










The Virtual Clinic application – a new solution for modern medical education

Wirtualna Klinika – nowe rozwiązanie dla nowoczesnej edukacji medycznej

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ABSTRACT

INTRODUCTION: The abrupt transition to remote learning caused by the COVID-19 pandemic clearly indicated the need to implement radical technological and institutional changes to the current approach to teaching. Virtual reality (VR) and artificial intelligence (AI) assisted programs have emerged as the new and effective methods utilized in education and medical training.

MATERIAL AND METHODS: The Virtual Clinic (VC) is a new online application developed by Polish medical universities which implement AI algorithms to teach students the medical interview including obtaining patients medical history, performing a physical examination as well as diagnostics and treatment planning. Our study enrolled 164 medical students who tested the VC and completed an online questionnaire.

RESULTS: The results of the survey showed that 93.9% of the respondents believe that the VC will prove effective as an educational tool supporting teaching at faculties of medicine and health sciences.

CONCLUSIONS: Our preliminary experiences suggest that the use of AI assisted programs such as the VC seems highly anticipated and justified in medical higher education.

KEYWORDS

virtual clinic, virtual patient, artificial intelligence, medical education, medical simulation

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STRESZCZENIE

WPROWADZENIE: Nagłe przejście na nauczanie zdalne spowodowane pandemią COVID-19 jednoznacznie wskazało na konieczność wprowadzenia radykalnych zmian technologicznych i instytucjonalnych do nauczania. Programy wspomagane wirtualną rzeczywistością (*virtual reality* – VR) i sztuczną inteligencją (*artificial intelligence* – AI) stają się nowymi i skutecznymi metodami wykorzystywanymi w edukacji i szkoleniach medycznych.

MATERIAŁ I METODY: Wirtualna Klinika (Virtual Clinic – VC) to nowa aplikacja internetowa opracowana przez polskie uniwersytety medyczne, które wdrażają algorytmy AI do nauki przeprowadzania wywiadu lekarskiego, w tym pozyskiwania historii choroby pacjenta, przeprowadzania badania przedmiotowego oraz diagnostyki i planowania leczenia. W badaniu wzięło udział 164 studentów medycyny, którzy przetestowali VC i wypełnili kwestionariusz online.

WYNIKI: Wyniki ankiety wykazały, że 93,9% respondentów uważa, iż VC sprawdzi się jako narzędzie edukacyjne wspomagające nauczanie na wydziałach medycznych i nauk o zdrowiu.

WNIOSKI: Nasze wstępne doświadczenia sugerują, że wykorzystanie programów wspomaganych AI, takich jak VC, wydaje się wysoce wyczekiwane i uzasadnione w wyższym szkolnictwie medycznym.

SŁOWA KLUCZOWE

wirtualna klinika, wirtualny pacjent, sztuczna inteligencja, edukacja medyczna, symulacja medyczna

INTRODUCTION

The recent coronavirus pandemic resulted in the temporary closure of educational institutions and a switch to distance learning. This abrupt transition to remote learning proved challenging both for students and educational professionals [1]. The experiences from the COVID-19 pandemic clearly indicate the need to implement radical technological and institutional changes to the current approach to teaching.

The challenges that higher education is currently facing result not only from the need to deal with emergency situations but also from the expectations of modern generations of students, exposed to the rapid development of technologies that are increasingly utilized in everyday life as well as in medicine [2]. Due to the specificity of medical education in which clinical work with the patient is an indispensable element, creating an environment that mimics real contact with a patient has become an urgent need. In addition, the use of medical simulations can complement standard education. Medical simulation allows the user to create an environment that simulates real situations, and gives the opportunity to test students' skills without the risk of consequences of a possible wrong decision. This is especially important in situations imitating a real therapeutic process [3]. Previous studies have confirmed that the use of simulation is beneficial to strengthening students' skills and can be used to evaluate their performance [4,5].

