Original Article

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Expectation and Needs of Medical Students Towards the Implementation of Virtual Simulation in Learning Rational Use of Medicine

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Abstract

Introduction: The irrational use of medicines remains prevalent globally despite education efforts, leading to decreased treatment quality and increased healthcare costs. With the rise of online learning during the COVID-19 pandemic, virtual simulation offers a promising solution to enhance the teaching of rational medicine use among medical students. This study aimed to investigate medical students' perspectives and needs regarding the implementation of virtual simulation in learning the rational use of medicines.

Methods: This study, conducted at Universitas Indonesia from August 2022 to September 2023, used a mixed-method approach to assess the needs for developing virtual simulation in education of rational medicine use. A validated questionnaire with 14 closed-ended and 14 open-ended questions was completed by 281 medical students. The quantitative data were analysed descriptively, using SPSS v16, while thematic analysis was applied to open-ended responses.

Results: Students perceived virtual simulations to be the most effective tool for distance learning and suggested features like case scenarios, realistic representation, a good user interface, and user-friendly navigation. The majority preferred a 10–20-minute duration for virtual simulations. Additionally, 52.3% had no prior knowledge of the rational use of medicines, but acknowledged its importance. Virtual simulations could be used to explain the concept, management, and implementation of the rational use of medicines.

Conclusion: Virtual simulation should be implemented in distance learning on rational medicine use to increase students' motivation, understanding, retention, interactivity, and focus. The findings might be utilized by medical educators to tailor virtual simulation design to meet medical students' needs and expectations.

Keywords: Medication errors, Medical education, Distance education, Simulation training

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Introduction

According to World Health Organization (WHO), the use of medicine can be said to be rational if patients receive medication that meets clinical needs at appropriate individual doses over a certain period of time, which provides the lowest risk to the individual and the community (1). Irrational use of medicines will have an impact on the possibility of side effects, will cause a decrease in the quality of treatment and services, and will affect the cost of patient treatment (2).

The irrational use of medicines is still found to occur worldwide, even though teaching on rational drug use has been provided for health workers. The rate of drug use worldwide is irrational due to various factors. These include the overprescription, underuse, and misuse of medicines, as well as the inappropriate prescribing, dispensing, and selling of drugs. WHO estimates that more than half of all medicines are prescribed, dispensed, or sold inappropriately, leading to a wastage of resources and to health hazards (3). In developing and transitional countries, less than 40% of patients in the public sector and 30% in the private sector receive treatment in accordance with standard guidelines (4).

There are several strategies to promote the rational use of medicines. They focus on the integration of general and specialized education programs, problem-based training in pharmacotherapy, and prescription in undergraduate curricula. The content on the rational use of medicines has been agreed by the International Network for Rational Use of Drugs (INRUD) to be included in the university curriculum (5). However, despite the availability of various programs to teach rational use of medicine, medical curricula are often fully packed, leaving little room for dedicated modules or courses specifically focused on the rational use of medicines (6). Therefore, there is a need to develop other educational strategies in promoting the rational use of medicines for prospective health workers, especially medical students.

Since the COVID-19 pandemic has shifted education to online learning, the need for innovative solutions to optimize online learning has accelerated. There is an increased interest in virtual simulation-based learning experiences which are predicted to become an integral component of transformative change and education for health and medical personnel. The accessibility, interactivity, and engagement features of this virtual simulation could serve as a solution to the access limitations in rational use of medicine learning among candidates and health workers to clinical and educational sites (7).

In order to develop an effective virtual simulation, a needs assessment is required to be conducted as the first step of the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) of an instructional model. Its purpose is to gather information that is appropriate and sufficient to develop an effective educational program that will address students' needs and wants. Without such consideration, many of them may fail either to be implemented or to solve the purported problems since educators may fail to consider the needs of students (8). Student needs and expectations are crucial for the success of learning because they reflect specific learning motivations and goals, driving active engagement in the learning process. When instruction is aligned with these needs and expectations, students are more likely to find the material relevant and motivating, which enhances participation and retention of the content. Moreover, this is also crucial to identify the gap between the current and the desired state of education. Based on these considerations, a needs assessment was considered necessary as a preliminary study for the development of virtual simulation in learning the rational use of medicines. Therefore, this study aimed to investigate students' perspectives and needs regarding the implementation of virtual simulation in learning the rational use of medicines.

