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RESEARCH ARTICLE

Pharmacy students' perceptions of computer-based simulation in light of the rise of online learning

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Abstract

Background: Computer-based simulation, such as "Pharmacy Simulator," teaches clinical and communication skills through virtual patients in a digital pharmacy. During the COVID-19 pandemic, students faced online learning challenges. While Australia's borders were locked for over two years, fully online teaching in Western Australia lasted only ten weeks. This study explores pharmacy students' perceptions of Pharmacy Simulator amid the rise of online learning. **Methods:** Master's pharmacy students at the University of Western Australia participated in two Pharmacy Simulator scenarios: anaphylaxis and salbutamol in 2019 and anaphylaxis and vaccination in 2021. Perceptions were assessed through qualitative interviews (2019) and a survey derived from the interviews (2021). Interviews underwent framework method analysis, while survey responses were analysed using descriptive statistics. Data triangulation aimed to detect the possible influence of growing online learning. **Results:** Data from 51 participants revealed that in 2019, Pharmacy Simulator was perceived as enjoyable, engaging, user-friendly, and bridging theory and practice. In 2021, participants affirmed its usability and role in knowledge acquisition, expressing confidence in counselling skills (median: 4 on a 5-point Likert scale). **Conclusion:** Master's students found Pharmacy Simulator helpful for acquiring pharmacy practice skills. Thus, computer-based simulation represents a valuable and universally accepted learning tool, irrespective of online learning burdens.

Introduction

Since the early 2000s, digital simulation has expanded as a novel virtual learning approach (Borelli & Wellmann, 2019). Especially in healthcare education, simulation-based teaching has evolved as a pedagogy due to the challenges of practical learning. Utilising simulation may assist with preventing putting patients at risk for error or inconveniencing them by repeatedly involving them in training scenarios (Lloyd *et al.,* 2018). Worldwide, pharmacy academics urge the need to link theoretical knowledge with practical skills to equip students for future practice in community pharmacies (Mak *et al.,* 2021). Simulated learning helps students overcome the gap between theory and practice (Mak *et al.,* 2021). Common simulation modalities include paper-, computer-, and actor-based, such as simulated patients, role play, or mannequin-based simulation (Tait *et al.,* 2018).

Pharmacy Simulator is an immersive, computer-based educational tool developed at the University of Tasmania, Australia. This virtual platform enables students to engage in computer-based encounters with digital patients, allowing them to train their clinical and communication skills in a digital community pharmacy environment through realistic pharmacy practice scenarios. It offers a valuable complementary learning experience besides traditional classroom activities (Imitated Environments Pty Ltd., 2018). The programme starts with a patient reaching the counter, and the student, acting as a pharmacist, initiates a dialogue. Several predetermined sections with questions, answers, and advice are available for the student to choose from as deemed appropriate and necessary. The selection influences the progression of the consultation as patients react to empathy or lack there of through their mimics, gestures, and specific phrases (Imitated Environments Pty Ltd., 2018). The scenarios are

standardised and can be performed repeatedly; they are accessible to students anywhere and anytime. Results are trackable, and instructors can deliver new content to all students (Imitated Environments Pty Ltd., 2018). The Pharmacy Simulator was introduced at the University of Western Australia (UWA) as a tool for formative and summative assessments in the pharmacy curriculum.

Between 2020 and 2022, the COVID-19 pandemic has changed life worldwide, including teaching. Overnight, traditional classroom activities had to be changed into online learning sessions, putting students and lecturers behind screens (Arnet *et al.,* 2020). Another strategy was followed in Australia in general and Western Australia in particular. The hermetic closure of the borders from 2020 to 2022 created a microcosm in the province with minimal physical restrictions. Full digital teaching was limited to ten weeks, and students returned to the campus in May 2020. Although restricted to a short period, the advantages of digital learning were recognised and purposively implemented in teaching (Courtney *et al.,* 2022).

This study aimed to investigate pharmacy students' perceptions of a virtual platform such as the Pharmacy Simulator in light of the rise of online learning.

Methods

Design

A qualitative study was performed among Master of Pharmacy students at UWA in 2019, followed by a quantitative study in 2021. It aimed to evaluate students' perceptions of digital simulation. In both years, students were recruited with a flyer supplied before data collection.

In both years, Pharmacy Simulator scenarios were created by a pharmacy academic with expertise in developing teaching materials. In 2019, an experienced external clinical pharmacist reviewed and pilot-tested the scenarios. Furthermore, two research students (FS and MM) reviewed the scenarios and provided feedback prior to release. In 2021, two research students (JW, TN), two research team members, pharmacy academics, and external pharmacy students established face validity by reviewing the scenarios. The pharmacy academic with expertise in developing teaching materials reviewed their correctness and comprehensiveness. The final scenarios were uploaded to the Pharmacy Simulator after content adaptation.