It is no surprise that virtual reality (VR) and artificial intelligence (AI) assisted programs are emerging as the new and effective methods utilized in education [6,7]. Some of them have already proved useful in medical training, i.e. ultrasonography, endoscopy and laparoscopy courses [8].

One of these new programs is the Virtual Clinic (VC) – an online application developed by the Medical University of Silesia in Katowice (SUM) and the Medical University of Warsaw in cooperation with the

technological company BD Polska. VC implements AI algorithms to teach students how to obtain a medical history, perform a physical examination as well as diagnostics and treatment planning. The VC app has been recognized by the Polish Ministry of Health and included it in its Innovation Map.

The aim of this study is to analyze the students' opinion about the VC and thus evaluate the potential to apply this tool in medical higher education.

MATERIAL AND METHODS

Virtual Clinic

Virtual Clinic is an online application (www.wirtualnaklinika.com/en) that consists of two modules: the Clinic and the Creator. The Clinic is dedicated to students and the Creator for academic tutors.

The academic module – the Creator allows tutors to create virtual patient (VP) cases utilizing as many as 14 728 physical examination options, 24 118 diagnostic examinations and tests, 43 576 questions and 19 158 answers. A dedicated medical knowledge database contains anthropometric features, personal data, information from medical histories and physical examinations, laboratory and diagnostic tests as well as medications and procedures, which allow tutors to create medical cases with almost no limitations. The cases created in the system can be drawn from theory or previous experience. In particular, the system supports the creation of scenarios based on a real medical history or experiences derived from medical practice. The VC database is constantly growing, as new data and anonymized multimedia are acquired, including diagnostic imaging, audio files, photographs and short videos.

The students' module – the Clinic – allows the user to work with VPs, created by experts and academic tutors. In the Clinic, the student can collect the VP's medical history in real-time using written or spoken



conversation in natural language, perform a physical examination consisting of the observation, auscultation, percussion and palpation of selected areas of the body. The application also gives the opportunity to conduct detailed neurological examinations, which is a unique feature, compared to other virtual patient programs. Students decide when and which additional examinations to order, choosing from a wide range of laboratory tests, diagnostic imaging, endoscopic or functional examinations and many others. Each diagnostic examination and test has allocated a realistic cost and time to measure expenses and diagnosis time, and therefore evaluates the students' performance. The Virtual Clinic gives the opportunity to simulate doctor-patient contact in different settings, including an ambulance, clinic, Emergency Room (ER) or a hospital ward, giving access to those diagnostic tools that would have been available in particular situations. Furthermore, the Clinic allows students to conduct an exam consisting of medical cases, tests and imaging examinations.

The VC project has been funded by the National Centre for Research and Development (NCBR) and is being implemented by experts from the Medical University of Silesia in Katowice, Medical University of Warsaw and BD Polska, a company that specializes in data analysis and the use of AI.

Participants

The study enrolled 164 Polish medical students from two separate groups: the International Federation of Medical Students Association (IFMSA) and SUM. Prior to the survey, the participants from both groups attended a lecture about the VC. Then they had a chance to interact with the application and use it during workshops.

IFMSA group

The study included 57 medical students from different medical universities in Poland, participants of the 10th summer camp of IFMSA Poland, held 12–16 September 2022.

ŚUM group

107 4th and 5th year medical students from the Medical University of Silesia in Katowice took part in the survey.

The questionnaire

The anonymous questionnaire consisted of 10 questions regarding the intuitiveness, usability, attractiveness of VC and the students' willingness to

Supplement. VC questionnaire

No.	Question	Answers
1.	Do you think that the VC will prove effective as an educational tool to support teaching at faculties of medicine and health sciences?	(Yes/No)
2.	Is the VC application easy to manage?	(Yes/No)
3.	Have you used similar applications before?	(Yes/No)
4.	Do you have a sense of agency (fully independent action) when diagnosing a patient in the VC app?	(Yes/No)
5.	Did you find the VC lecture attractive?	(Yes/No)
6.	Did you find solving the clinical cases in the VC application interesting?	(Yes/No)
7.	Where would you like to use the VC app?	(1 – at home, 2 – at the university, 3 – not interested)
8.	During which years of medical studies would you like to use the app?	(1 – 6)
9.	Is the dialogue with the VP in natural language (going beyond the closed pattern of questions) attractive for you?	(Yes/No)
10.	Which of the elements of the application do you think requires further development?	(1 – apps layout, 2 – collecting the medical history, 3 – patients chart, 4 – physical examination, 5 – laboratory tests and diagnostic examinations, 6 – application errors)