Methods

This study was conducted at Universitas Indonesia from August 2022 to September 2023. A mixed-method approach that combines quantitative and qualitative elements was used in the needs assessment process as the first step of the development of virtual simulation related to the rational use of medicines. The questionnaire used in the study was developed by experts and subsequently validated to obtain inter-item correlation values and Cronbach's alpha. The questionnaire consists of 14 closed-ended questions (rating-based questions) and 14 open-ended questions (short-answer questions). Quantitative measurements are taken from rating-based question while qualitative measurement is taken by short-answered type questions. Web-based virtual simulation means that a program (i.e. the virtual simulation) are built on World Wide Web and visitors will be able to access its features -such as story-based learning- through a browser via Internet, similar to opening a page from the Internet. Thematic analysis of open-ended questions was also used to identify dominant themes.

Participants

Recruitment of participants was done voluntarily. Before the study began, the participants were required to meet the inclusion criteria. The participants were medical students who were in their 1st to 3rd year of study. The participants who were willing to take part in the study consented and filled out the designed questionnaire. Those who answered 'no' on the informed consent form and failed to complete all questions were excluded from the study. A total of 286 medical students voluntarily participated and filled the questionnaire survey, but only 281 provided informed consent.

Research Instrument and Data Collection

In this study, a questionnaire survey was used in the needs assessment process. The questionnaire was designed by combining scale, closed-, and open-ended questions and validated using content validity. The questionnaire consisted of four types of questions, which were designed to gather information related to students' characteristics, technology readiness, understanding of the rational use of medicines, perspectives, and needs for the development of virtual simulation. The content in this questionnaire was reviewed by two content experts in medical education and the e-learning team in our faculty. In addition to the validation conducted by experts, validity and reliability tests were also performed on the questionnaire. All questionnaire items had an inter-item correlation of less than 0.3, with a Cronbach's alpha of 0.6. The questionnaire was developed using a Google form due to the variation in location of the participants as well as access to a larger number of participants.

Data Analysis

Statistical analysis was conducted using the statistical analysis program The International Business Machines Statistical Product and Service Solutions SPSS, v16. Descriptive quantitative analysis was conducted to examine and characterize the numerical data obtained. Close-ended questions were analysed, using descriptive qualitative analysis. To gain a more in-depth perspective of students, thematic analysis of the open-ended question was used to identify dominant themes that arose from the participants' responses.

Ethics Approval

The ethics committee of the Faculty of Medicine, Universitas Indonesia – Cipto Mangunkusumo Hospital approved this study (ethics reference number: KET-1001/UN2.F1/ETIK/PPM.00.02/2022).

Results

Characteristic of Respondents

There were 286 respondents who consented and filled in the questionnaire, but after a data filtering process, there were only 281 subjects who were valid for analysis. Table 1 shows that there were 44.1% male students and 55.9% female students. The age of the students ranged from 17 – 23 years. Most of the students accessed online courses using an Internet subscription (85.8%) and a laptop (75.1%) (Table 1).

Previous exposure of medical students to virtual simulation

Out of the 281 medical students assessed in this study, 69 (24.6%) students had had previous exposure to virtual simulation, while a majority of 214 (75.4%) students had not.

Medical students' understanding of the rational use of medicines

We found that 148 (52.3%) participants did not have a previous understanding or

Table 1: Characteristics of respondents

Variables		N	%
Gender	Male	124	44.1
	Female	157	55.9
Age	16-17	6	5.7
	18-20	239	85.0
	21-23	26	9.3
Connection	LAN Cable*	10	3.6
	Public Hotspot	9	3.2
	Internet Subscription	241	85.8
	Data Package	21	7.5
Device	Computer	61	21.7
	Laptop	211	75.1
	Tablet/iPad	4	1.4
	Smartphone	5	1.8

*LAN: Local Area Network

knowledge of the rational use of medicines, while the rest of the participants had previous understanding and knowledge. Seventy (24.7%) participants had learned the rational use of medicines through official websites, 60 (21.2%) participants during their study in medical school, 25 (8.8%) participants through books or articles, 13 (4.6%) participants through YouTube videos, 7 (2.5%) participants through seminars or webinars, and 1 (0.4%) participant through an online course.