The scenarios included four and five sections, respectively: greeting, questions, advice, and end (2019) and greetings, advice, questions, admin, and end (2021). Examples of items in the sections are: "Hi, I'm the pharmacist on duty. How can I help you?" (greeting section); "In the past week, has your asthma limited your ability to carry out daily activities such as housework or your job?" (questions section); "Additionally, vaccination protects those around us most vulnerable to the virus as you will be unable to be a carrier for the virus" (advice section).

After receiving the vaccine shot, the patient Aidan exhibited symptoms of an anaphylactic reaction shortly thereafter. He began coughing and experienced difficulty breathing. Aidan had to lie down on the floor, requiring Jane, a co-worker, to stay with him for supervision while the pharmacist retrieved the anaphylaxis kit: "Aidan, I am going to get the anaphylaxis kit. Jane! Stay with Aidan while I get the anaphylaxis kit." (end section).

In 2021, students could add short answers, such as the correct medication dosage, in free text fields.

After completing the scenarios, students received an evaluation of their performance, including a score out of a maximum score and immediate feedback on appropriate or inappropriate choices made during the simulation. The scenarios focused on anaphylaxis and salbutamol in 2019, and anaphylaxis and vaccination in 2021.

An interview guide was developed by FS and MM for the qualitative study in 2019. It included open-ended questions seeking general thoughts about the platform, scenarios, and place of the Pharmacy Simulator in online learning. KL reviewed the guide. A pilot interview was conducted with a Master of Pharmacy student not involved in the research to test the usability of the questions. The final version of the guide contained five key questions and prompting questions (Appendix A). Demographic information included age, gender, year of master's course, and work experience in a community pharmacy. FS and MM conducted semi-structured, face-to-face interviews on the campus of UWA, each with five students per master course (i.e., year 1 or 2 of the course). The interviews were audio-recorded, and field notes were taken. Data saturation was reached after the tenth interview.

For the quantitative study in 2021, a 25-item survey (Appendix B) was derived from interviews and published literature (Bindoff *et al.,* 2014; Tait *et al.,* 2018), asking the users about their perceptions of usability, enjoyment and engagement, the realism of the environment, knowledge acquisition, and feedback helpfulness. Three research team members, two experienced pharmacists, five external pharmacy students, and an English language expert pilot-tested and reviewed the survey to verify comprehension of the questions and responses, ensure precise terminology, develop a simple structure, and avoid

potential bias and variance. After pilot testing, questions and response alternatives were aggregated, specified, and better articulated to ensure appropriate question wording. Additionally, questions that raised observations, specifications, explanations, or criticisms were revised or deleted to avoid unnecessary complexity. Finally, missing topics were integrated, and questions were tested for logic, good linking, and chronological arrangement. The survey included three main parts: an introduction, instructions, and the main body. The main body contained four sections: demographic information, clinical encounters with vaccines, anaphylaxis, and the Pharmacy Simulator. In the first section, students answered demographic questions like age, sex, year of study, and years of experience working in a pharmacy. The second section guided students to reflect on their clinical vaccine encounters, and the third section assessed post-immunisation anaphylaxis after playing the two Pharmacy Simulator scenarios. Both sections evaluated participants' perceived confidence, competence level, and knowledge acquisition of the topic on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The last section investigated Pharmacy Simulator's usability with seven descriptors. Answers were rated on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). Lastly, students could give consent for the use of the collected data for analysis purposes; this request was mentioned in the introduction section of the questionnaire. This order was selected because it might be difficult to give consent before having read the questions. Qualitative feedback was gathered with open-ended questions at the end of the survey. The online survey was created with Qualtrics (Qualtrics, n.d.). Data were collected between March and April 2019 (qualitative) and 2021 (quantitative).

Statistical analysis

Qualitative data were transcribed verbatim into electronic format with the data management assistance of MAXQDA. The framework method was used to analyse the transcripts inductively (Gale *et al.,* 2013). FS and MM conducted a thematic analysis (Castleberry & Nolen, 2018) by developing the codes and elaborating on the analysis. Quantitative data were analysed in Microsoft Excel using descriptive statistics. The open-ended questions were analysed inductively by first reviewing the responses, generating initial codes, categorising them, and grouping them into themes. Results were given as median, interquartile range (IQR), mean, standard deviation (SD), frequency, and percentage, where appropriate. All codes, categories, and themes were generated by JW and verified by TN. Adaptations were made after a consensual discussion.

