (through the demonstration of data from clinical and additional studies), but the emergence of virtual clinical scenarios has provided a revolutionary leap in the effectiveness of this form of lecture. Teachers at the Medical University in Zagazig (Egypt) compared the effectiveness of deductive and inductive methods in shaping clinical thinking based on the presentation of the VP at a lecture. It was found that there were no significant differences in the results of both methods, provided that the inductive method was fully monitored by the teacher [27].

Conclusions. An analysis of publications shows that virtual patients are a very effective supplement to the traditional methods of teaching clinical thinking to medical students as well as communication skills to patients. The popularization and widespread introduction of the experience already gained in the use of virtual patients in medical education can significantly improve the training of future physicians in medical schools as well as in post-graduate education.

References:

1. Quail, N., Boyle, J. (2019). Virtual Patients in Health Professions Education. *Biomedical Visualisation*. Cham: Springer, 25-35, doi: 10.1007/978-3-030-24281-7_3.
2. Karasmani, A., Antoniou, P., & Bamidis, P. (2017). Virtual patient cases: to use or not to use? Exploring creators' attitudes against their use in the undergraduate medical curriculum. *MEFANET Journal*, 5(1), 6-12.
3. Kononowicz, A., Woodham A., & Edelbring, S. (2019). Virtual patient simulations in health professions education: Systematic review and meta-analysis by the digital health education collaboration. *Journal of medical Internet research*, 21(7), e14676. doi:10.2196/14676.

4. Daher, S., Hochreiter, J., Schubert, R. (2020). The Physical-Virtual Patient Simulator: A physical human form with virtual appearance and behavior. *Simulation in Healthcare*. 15(2),115-121. doi: 10.1097/SIH.0000000000000409.
5. Peddle M., Bearman, M., & McKenna, L. (2019). Exploring undergraduate nursing student interactions with virtual patients to develop 'non-technical skills' through case study methodology. *Advances in Simulation*, 1, 2-11, doi:10.1186/s41077-019-0088-7.
6. Lok, B., Foster, A. (2019). Can Virtual Humans Teach Empathy? *Teaching Empathy in Healthcare*. Cham: Springer, 143-163. doi:10.1007/978-3-030-29876-0_9.
7. Strelakova, Y., Krieger, J., & Neil, J. (2017). I understand how you feel: The language of empathy in virtual clinical training. *Journal of Language and Social Psychology*, 36(1), 61-79, doi:10.1177/0261927x16663255.
8. Jacklin, S., Chapman, S., & Maskrey, N. (2019). Virtual patient educational intervention for the development of shared decision-making skills: a pilot study. *BMJ Simulation and Technology Enhanced Learning*, 5(4), 215-217, doi:10.1136/bmjstel-2018-000375.
9. Maicher, K., Zimmerman, L., & Wilcox, B. (2019). Using virtual standardized patients to accurately assess information gathering skills in medical students. *Medical teacher*, 41(9), 1053-1059, doi:10.1080/0142159X.2019.1616683.
10. Borja-Hart N., Spivey, C., & George C. (2019). Use of virtual patient software to assess student confidence and ability in communication skills and virtual patient impression: A mixed-methods approach. *Currents in Pharmacy Teaching and Learning*, 11, 710-718. doi:10.1016/j.cptl.2019.03.009.
11. Banzski, F., Beilby, J., & Quail, M. (2018). A clinical educator's experience using a virtual patient to teach communication and interpersonal skills. *Australasian Journal of Educational Technology*, 34(3), 60-74, doi:10.14742/ajet.3296.
12. Ten Cate, O., Durning, S. (2018). Approaches to Assessing the Clinical Reasoning of Preclinical Students. *Principles and Practice of Case-based Clinical Reasoning Education*. Cham: Springer, 65-72, doi:10.1007/978-3-319-64828-6_5.
13. Sahin, G., Basak, T. (2019). The use of virtual patient in teaching clinical practice skills to nursing students. *Journal of Human Sciences*, 6(4), 907-915, doi:10.14687/jhs.v16i4.5720.
14. Al-Dosari, S., Drees, A., & Al-Qahtani, F. (2017). Virtual Patient as A Multimedia Learning Tool to Help Students Learn Clinical Reasoning Skills in Medicine. *International Journal of Pharmaceutical Research & Allied Sciences*, 6(4), 88-94.
15. Lee, J., Kim, H., & Kim H. (2020). Effective virtual patient simulators for medical communication training: a systematic review. *Medical education*, 54(9),786-795. doi:10.1111/medu.14152.
16. Hayward, J., Cheung, A. & Velji, A. (2016). Script-theory virtual case: A novel tool for education and research. *Medical teacher*, 38(11), 1130-1138, doi:10.3109/0142159x.2016.1170776.
17. Sobocan, M., Klemenc-Ketis, Z. (2017). Medical students' attitudes towards the use of virtual patients. *Journal of Computer Assisted Learning*, 33(4), 393-402, doi:10.1111/jcal.12190.
18. Forsberg, E., Bäcklund B., & Hjort-Telhede E. (2019). Virtual Patient Cases for Active Student Participation in Nursing Education—Students' Learning Experiences. *Creative Education*. 10(7), 1475-1491, doi:10.4236/ce.2019.107108.
19. Barnett, S., Gallimore, C. & Pitterle, M. (2016). Impact of a paper vs virtual simulated patient case on student-perceived confidence and engagement. *American Journal of Pharmaceutical Education*. 80(1), 16-25, doi:10.5688/ajpe80116.
20. McCoy, L., Pettit, K., & Lewis, J. (2016). Evaluating medical student engagement during virtual patient simulations: a sequential, mixed methods study. *BMC medical education*, 16(1), 20-29, doi:10.1186/s12909-016-0530-7.
21. Macauley, K., Brudvig, T. & Kadakia, M. (2016). Systematic Review of Assessments That Evaluate Clinical Decision Making, Clinical Reasoning, and Critical Thinking Changes After Simulation Participation. *Journal of Physical Therapy Education*, 31(4), 64-75, doi:10.1097/JTE.000000000000011.