Most medical students (63.3%) perceived that it was very important for prospective health workers to have an understanding of the rational use of medicines (Table 2). A mean value of 5.40 out of a scale of 1 to 6 also indicated that medical students' perceived understanding of the rational use of medicines is very important (Table 2).

Challenges during online learning

Based on a thematic analysis of open-ended questions, various themes emerged that was related to challenges that students had faced during online learning. The findings encompassed a spectrum of challenges, including poor Internet connection, low interaction and engagement, boredom and distraction, poor quality of learning materials, difficulty in understanding, information overload, and technical issues. The first five of these issues constitute the dominant components of the challenges faced by students during online learning.

The Most preferred media for online learning

With the transition of education to online learning, three methods are most commonly used, namely virtual simulation, interactive video, and a branching scenario (Table 3).

The effectiveness of virtual simulation from the perspective of students

Several findings also emerged in the analysis of the participants' opinions regarding the effectiveness of virtual simulations in helping online learning. These comprised three dominant themes, including increased interest, motivation, participation, improvement in student understanding and retention, improved focus, and other two secondary findings, namely increased interactivity and engagement, and increased accessibility.

Features required for the development of virtual simulation

The participants suggested several main features in virtual simulation, namely, good user interface, e.g. by optimizing animation and graphics, interesting scenario or storyline (cased-based situation and branching scenarios), availability of review, evaluation, interactivity through forum discussion and direct message, and gamification elements (checkpoint, goal, achievement, reward, leaderboard, hint, multiplayer). In addition to the main features, respondents mentioned several additional features, such as reasonable accessibility by maximizing user-friendly navigation, explanation, and clear instruction.

The most effective duration of virtual simulation

The opinions of medical students about the most effective duration of virtual simulation implementation are shown in Figure 1. This demonstrates that 91 (32.4%) of participants thought that 11 – 20 minutes was the most effective duration for virtual simulation. Meanwhile, 89 (31.7%) participants preferred 21 – 30 minutes and 48 (17.1%) participants preferred 31 – 40 minutes (Figure 1).

Table 2: Students' perspective of the importance of understanding the rational use of medicines for prospective health workers

Variable	Scale (Scored 1-6)	f	%	Mean±SD
The Importance of Understanding regarding the Rational Use of Medicines for Prospective Health Workers	Strongly unimportant (1)	3	1.1	5.40±0.978
	Unimportant (2)	1	0.4	
	Slightly unimportant (3)	13	4.6	
	Slightly important (4)	25	8.9	
	Important (5)	61	21.7	
	Strongly important (6)	178	63.3	
	Total	281	100.0	

Table 3: The most effective media in supporting distance learning scored 1-6

Type of Media	Mean±SD	Min	Max
Document	4.51±1.059	1	6
Video	4.89±0.882	2	6
Interactive Video	5.28±0.838	1	6
Branching Scenario	5.02±1.061	1	6
Virtual Simulation	5.15±1.031	1	6