VC – Virtual Clinic; VP – virtual patient.

continue using the application, previous experiences with similar solutions as well as elements of the app that require improvement. The full questionnaire is presented in the supplementary material (Supplement). The survey was made available on-line via a direct link sent to the respondents after the workshops.

Users comments

The respondents had the opportunity to give written feedback in the comments section located at the end of the questionnaire. All the comments were assessed objectively as positive or negative.



RESULTS

Survey

Only 20% of all the participants had had previous experience with similar applications. 95.1% of the participants found solving the medical cases in the VC application interesting. The dialogue with the VP in natural language was found attractive by 88.4% of the participants. A sense of agency when diagnosing a patient in the VC app was reported by 76.8% of the respondents. As much as 99.4% of the participants were interested in continuing to use the VC app – 73.8% expressed a desire to use the app at home, the remaining 25.6% preferred to use the app at the university. Only 1 person (0.6%) expressed no interest in using the app. Most of the respondents indicated a desire to use the VC while studying in the 4th and 3rd year of medical studies (35.3% and 27.4% respectively). 81.7% of the participants found the VC app intuitive and 93.9% believe that it will prove effective as an educational tool to support teaching at faculties of medicine and health sciences. Among the respondents who pointed out the need to improve the app, 74.8% indicated shortcomings in the conversation with the patient (this was prior to major developments regarding conversational AI). Statistically significant differences between the two groups of respondents concerned questions 2–5. In particular, SUM students have had more experience with similar apps and were more sceptic towards the VC. The complete results are presented in Figure 1 and Tables I and II.

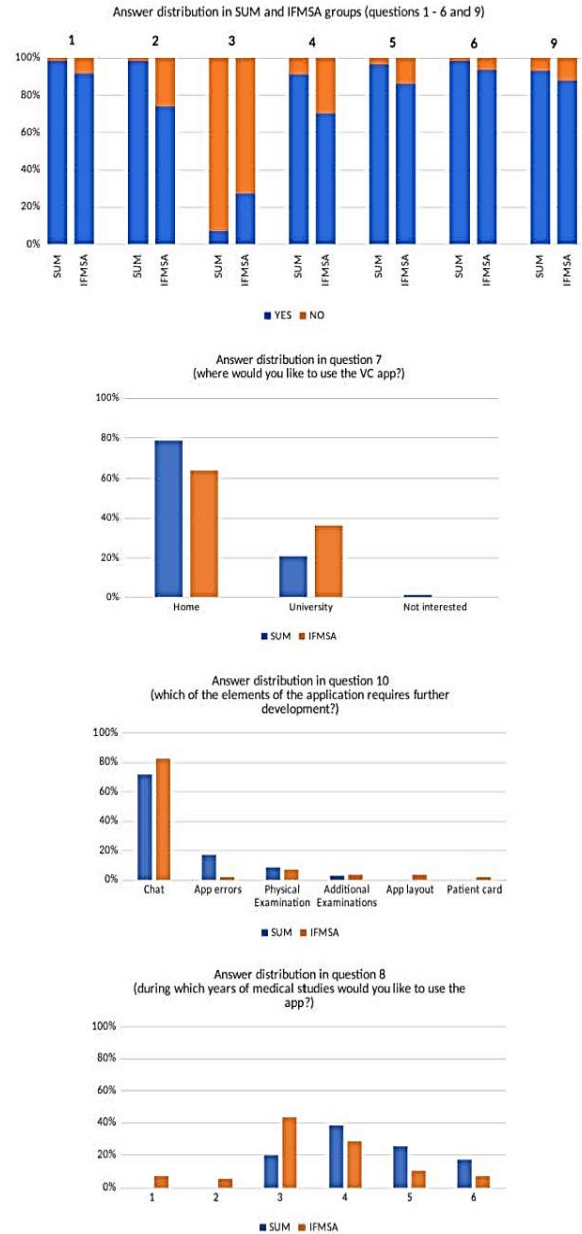


Fig. 1. Graphic presentation of answer distribution in SUM and IFMSA groups.