Results

A total of 51 students played the scenarios with the Pharmacy Simulator. They were well distributed over both years of the master's course, with 25 (49%) in their first year (10 in 2019; 15 in 2021) and 26 (51%) in their second year (10 in 2019; 16 in 2021). Data from 20 interviews and 31 surveys were obtained and analysed (Table I).

Table I: Demographic characteristics

	2019 (N=20) n (%)	2021 (N=31) n (%)	Total (N=51) n (%)
Age in years			
20-22	16 (80)	24 (77)	40 (78)
23-25	3 (15)	3 (10)	6 (12)
25+	1 (5)	4 (13)	5 (10)
Sex			
Female	13 (65)	19 (61)	32 (63)
Male	7 (35)	12 (39)	19 (37)
Working experience in months (excluding compulsory 75 hour in community pharmacy before starting the Master of Pharmacy) *			
0-12	5 (35)	15 (48)	20 (44)
13-24	7 (30)	9 (29)	16 (36)
25-36	1 (5)	3 (10)	4 (10)
>36	1 (5)	4 (13)	5 (10)

* No data on work experience for 6 participants in 2019

Interviews

Overall, participants considered the Pharmacy Simulator an entertaining and straightforward learning tool and acknowledged the user-friendly learning atmosphere. They quickly understood how to navigate the programme. In terms of visual presentation, students commented on how realistic the set-up of the pharmacy environment and the encounter with the patients appeared.

Safe learning environment

Participants mentioned that using the Pharmacy Simulator platform gave them a safe feeling because they could make mistakes without harming an actual patient.

> *"[…] that would have been a mistake to an actual patient and even though that's not a life threatening thing, it's still a mistake you've made to an actual patient, rather than a simulated patient. So, um, I think it helps you work better in a pharmacy, […], so then an actual patient would get the best out of their care."*

Feedback section

The most helpful feature of the platform was the feedback section provided at the end of the session, as it gave a good overview of participants' performances. The feedback included rating every action, and participants liked the display of descriptive information to understand why specific actions were correct or incorrect. Several participants mentioned that learning from their mistakes helped them memorise more efficiently.

Communication skills and competencies

All participants felt that the most valuable point they learned was the communication aspect of the scenarios, as training for acquiring communication skills is scarce in the pharmacy curriculum. Generally, the participants appreciated how the questions were phrased and the fact that they knew which questions they needed to ask.

> *"[…] it is really good because your whole simulation is communication with the patient. So, prompting you to ask these questions will kind of set in your mind, how to communicate better, I feel. So, mainly just the communication."*

All participants stated overall confidence in counselling and felt more confident in supplying salbutamol and administering the Epipen® as they learned to focus on the relevant questions.

> *"I think I'm more confident [to supply Salbutamol] in the way I can ask things. […] what I would do just be like, like how often are you using it or do you use it that often? I think, I just wanna ask more open questions […]".*

Integrating the theoretical approaches from lectures

Overall, the platform was perceived to integrate the theoretical approaches from lectures into the mastery of practical skills.

> *"I feel like the simulator's a nice little bridge between. Converting it from what you've learnt from the lecture slides in class to what you have to practice in real-life."*

Therefore, all participants wished to integrate more scenarios into their pharmacy studies, mainly for self-study and exam preparation. Participants mentioned using the Pharmacy Simulator in their first master's year as it would be helpful for learning about topics and getting to know a community pharmacy setting. A few commented on having access to the Pharmacy Simulator in their second master's year to refresh their knowledge.

Impact on self-confidence

Two participants mentioned that they did not experience any changes in their confidence level regarding the supply of non-prescription salbutamol due to the scenarios' predetermined answers that limited their abilities to phrase replies. Several participants believed that the Pharmacy Simulator could only partially replace existing teaching methods as it lacks non-verbal communication.

> *"The tutor one-on-one-interaction that we have in tutorials would kind of, is more interactive to me because you have an actual person you're talking to and they're pretending to be a patient. […] on the computer you probably don't get invested emotionally and you can't practice things such as empathy in your practice."*

Surveys

Table II summarises participants' quantitative answers regarding their satisfaction, perceptions, and readiness to manage clinical vaccination encounters and post-immunisation anaphylaxis.