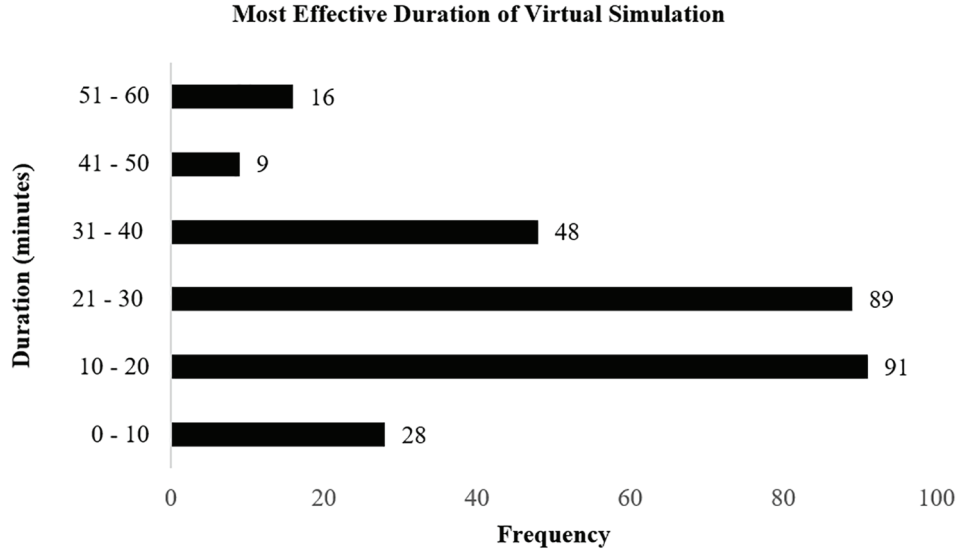

Figure 1: Effective duration for the implementation of the virtual simulation learning method

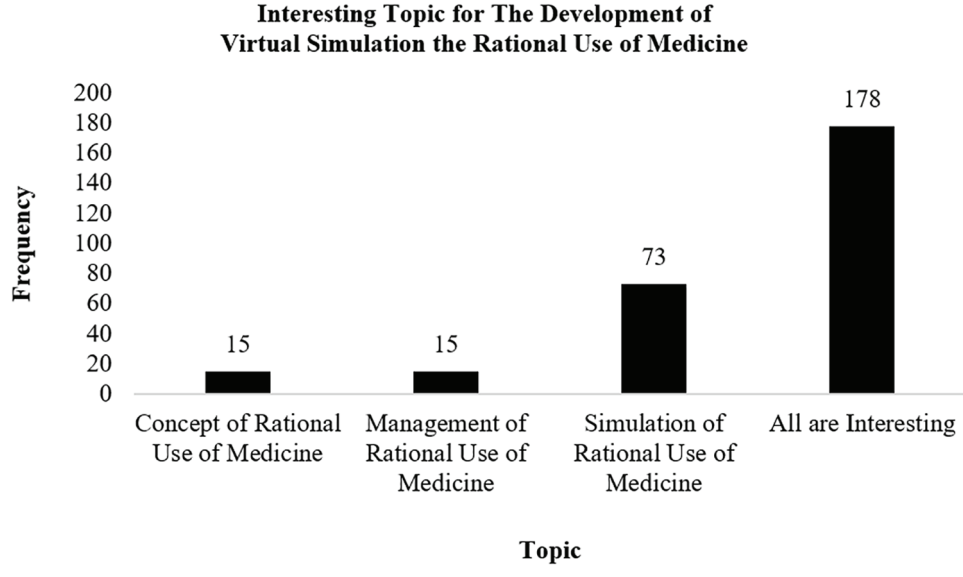

Figure 2: Students' views on interesting topics for the development of virtual simulation of the rational *use of medicines*

From open-ended questions, we also found that students considered the effective duration for the implementation of the virtual simulation learning method was based on its ability to maintain focus and avoid boredom and fatigue.

Virtual simulation implementation in learning the rational use of medicines

Related to the topic of the rational use of medicines, the suggestions made by medical students were that virtual simulation needs to cover concept, management, and implementation of the rational use of medicines (Figure 2).

Discussion

Current Situation

Currently, the rational use of medicines is included in Indonesia's medical education curriculum through pharmacology modules. This study evaluated medical students' perceived understanding of this topic, recognizing its significance for educating future health professionals.

Learning the rational use of medicines is very important but there are challenges in its practical application in medical practice (9). Current methods used to teach the rational use of medicines are mainly limited to conventional styles of teaching, such as adopting the WHO 6-Step Model for Rational Prescribing or conventional case-based learning (10). However, many studies have demonstrated the ineffectiveness of these methods. Medical students have reported that they are not prepared to prescribe medications

(11) while first-year doctors have reported a lack of confidence and competence (12). These reports underscore the ineffectiveness of undergraduate medical education and hence the need for a novel and more effective method of teaching.

Recently, virtual simulation has emerged as a promising, effective, and innovative approach for educating medical students since it provides a safe practice environment to support their learning process (13). Its versatility is evident across various levels of medical education, from teaching basic biomedical science to advanced clinical training (14).