Table I. Answer distribution in questions 1–6 and 9

Question	Answer N, (%), [95% confidence level]				p
	IFMSA		ŚUM		
	Yes	No	Yes	No	
1. Do you think that the VC will prove effective as an educational tool to support teaching at faculties of medicine and health sciences?	56 (98.2) [100%]	1 (1.8) [5%]	98 (91.8) [97%]	9 (8.4) [14%]	0.0697
2. Is the VC application easy to manage?	55 (98.2) [100%]	1 (1.8) [5%]	79 (73.8) [82%]	28 (26.2) [34%]	< 0.001
3. Have you used similar applications before?	4 (7) [86%]	53 (93) [100%]	29 (27.1) [36%]	78 (72.9) [81%]	< 0.01
4. Do you have a sense of agency (fully independent action) when diagnosing a patient in the VC app?	51 (91.1) [99%]	5 (8.9) [16%]	75 (70.1) [79%]	32 (29.9) [39%]	< 0.01
5. Did you find the VC lecture attractive?	54 (96.4) [100%]	2 (3.6) [8%]	91 (85.8) [92%]	15 (14.2) [21%]	< 0.05
6. Did you find solving the clinical cases in the VC application interesting?	56 (98.2) [100%]	1 (1.8) [5%]	100 (93.5) [98%]	7 (6.5) [11%]	0.1362
7.	–	–	–	–	–
8.	–	–	–	–	–
9. Is the dialogue with the VP in natural language (going beyond the closed pattern of questions) attractive for you?	53 (93) [100%]	4 (7) [14%]	92 (87.6) [94%]	13 (12.4) [19%]	0.1284
10.	–	–	–	–	–

p was calculated using Fisher’s exact test. Statistical significance was set at a p-value below 0.05.

IFMSA – International Federation of Medical Students Association; ŚUM – Medical University of Silesia.

Table II. Answer distribution in questions 7, 8 and 10

Question 7 (Where would you like to use the VC app?)			
Answer	N, (%), [95% confidence level]		p
	IFMSA	ŚUM	
Home	39 (63.9) [76%]	84 (78.5) [87%]	< 0.05
University	22 (36.1) [52%]	22 (20.6) [71%]	< 0.05
Not interested	0	1 (0.9)	–
Question 8 (During which years of medical studies would you like to use the app?)			
Answer	N, (%), [95% confidence level]		p
	IFMSA	ŚUM	
1	4 (6.7) [1%]	0 [0%]	< 0.05
2	3 (5) [0%]	0 [0%]	< 0.05
3	26 (43.4) [30%]	21 (19.6) [12%]	< 0.001
4	17 (28.3) [17%]	41 (38.3) [29%]	0.0589
5	6 (10) [2%]	27 (25.2) [17%]	< 0.01
6	4 (6.7) [1%]	18 (16.8) [10%]	< 0.05



Question 10 (Which of the elements of the application requires further development?)			
Answer	N, (%), [95% confidence level]		<i>p</i>
	IFMSA	ŚUM	
Chat	47 (82.5) [63%]	76 (71.7) [73%]	< 0.05
App errors	1 (1.8) [10%]	18 (17) [0%]	< 0.01
Physical examination	4 (7) [4%]	9 (8.5) [1%]	0.2302
Additional examinations	2 (3.5) [0%]	3 (2.8) [0%]	0.3416
App layout	2 (3.5) [0%]	0 [0%]	0.1209
Patient card	1 (1.8) [0%]	0 [0%]	0.3497

p was calculated using Fisher's exact test. Statistical significance was set at a *p*-value below 0.05.