All 30 participants (100%) agreed with the four descriptors about managing post-immunisation anaphylaxis (median: 4 on a 5-point Likert scale, IQR: 0.8–2). Regarding the scenario about managing clinical vaccination encounters, all 31 participants (100%)

somewhat agreed with 2 statements (median: 3 on a 5-point Likert scale, IQR: 1.5–2) and agreed with 2 statements (median: 4 on a 5-point Likert scale, IQR: 1.0).

All 31 participants (100%) agreed with the seven descriptors about the Pharmacy Simulator's usability (median: 4 on a 5-point Likert scale; Table III).

Table II: Satisfaction and perception of the scenarios

Statements	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)
	1st year (N=15)		2nd year (N=16)		Total (N=31)	
I feel more confident recommending and giving advice about vaccination after using Pharmacy Simulator	4.0 (1.0)	3.6 (1.1)	4.0 (1.3)	3.8 (0.9)	4.0 (1.0)	3.7 (1.0)
I feel more confident administering vaccination after using Pharmacy Simulator	3.0 (1.5)	3.3 (1.0)	3.5 (2.0)	3.1 (1.1)	3.0 (2.0)	3.2 (1.1)
I feel more competent administering vaccination after using Pharmacy Simulator	4.0 (1.0)	3.5 (1.1)	3.0 (2.0)	3.1 (1.1)	3.0 (1.5)	3.3 (1.1)
I feel the tasks given were of importance to the vaccination process	4.0 (0.0)	3.9 (1.0)	5.0 (1.0)	4.5 (0.6)	4.0 (1.0)	4.2 (0.8)
	1st year (N=14)		2nd year (N=16)		Total (N=30)	
I feel more confident managing an anaphylactic reaction after using Pharmacy Simulator	4.0 (0.0)	3.5 (1.3)	4.0 (1.3)	3.4 (1.3)	4.0 (1.0)	3.4 (1.3)
I feel more competent managing an anaphylactic reaction after using Pharmacy Simulator	4.0 (1.0)	3.5 (1.3)	4.0 (1.0)	3.6 (1.0)	4.0 (1.0)	3.6 (1.2)
I feel using Pharmacy Simulator is a good way to learn about an anaphylactic reaction	4.0 (0.0)	3.9 (1.0)	4.0 (2.0)	4.0 (1.0)	4.0 (1.0)	4.0 (1.0)
I feel the tasks given were of importance to manage an anaphylactic reaction	4.0 (0.0)	3.9 (1.0)	4.0 (1.0)	4.0 (1.0)	4.0 (0.8)	4.0 (1.0)

Survey results regarding the satisfaction and perception of the scenarios about clinical vaccination encounters by 31 Pharmacy students and post-immunisation anaphylaxis given by 30 Pharmacy students in 2021 on a 5-point Likert scale (the higher the value, the higher the agreement to the descriptors; maximum of 5)

Table III: Pharmacy Simulator's usability

Statements	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)
	1st year (N=15)		2nd year (N=16)		Total (N=31)	
I feel Pharmacy Simulator was easy to use	4.0 (0.5)	4.0 (0.8)	3.5 (2.0)	3.3 (1.1)	4.0 (1.0)	3.6 (1.1)
I feel besides the usability of the program the scenarios had an acceptable level of difficulty	4.0 (0.0)	4.0 (0.7)	4.0 (0.3)	4.1 (0.8)	4.0 (0.0)	4.0 (0.7)
I feel Pharmacy Simulator was enjoyable to play with	4.0 (0.5)	4.1 (0.7)	4.0 (1.0)	4.2 (0.7)	4.0 (1.0)	4.2 (0.7)
I feel Pharmacy Simulator was engaging to play with	4.0 (0.5)	4.0 (1.0)	4.0 (1.3)	4.1 (0.8)	4.0 (1.0)	4.1 (0.9)
I feel Pharmacy Simulator was a helpful tool to acquire new knowledge	4.0 (1.0)	4.1 (1.1)	4.0 (1.0)	4.3 (0.6)	4.0 (1.0)	4.2 (0.8)
I feel Pharmacy Simulator's feedback was helpful	4.0 (0.0)	3.9 (1.0)	4.0 (1.3)	4.1 (1.0)	4.0 (1.0)	4.0 (0.9)
I feel Pharmacy Simulator portrayed a realistic pharmacy environment	4.0 (0.5)	3.7 (1.0)	4.0 (1.0)	3.7 (0.9)	4.0 (1.0)	3.7 (1.0)

Survey results regarding the Pharmacy Simulator's usability given by 31 Pharmacy students in 2021 on a 5-point Likert scale (the higher the value, the higher the agreement to the descriptors; maximum of 5)

Out of the 24 participants (77%) who answered the open-ended questions, 5 (21%) declared that the scenarios provided them with a structured approach to administering vaccines, and 7 (29%) stated that the platform provided a deeper understanding of the different steps involved in administering a vaccine.