Summary of findings

Most medical students rely on various resources like websites, YouTube, and books to learn about rational medicine use, but only about half grasp the topic well. Online learning faces challenges such as poor connectivity, boredom, and limited access to credible sources. Interactive video, virtual simulation, and branching scenarios are the best methods for online learning. Virtual simulation is seen as a promising solution, enhancing focus, understanding, and retention while boosting interest and motivation. Students believe it should supplement existing resources and emphasize features like user-friendly interfaces, engaging scenarios, and interactivity. Furthermore, they suggest that the ideal durations for virtual simulation are 11-20 minutes and 21-30 minutes.

Psychological Aspects of Virtual Simulation

Virtual simulation is an increasingly used pedagogy and has been reported as an effective pedagogical approach for improving student learning outcomes (7, 15). This is in line with our study finding that describes medical students' perception of the use of virtual simulation in assisting online learning. They perceived virtual simulation to be effective due to its feasibility to increase students' interest and motivation, and improve their understanding, learning retention, and focus.

Virtual simulation can increase the participants' motivation, readiness, and engagement in learning activities by tapping into their intrinsic motivation, providing clear goals and feedback, promoting autonomy and control, and fostering social interaction. By incorporating game design principles into educational contexts, gamification creates a more engaging and enjoyable learning experience, ultimately enhancing participants' motivation and willingness to actively participate in the learning process (16).

Virtual simulation has proven to be effective not only for online learning, but also as an effective teaching and learning modality, especially in adapting to the new normal era brought about by the increased use of technology and e-learning during the COVID-19 pandemic (17). There is a wide range of innovative commercial virtual simulation products currently available, each with its own terminology, including virtual worlds, virtual patients, and screen-based computer simulations (18). However, several factors should be considered when selecting the right virtual simulation to ensure successful integration of the one that aligns with the educational program's needs. These selection criteria include specific use, cost, content, technology, and time (19).

Effectiveness of virtual simulation

The integration of theoretical and practical competencies is crucial for developing proficient professionals, including medical workers. Virtual simulation is recognized as a valuable method for fulfilling this need, offering partially immersive learning environments where students actively engage in their roles (20). In this way, students are forced to perform related tasks or deal with certain scenarios that elicit their skills, such as interpersonal skills, cultural safety, and implementation of the evidence-based medicine they have learned (21). This approach not only facilitates knowledge implementation but also enhances attention by reducing cognitive fatigue and sustaining engagement with executive functions. Moreover, interactions in virtual simulations help maintain emotional stability, thereby preventing focus failure and distractions (22).

Challenges of Online Learning

In order to determine which technology should be used to develop virtual simulation in the rational use of medicines, Internet connection must be considered as it is the most influential factor in online learning. This is also supported by studies that have demonstrated that students have experienced problems related to poor internet connectivity during online learning (17, 23). This is particularly true in developing countries such as Indonesia, which has unevenly distributed Internet access over the areas. Internet connection limitations in certain areas in Indonesia might be caused by financial limitations which prevented them from having a subscribed Wi-Fi connection as well as a lack of stability and coverage of the Internet network in remote areas and particularly in many of the eastern regions of Indonesia (24). To overcome this challenge, the technology used must be accessible even in limited infrastructural

settings. Therefore, H5P technology may be used as it does not require an Internet connection in order to work, making it possible to be used on limited Internet access settings (25).

Medical students have encountered challenges such as lack of interactivity, engagement, boredom, and reduced focus. Muthuprasad, et al. recommend class durations of 45 minutes with a 15-minute break to prevent cognitive overload and physical strain from prolonged device use (26). To address these issues, successful online learning strategies should incorporate interactive virtual simulation methods. These methods should be accompanied by accurate preparation materials and gamification features such as levelling, quests, and bosses. Feasibility aspects, including Internet requirements and technical considerations, should be thoroughly considered in the development process.

Virtual simulation and learning theories

Learning styles refer to students' preferences for learning efficiently and effectively (27). Some of the most favoured learning styles among medical students are kinaesthetic (32%), aural (26%), visual (21%), and reading (21%) (28). A previous review has proposed the use of virtual simulation to cater for these diverse learning styles (29). Virtual simulation has the potential to accommodate different learning styles as its design can be adapted to offer information in audio, visual, or written formats (30).