IFMSA – International Federation of Medical Students Association; ŚUM – Medical University of Silesia.

Comments

35 comments were added to the questionnaire and 23 (65.7%) of them were recognized as positive.

The positive comments focused mainly on the innovative approach to teaching. The majority of the students expressed a positive opinion about learning independence in decision-making, conducting the interview with the VP and interpreting test results. Students also positively assessed the opportunity to learn about rare diseases, which they cannot often see during clinical classes.

The negative comments were mostly indications of errors found in the app and suggestions for application development.

led to the use of partly remote or hybrid teaching in education after lifting restrictions. Another great advantage of e-learning programs is the possibility to provide students constant access to training materials, anywhere and at any time.

The VC was designed to prepare students for contact with the patient, and in this manner it can also act as a substitute in emergency situations. The application is available online both on computers and mobile devices including smartphones.

Most of the respondents in our study found the VC app interesting and believe that it will prove effective to support teaching at faculties of medicine and health sciences. Most of the participants also indicated a desire to use VC while studying in the 3rd and 4th years of medical studies, which corresponds to the early stages of clinical education. Similar results were seen for both endoscopy and surgery training that utilized VR techniques. The participants in these courses had better learning outcomes compared to the participants of courses with a classic approach [13,14,15,16]. It was also observed that VR training met with greater enthusiasm [13].

One of the current challenges in higher education is the growing number of students admitted to universities and the possible inability of universities to meet their expectations and maintain a high quality of training. The use of a virtual environment like the VC app allows tutors to supplement the clinical experience of students. It is worth noting that majority (99.4%) of the students surveyed in our study wished to continue using the VC app, mostly at home. Although the use of the VC does not compete with the standard form of medical education with a real patient, it allows the student's experience to be expanded by working with additional clinical cases presented in VR. Another advantage of the App is the possibility for the student to make independent clinical and therapeutic decisions. A sense of agency when diagnosing a patient in the VC was reported by the majority of students (76.8%). It should be noted, however, that some groups had worked with the application together with a teacher, which could

DISCUSSION

Online learning, despite the fact that it has been a method known for years, was not widely used until recently. Distance learning introduced during the SARS-CoV-2 pandemic allowed the continuity of education to be maintained [9]. However, it was not achieved without shortcomings [1]. The most significant disadvantage was limited contact with the patient and limitations in acquiring clinical skills by medical students [10,11]. Among other concerns were the constraints related to internet access and technical problems with educational platforms. Similar observations, not related to the sudden epidemic situation, appear during the implementation of distance learning in educational institutes. The key barriers which affect the development and implementation of online learning in medical education include time constraints, poor technical skills, an inadequate infrastructure, the absence of institutional strategies and support, as well as negative attitudes of all those involved [12]. Nevertheless, some of these drawbacks can be prevented through systematic educational training and software investments. Moreover, the lessons learned from the pandemic experiences have



have affected this indicator. According to the available scientific research, supplementing education with simulation-based medical training is an effective way to improve clinical skills and increase patient safety by reducing the risk of medical errors [17,18]. These results clearly indicate the need to implement the solutions that simulate the patient-doctor conversation as well as the diagnostic and therapeutic process in medical education.

The presented study has some limitations that should be noted. First, the participants included in the survey differed in terms of experience of working with the application, which could have affected the overall experience of working with the VC app. Second, the data collected in the study came mainly from students in the 4th and 5th year of medicine, which may have prevented the generalization of results for all medical students. Third, the survey assessed students' satisfaction with the application, but did not assess the usefulness of the VC as an educational tool.

CONCLUSIONS

The use of AI assisted programs such as the VC seems highly anticipated and justified in the medical higher education. Further research is needed to assess the effectiveness of this solution in improving the skills of medical students.

Conflict of interest

None declared.

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Author's contribution

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Literature research – M. Winder

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