> *"It taught me more about how to deliver vaccines […] through trial and error and also application of knowledge".*

Participants considered they were better prepared for future encounters because they felt more confident in recognising anaphylaxis as a primary concern after

vaccination. They gained better insight into what is anticipated in a real-life situation and how to approach it.

> *"Taught me the fundamental tip (sitting upright if conscious, laying on ground on left side if unconscious to allow open airway)".*

All 31 participants (100%) would recommend the Pharmacy Simulator as a training tool for future pharmacists. The burden of digital teaching was not mentioned as a barrier.

Improving the Pharmacy Simulator

A suggestion to improve the Pharmacy Simulator was an instruction session on navigating the space and layout and a specific introduction about the scenario's topic, such as asthma, epinephrine, anaphylaxis, and the vaccination process.

> *"A prior info session before the scene could be helpful. Giving details on how to react in anaphylaxis management could be helpful for 1st year students like us who have no previous knowledge".*

Participants mentioned having some technical issues, such as downloading the platform, login issues, or problems with the dispensing part. The robot, for example, did not move to get the medication, or the player could not select the medication manually. In the future, participants wished to receive a detailed solution to the scenarios, including the correct wording, to understand the feedback at the end. A marking guide was mentioned to help participants understand the scoring system better.

One participant found the digital experience of administering a vaccine and managing anaphylaxis hard to relate to the real-life situation. Participants would have appreciated more details, as the scenario was very text-based. It also included getting the vaccine out of the fridge, sitting down with the patient, and the physical components of the injection, such as picking the site and angle.

> *"Yeah, I would like it if during the "injection" of the vaccine rather just a click it could be like another mini game. Where we need to draw the injection to the appropriate vol[ume] in the syringe and tap and make sure no bubbles. Then move over to the arm and you have the cursor controlling the syringe and you click on where about on the arm you would inject it."*

Discussion

The overall acceptance level of the computer-based simulation was high in 2019 and 2021, as pharmacy students agreed with the use of the Pharmacy Simulator in pharmacy education. Such findings align with the literature on computer-based simulations published before the COVID-19 pandemic (Curtin *et al.,* 2011; Bindoff *et al.,* 2014; Barnett *et al.,* 2016; McDowell *et al.,* 2016; Ferrone *et al.,* 2017; Gustafsson *et al.,* 2017; Ambroziak *et al.,* 2018; Berger *et al.,* 2018; Shin *et al.,* 2018; Tai *et al.,* 2020). Students were convinced that the digital tool made it easier to apply theory to practice and did not mention any saturation of digital learning. Thus, the results support the digital transformation in pharmacy education and the maintenance of digital learning after returning to traditional, in-person teaching. Such findings coincide with the observations of others in pharmacy education. Even if teachers and students preferred a face-to-face teaching format to an online format post-COVID, they supported a blend of traditional classroom and online learning methods (Phillips *et al.,* 2016; Farahani *et al.,* 2020; Hamilton *et al.,* 2020; Morling *et al.,* 2022).

Students at UWA in 2019 and 2021 considered the Pharmacy Simulator an innovative, fun, engaging, and worthwhile learning experience. Another positive feature of the platform was the visual presentation. Students in both years perceived the Pharmacy Simulator as a realistic learning environment. However, in some aspects, students found it challenging to adapt the simulation experiences to real-life situations. For example, they needed features such as a visual demonstration of the asthma device inhaler technique (2019) or selecting the correct injection site for patients (2021). The literature is in accordance with these results and shows inconsistency regarding computer-based simulation as a realistic approach to the community pharmacy practice environment (Gustafsson *et al.,* 2017; Ambroziak *et al.,* 2018; Gharib *et al.,* 2023).

The primary teaching purpose of the scenarios was to ask the patient appropriate and most relevant questions to determine the patient's needs, identify problems that need to be addressed, and, finally, take a suitable course of action. Furthermore, students had to define the medicine's correct dosage and the administration route. These skills are taught in the first master's year before the pharmacy placement of five weeks in June and July. Interestingly, the acceptance of the digital platform was high in both the first- and second-year master's students, whether they had completed the five-week full-time placement or not. These results may indicate that digital platforms such as the Pharmacy Simulator are valued tools

independent of students' level of expertise. This strengthens the purpose of digital learning platforms to reinforce confidence in medication counselling through training. Bindoff and colleagues (2014) compared traditional paper-based teaching methods to a computer-based approach with the Pharmacy Simulator, using equivalent scenarios with third- and fourth-year bachelor students. Generally, third-year students perceived the Pharmacy Simulator as a good and fun way to learn about community pharmacy. However, fourth-year students said the Pharmacy Simulator was not an adequate method to learn about community pharmacy due to the inappropriate difficulty level. Thus, developing, editing, updating, and grading scenarios are identified as potential barriers for educators, as it is challenging to develop appropriate scenarios (Gharib *et al.,* 2023). In the studies, the scenarios were developed targeting content-wise both first- and second-year master's students equally. Therefore, students could evaluate the platform positively without interference with their competence and skill levels.