22. Sobocan, M., Turk, N., & Dinevski, D. (2017). Problem-based learning in internal medicine: virtual patients or paper-based problems? *Internal medicine journal*, 47(1), 99-103, doi:10.1111/imj.13304.
23. Urresti-Gundlach, M., Tolks, D., & Kiessling, C. (2017). Do virtual patients prepare medical students for the real world? Development and application of a framework to compare a virtual patient collection with population data. *BMC medical education*, 17(1), 174-181.
24. Robison, D., Rajasekaran, S. & Berman, N. (2017). "It Feels Like Being a Real Doctor:" The Virtual Family Approach in Medical Education. *MedEdPublish*, 6, 1-11, doi:10.15694/mep.2017.000187.
25. Schubach, F., Goos M & Fabry, G. (2017). Virtual patients in the acquisition of clinical reasoning skills: does presentation mode matter? A quasi-randomized controlled trial. *BMC medical education*, 17(1), 165-172, doi:10.1186/s12909-017-1004-2.
26. Marei, H., Donkers J., & Al-Eraky, M. (2020). Collaborative use of virtual patients after a lecture enhances learning with minimal investment of cognitive load. *Medical teacher*, 41(3), 332-339. doi: 10.1080/0142159X.2018.1472372.
27. Tolsgaard, M., Jepsen, R. & Rasmussen, M. (2016). The effect of constructing versus solving virtual patient cases on transfer of learning: a randomized trial. *Perspectives on medical education*, 5(1), 33-38, doi:10.1007/s40037-015-0242-4.

Література:

1. Quail, N., Boyle, J. (2019). Virtual Patients in Health Professions Education. *Biomedical Visualisation*. Cham: Springer, 25-35, doi: 10.1007/978-3-030-24281-7_3.
2. Karasmani, A., Antoniou, P., & Bamidis, P. (2017). Virtual patient cases: to use or not to use? Exploring creators' attitudes against their use in the undergraduate medical curriculum. *MEFANET Journal*, 5(1), 6-12.
3. Kononowicz, A., Woodham A., & Edelbring, S. (2019). Virtual patient simulations in health professions education: Systematic review and meta-analysis by the digital health education collaboration. *Journal of medical Internet research*, 21(7), e14676. doi:10.2196/14676.
4. Daher, S., Hochreiter, J., Schubert, R. (2020). The Physical-Virtual Patient Simulator: A physical human form with virtual appearance and behavior. *Simulation in Healthcare*. 15(2), 115-121. doi: 10.1097/SIH.0000000000000409.
5. Peddle M., Bearman, M., & McKenna, L. (2019). Exploring undergraduate nursing student interactions with virtual patients to develop 'non-technical skills' through case study methodology. *Advances in Simulation*, 1, 2-11, doi:10.1186/s41077-019-0088-7.
6. Lok, B., Foster, A. (2019). Can Virtual Humans Teach Empathy? *Teaching Empathy in Healthcare*. Cham: Springer, 143-163. doi:10.1007/978-3-030-29876-0_9.
7. Strelakova, Y., Krieger, J., & Neil, J. (2017). I understand how you feel: The language of empathy in virtual clinical training. *Journal of Language and Social Psychology*, 36(1), 61-79, doi:10.1177/0261927x16663255.
8. Jacklin, S., Chapman, S., & Maskrey, N. (2019). Virtual patient educational intervention for the development of shared decision-making skills: a pilot study. *BMJ Simulation and Technology Enhanced Learning*, 5(4), 215-217, doi:10.1136/bmjstel-2018-000375.
9. Maicher, K., Zimmerman, L., & Wilcox, B. (2019). Using virtual standardized patients to accurately assess information gathering skills in medical students. *Medical teacher*, 41(9), 1053-1059, doi:10.1080/0142159X.2019.1616683.
10. Borja-Hart N., Spivey, C., & George C. (2019). Use of virtual patient software to assess student confidence and ability in communication skills and virtual patient impression: A mixed-methods approach. *Currents in Pharmacy Teaching and Learning*, 11, 710-718. doi:10.1016/j.cptl.2019.03.009.