Some of the most widely discussed theories in the medical education literature include self-directed learning, reflection, cognitive theory of multimedia, and active engagement (27). Aligned with these theories, virtual simulations can facilitate the implementation of all these concepts within a single activity. Virtual simulations use multimedia to actively engage students, enabling them to self-direct their learning while providing opportunities for self-reflection (28, 29).

Required features, expectations and rationale

To overcome challenges regarding limited access to the Internet and technology, the technology used must be accessible even in limited infrastructure settings. H5P technology in general does not require an Internet connection in order to work, making it possible to be used in limited Internet access settings (25). Since most students use laptops to access online learning, computer-based simulation might be considered to be the most effective type of virtual simulation. It does not require any additional device to access, hence the cost can be reduced. Technological considerations are also correlated with the students' desire to engage, in terms of ease of use and usability (19). Technical issues have emerged as one of the themes of challenge that students experience during learning, although it has not emerged as a dominant theme in this study. H5P technology is simple to use both for students and educators since it does not require advanced knowledge of coding or any other technical skill (25).

Results show that medical students have also been faced with a lack of interactivity and engagement, boredom, and low focus. A study by Muthuprasad, et al. demonstrated that students prefer 45 min duration for each class with a break of 15 min between classes. This will not only avoid cognitive overload but also take care of the physical strain caused due to prolonged use of electronic gadgets (26).

As a result, we suggest a strategy that will accommodate both interactivity and focus time span issues: virtual simulation that is accompanied by accurate and appropriate preparation materials, installed with game-like features such as levelling, quest, and bosses. Many features of gamification can be implemented since it is becoming apparent that institutions are starting to develop more virtual simulation learning methods. However, a study in 2018 by Cant RP, mentioned that whilst simulation-based education improves students' clinical skills in educational setting, it proves to be inconsistent with how it translates in real clinical settings (31). Therefore, gamification features and model development should thoroughly consider the feasibility aspects mentioned above, especially Internet requirements and technical considerations.

Suggestion

Several factors must be addressed when implementing virtual simulation, including Internet connectivity, interactivity, boredom risk, accessibility, and attention span. To mitigate these challenges, H5P technology may be used to develop simulation-based learning material as it requires no Internet connection and enables synchronized discussion forums, facilitating real-time interaction and feedback from instructors. Alternatively, discussion forums on the platform can be utilized, with written feedback from instructors. Technical preparation should be aligned with the providers' capabilities and credible preparation materials should be curated for students to enhance retention. Adopting a compartmentalized approach in designing learning materials, breaking scenarios into digestible chunks with breaks can optimize attention span and minimize distractions. For further analytical research from ADDIE framework, it's advised

to come up with realistic cases formulation to be used in the developmental phase.

Limitations

The study has several limitations, including small sample sizes, institutional bias, and acquiescence bias. The sample data were obtained from a single institution, limiting the generalizability of findings to other medical institutions with different curriculum designs. Moreover, the absence of national-level data further restricts broader applicability. Acquiescence bias may also influence results, despite attempts to mitigate it by including neutral response options. These limitations underscore the need for cautious interpretation of the study's findings.

Conclusion

Despite the longstanding integration of the rational use of medicines into Indonesia's medical education curriculum through pharmacology modules, there remains a critical need for the development of an educational strategy to promote its understanding among prospective health workers, particularly medical students. Virtual simulation needs to be implemented in distance learning about the rational use of medicines to increase students' motivation, understanding and retention, promote interactivity, and improve focus. Various essential requirements have been identified for the successful implementation of virtual simulation in learning the rational use of medicines, including a user-friendly interface, captivating scenarios or storylines, thorough review and evaluation processes, interactive discussions, multiplayer capabilities, leaderboard functionality, effective gamification elements, and the incorporation of branching scenarios.

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Conflict of Interest

The authors declare no conflicts of interest.

Authors' Contribution

Conceptualization: DGBK, AK, AD, PR; methodology: DGBK, AK, AD, PR; questionnaire content and review: DGBK, AK; data analysis: DC, NJW, JFS; writing original draft preparation: DGBK, DC, NJW, JFS, PR; review and editing: DGBK, DC, NJW, JFS, PR; approval of final manuscript: all authors.

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