Strengths and limitations

This study had several strengths. First, two related studies at two different time points, including face-to-face interviews and a survey, were analysed. Doing this provided depth and breadth for understanding student perceptions of computer-based simulation. Second, data collection was in March and April for both years, which allows the authors to claim that participants had the same knowledge regarding pharmaceutical practices and a similar degree of expertise. Third, all Master of Pharmacy students were familiar with computer-based simulation modalities, as these teaching methods are already implemented in the pharmacy curriculum. Thus, students were not distracted by the platform's novelty or technical aspects but could concentrate on the scenario's content and aim. Consequently, the results are directly related to the teaching purpose of the simulation.

Some limitations are acknowledged. First, the sample size for the quantitative approach is small, with 31 complete data sets. Nevertheless, because the sample is highly homogeneous, the results are representative. Further, 20 interviews were performed, reaching data saturation for qualitative data. Therefore, 51 participants were deemed sufficient to draw valid results from the data. Second, data were gathered from only one academic institution, making it difficult to generalise the quantitative findings. Nevertheless, similar conditions might be present at other universities proposing digital learning. Third, participants were recruited voluntarily, and it is therefore likely that more interested and motivated students took part in the study. Thus, a recruitment bias cannot be excluded. Fourth, the effectiveness of the Pharmacy Simulator compared to traditional education was not evaluated. A systematic review of interactive digital simulations with clinical scenarios in health professions suggests mixed evidence regarding skills and knowledge improvement. Low-quality evidence showed that virtual patients are at least as effective as traditional education for knowledge outcomes and more effective in acquiring technical skills, such as skills required for basic life support. Students were generally satisfied with virtual patients, but some studies in the review pointed out some diminished confidence among users regarding learning with virtual patients (Kononowicz *et al.,* 2019).

Overall, results from this study and a narrative review of pharmacy students' perspectives on e-learning show that digital simulation methodologies have several strengths and seem to be a suitable approach to educating pharmacy students. However, some improvements, such as providing a realistic learning environment (Pires, 2023), are required to resolve its weaknesses. Digital education will be reinforced in the post-COVID era (Unicef, 2023), and therefore, further studies are needed to implement digital tools such as the Pharmacy Simulator wisely in the master's curriculum.

Conclusion

Students in 2019 and 2021 deemed the Pharmacy Simulator a valuable digital teaching tool for developing pharmacy practice skills. Despite the rise of online learning, computer-based simulation appears to be an effective and accepted learning method in pharmacy. Thus, virtual learning should continue to be a part of the learning process for pharmacy students.

Ethics approval and informed consent

In 2019, ethical approval was granted by the UWA Human Research Ethics Committee with the reference number 2019/RA/4/20/4870 and in 2021, with the reference number 2019/RA/4/20/5955. All participants had the option to either consent to their responses being used for the project, or for the data not to be used.

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Conflict of interest

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APPENDIX A: Interview guide

1. What are your thoughts on the Pharmacy Simulator platform?

a. PROMPT: Having played the scenarios in Pharmacy Simulator, how do you feel about the Pharmacy Simulator platform?

I. FOLLOW-UP: What aspects of Pharmacy Simulator did you like? Why?

II. FOLLOW-UP: What aspects of Pharmacy Simulator did you dislike? Why?

III. FOLLOW-UP: How could your experience with Pharmacy Simulator be improved?

2. What are your thoughts on the salbutamol scenarios?

a. PROMPT: Having played the two salbutamol scenarios, how do you feel about each of the scenarios?

a. FOLLOW-UP: What aspects of the scenarios did you like? Why?

b. FOLLOW-UP: What aspects of the scenarios did you dislike? Why?

c. FOLLOW-UP: What do you feel you have learnt from playing the salbutamol scenario? IF they have not learnt something, Why?

d. FOLLOW-UP: What are your thoughts on the feedback provided at the end of each scenario?