11. Banszki, F., Beilby, J., & Quail, M. (2018). A clinical educator's experience using a virtual patient to teach communication and interpersonal skills. *Australasian Journal of Educational Technology*, 34(3), 60-74, doi:10.14742/ajet.3296.
12. Ten Cate, O., Durning, S. (2018). Approaches to Assessing the Clinical Reasoning of Preclinical Students. *Principles and Practice of Case-based Clinical Reasoning Education*. Cham: Springer, 65-72, doi:10.1007/978-3-319-64828-6_5.
13. Sahin, G., Basak, T. (2019). The use of virtual patient in teaching clinical practice skills to nursing students. *Journal of Human Sciences*, 6(4), 907-915, doi:10.14687/jhs.v16i4.5720.
14. Al-Dosari, S., Drees, A., & Al-Qahtani, F. (2017). Virtual Patient as A Multimedia Learning Tool to Help Students Learn Clinical Reasoning Skills in Medicine. *International Journal of Pharmaceutical Research & Allied Sciences*, 6(4), 88-94.
15. Lee, J., Kim, H., & Kim H. (2020). Effective virtual patient simulators for medical communication training: a systematic review. *Medical education*, 54(9), 786-795. doi:10.1111/medu.14152.
16. Hayward, J., Cheung, A. & Velji, A. (2016). Script-theory virtual case: A novel tool for education and research. *Medical teacher*, 38(11), 1130-1138, doi:10.3109/0142159x.2016.1170776.
17. Sobocan, M., Klemenc-Ketis, Z. (2017). Medical students' attitudes towards the use of virtual patients. *Journal of Computer Assisted Learning*, 33(4), 393-402, doi:10.1111/jcal.12190.
18. Forsberg, E., Bäcklund B., & Hjort-Telhede E. (2019). Virtual Patient Cases for Active Student Participation in Nursing Education—Students' Learning Experiences. *Creative Education*. 10(7), 1475-1491, doi:10.4236/ce.2019.107108.
19. Barnett, S., Gallimore, C. & Pitterle, M. (2016). Impact of a paper vs virtual simulated patient case on student-perceived confidence and engagement. *American Journal of Pharmaceutical Education*. 80(1), 16-25, doi:10.5688/ajpe80116.
20. McCoy, L., Pettit, K., & Lewis, J. (2016). Evaluating medical student engagement during virtual patient simulations: a sequential, mixed methods study. *BMC medical education*, 16(1), 20-29, doi:10.1186/s12909-016-0530-7.
21. Macauley, K., Brudvig, T. & Kadakia, M. (2016). Systematic Review of Assessments That Evaluate Clinical Decision Making, Clinical Reasoning, and Critical Thinking Changes After Simulation Participation. *Journal of Physical Therapy Education*, 31(4), 64-75, doi:10.1097/JTE.000000000000011.
22. Sobocan, M., Turk, N., & Dinevski, D. (2017). Problem-based learning in internal medicine: virtual patients or paper-based problems? *Internal medicine journal*, 47(1), 99-103, doi:10.1111/imj.13304.
23. Urresti-Gundlach, M., Tolks, D., & Kiessling, C. (2017). Do virtual patients prepare medical students for the real world? Development and application of a framework to compare a virtual patient collection with population data. *BMC medical education*, 17(1), 174-181.
24. Robison, D., Rajasekaran, S. & Berman, N. (2017). "It Feels Like Being a Real Doctor:" The Virtual Family Approach in Medical Education. *MedEdPublish*, 6, 1-11, doi:10.15694/mep.2017.000187.
25. Schubach, F., Goos M & Fabry, G. (2017). Virtual patients in the acquisition of clinical reasoning skills: does presentation mode matter? A quasi-randomized controlled trial. *BMC medical education*, 17(1), 165-172, doi:10.1186/s12909-017-1004-2.
26. Marei, H., Donkers J., & Al-Eraky, M. (2020). Collaborative use of virtual patients after a lecture enhances learning with minimal investment of cognitive load. *Medical teacher*, 41(3), 332-339. doi: 10.1080/0142159X.2018.1472372.
27. Tolsgaard, M., Jepsen, R. & Rasmussen, M. (2016). The effect of constructing versus solving virtual patient cases on transfer of learning: a randomized trial. *Perspectives on medical education*, 5(1), 33-38, doi:10.1007/s40037-015-0242-4.