e. FOLLOW-UP: Did you look up any information while playing the salbutamol scenarios? If yes, What?

f. FOLLOW-UP: After playing the salbutamol scenarios, how do you feel about supplying salbutamol?

g. FOLLOW-UP: How confident were you in supplying salbutamol before playing the Pharmacy Simulator compared to how confident you feel now?

h. FOLLOW-UP: In what ways do you feel (more/less) confident, compared to before playing the scenarios in the Pharmacy Simulator? (IF participants comment there is a change)

i. FOLLOW-UP: In what ways do you feel that your confidence level hasn't changed? (IF participants comment there is no change) i. What do you think could be done to make you feel more confident?

j. FOLLOW-UP: Do you think the scenarios can be improved? In what ways can they be improved?

3. What are your thoughts on the EpiPen scenarios?

a. PROMPT: Having played the two EpiPen scenarios, how do you feel about the scenarios?

a. FOLLOW-UP: What aspects of the scenarios did you like? Why?

b. FOLLOW-UP: What aspects of the scenarios did you dislike? Why?

c. FOLLOW-UP: What do you feel you have learnt from playing the EpiPen scenarios? IF they have not learnt something, Why?

d. FOLLOW-UP: What were your thoughts on the feedback provided at the end of each scenario?

e. FOLLOW-UP: Did you look up any information while playing the EpiPen scenarios? If yes, What?

f. FOLLOW-UP: After playing the EpiPen scenarios, how do you feel about supplying EpiPen?

g. FOLLOW-UP: How confident were you in supplying EpiPen before playing the Pharmacy Simulator compared to how confident you feel now?

h. FOLLOW-UP: In what ways do you feel (more/less) confident, compared to before playing the scenarios in the Pharmacy Simulator? (IF participants comment there is a change)

i. FOLLOW-UP: In what ways do you feel that your confidence level hasn't changed? (IF participants comment there is no change) i. What do you think could be done to make you feel more confident?

j. FOLLOW-UP: Do you think the scenarios can be improved? In what ways can they be improved?

4. What are your thoughts on using Pharmacy Simulator as part of your studies?

a. PROMPT: How would you feel about using Pharmacy Simulator as part of your pharmacy degree?

I. FOLLOW-UP: In what way would you like Pharmacy Simulator to be used in your studies? Why? (IF participants indicate they would like to use it)

II. FOLLOW-UP: Why not? (IF participants indicate they wouldn't like it)

III. Would you like to play more scenarios? IF yes, which topics would you like to see?

What other comments do you have about the scenarios or about Pharmacy Simulator?

APPENDIX B: Survey

As discussed in the Participant Information Form for the project titled Use of a computer-based simulation game to support pharmacy students' perceived readiness to immunise:

A series of pilot studies, we are asking you to complete the following questionnaire.

The questionnaire should take 5-10 minutes to complete.

At the end of the questionnaire, you will have the option to either consent to your questionnaire responses being used for the abovementioned project, or for the data not to be used.

Please ensure you have read the full Participant Information Form before continuing with this questionnaire.

Q1 This questionnaire requires that you have already played both immunisation-related scenarios on the Pharmacy Simulator game. Have you played BOTH scenarios on the Pharmacy Simulator game?

Yes (1)

No (2)

Q2 What is your age in years?

Q3 What is your sex?

Male (1)

Female (2)

Prefer not to say (3)

Q4 Which year of the Mater of Pharmacy program are you currently in?

1st year (1)

2nd year (2)

Q5 How many years and/or months of work experience do you have in a community pharmacy as a student or paid employee? Write your answer as "X years and Y months". E.g., 1 year and 2 months; or 0 years and 6 months.

The following questions focus on the clinical encounter of vaccination. The clinical encounter entails the whole vaccination process from arriving in the pharmacy up until leaving. The interaction between pharmacist and patient is the main focus point.

Q6 Before playing the scenarios on Pharmacy Simulator, did you have prior knowledge/experience of the clinical encounter of vaccination? For example, self-experienced, third-person experienced (i.e., been present when someone received a vaccine), through learning such as in lectures (theoretical).

Yes (21)

No (22)

Q7 Before playing the two Pharmacy Simulator scenarios, did you have training regarding the clinical encounter of vaccination?

Yes (21)

No (22)

Q8 This question refers to the previous question: "Before playing these scenarios did you have training regarding the clinical encounter of vaccination?" Please briefly describe what you learned in this training.

The following questions will ask you about anaphylaxis management and your knowledge before playing the two Pharmacy Simulator scenarios. Anaphylaxis is a serious allergic or hypersensitivity reaction of the body that can be life threatening or fatal.

Q9 What experiences do you have with an anaphylactic reaction? For example, self-experienced, third-person experienced (i.e., been present when someone experienced an anaphylactic reaction), through learning such as in lectures (theoretical).

Lectures at university or another institution (theoretical) (4)

Personal experience (yourself or witness) +/- Lectures at university or another institution (theoretical) (5)

No experience (6)

Q10 As far as you can remember, when was the last time you witnessed an anaphylactic reaction (self-experienced or a patient/relative).

Within the last week (1)

Within the last month (2)

Within the last six months (3)

Within the last year (4)

More than one year (5)

Q11 Regarding the content you studied in lectures at university or another institution before playing the two Pharmacy Simulator scenarios, please describe how you would manage the process of an anaphylactic reaction? Please provide details.

Q12 In relation to your personal experience and/or lectures at university or another institution before playing the two Pharmacy Simulator scenarios; Please describe the process you used to manage the anaphylactic reaction of another person or what you did when you experienced it by yourself. Please provide details.

Q13 Before your personal experience of an anaphylactic reaction occurred, did you have any previous training to deal with the event?

Yes (1)

No (2)

The following questions will ask about your experience with regard to previous anaphylaxis management training BEFORE playing the two Pharmacy Simulator scenarios.

Q14 Please briefly describe what you learned in the training you completed regarding the event of an anaphylactic reaction BEFORE playing the two Pharmacy Simulator scenarios.

Q15 On a scale from 1 (strongly disagree) to 5 (strongly agree), please rate to what extent do you agree with the following statement regarding previous anaphylactic reaction training BEFORE playing the two Pharmacy Simulator scenarios.

The previous training helped me to manage the anaphylactic reaction. (1)

Q16 Please elaborate why you chose (answer to Q15) in the previous question.

In this section, the focus is on general information and preferences on Pharmacy Simulator. Answers are solely based on your preferences regarding Pharmacy Simulator and the impact it had.

Q17 On a scale from 1 (strongly disagree) to 5 (strongly agree), please rate to what extent do you agree with the following statements regarding Pharmacy Simulator.

1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree

I feel Pharmacy Simulator was easy to use. (1)

I feel besides the usability of the program the scenarios had an acceptable level of difficulty. (2)

I feel Pharmacy Simulator was enjoyable to play with. (3)

I feel Pharmacy Simulator was engaging to play with. (4)

I feel Pharmacy Simulator was a helpful tool to acquire new knowledge. (5)

I feel Pharmacy Simulator's feedback was helpful. (6)

I feel Pharmacy Simulator portrayed a realistic pharmacy environment. (7)

Q18 On a scale from 1 (strongly disagree) to 5 (strongly agree), please rate to what extent do you agree with the following statements regarding clinical encounter.

1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree

I feel more confident recommending and giving advice about vaccination after using Pharmacy Simulator. (1)

I feel more confident administering vaccination after using Pharmacy Simulator. (2)

I feel more competent administering vaccination after using Pharmacy Simulator. (3)

I feel the tasks given were of importance to the vaccination process. (4)

Q19 How did Pharmacy Simulator impact your delivery of vaccines?

Q20 Are there any additions to the Pharmacy Simulator that would have enhanced your learning experience regarding the clinical encounter of immunisation? Explain your response.

Q21 On a scale from 1 (strongly disagree) to 5 (strongly agree), please rate to what extent do you agree with the following statements regarding anaphylaxis management.

1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree

I feel more confident managing an anaphylactic reaction after using Pharmacy Simulator. (1)

I feel more competent managing an anaphylactic reaction after using Pharmacy Simulator. (2)

I feel using Pharmacy Simulator is a good way to learn about an anaphylactic reaction. (3)

I feel the tasks given were of importance to manage an anaphylactic reaction. (4)

Q22 How did Pharmacy Simulator impact your management of anaphylaxis?

Q23 Are there any additions to the Pharmacy Simulator that would have enhanced your learning experience regarding anaphylaxis management? Explain your response.

Q24 Would you recommend Pharmacy Simulator as a training tool for future pharmacists?

Yes (1)

No (2)

Q25 Thank you for taking the time to complete this questionnaire.

As a final question, please indicate whether you consent to your responses to be used for the purpose of this research project (i.e., the project titled Use of a computer-based simulation game to support pharmacy students' perceived readiness to immunise: A series of pilot studies).

Yes, I consent to my responses from this questionnaire to be used for the abovementioned research project. (1)

No, I do NOT consent to my responses from this questionnaire to be used for the abovementioned research project. (2)