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Research Article

The Assessment of Students' Perception Regarding the Learning Experience in the Virtual Pharmacology Laboratory

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Abstract

Objective: The current study was conducted to evaluate students' feedback on the virtual pharmacology classes among the second-year students in Faculty of Medicine, Northern Border University, Saudi Arabia.

Materials and Methods: The study was conducted through distribution of a structured self-administered questionnaire of three sections covering satisfaction of participants regarding the virtual pharmacology classes, their effect on students' performance, and the attitude of students toward the virtual classes.

Results: A total of 152 responses were enrolled in the study. The number of female and male participants were 78 (51.3%) and 74 (48.7%), respectively. The overall answers of the respondents were satisfactory for the different sections with an overall average score of 3.4 (ranging from 3.3 to 3.47). Paired t-test revealed a statistically significant difference between male and female responses ($p<0.0001$). Male participants showed higher levels of satisfaction in all questions with an average response of 3.7 while the female participants showed an average satisfaction level of 3.1.

Male participants were significantly more satisfied about convenience aspect of the practical classes ($p=0.0052$) with clearer results ($p=0.0094$), time saving ($p=0.045$), and better class organization ($p=0.033$). Also, male participants reported significantly higher satisfaction levels regarding the effect of virtual classes on their topic understanding ($p=0.025$), exam grades ($p=0.0007$), and improvement of thinking abilities ($p=0.0058$). Also, both questions of attitude showed that male participants significantly had a better attitude toward virtual classes.

Conclusion: The current data revealed satisfactory levels of satisfaction among students attending virtual pharmacology classes with their belief that these classes improved achievement of learning outcomes and a positive attitude toward having more virtual classes.

Keywords: learning process, pharmacology, virtual laboratory, medical students, student centered learning

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1. Introduction

The concept of implementing student-centered, constructivist educational approaches is generally acknowledged worldwide. This is because traditional, teacher-centered methods have not provided enough opportunity for students to create their own learning. Only student-centered educational approaches can effectively unleash students' unique potential, intelligence, and creative thinking [1].

While the idea of "learning by doing" is not new, letting students apply it in a classroom setting provides an alternative to more conventional teaching strategies [2]. In this regard, laboratories play a crucial role in the educational process by allowing students to gain experience [3]. Pharmacology is an applied medical science, and laboratory practical teaching plays a crucial role. Students take an active role in their education by seeing, observing, and doing in pharmacology labs. These applications result in improved and long-lasting learning [4]. Numerous scientists who study scientific education acknowledged that lab work boosts students' enthusiasm and aptitude for the taught courses [5].

While laboratory application plays a significant role in science education, it is not without limitations and issues [6]. These include concerns about the use of experimental animals in practical teaching, which is vital for medical students studying the pharmacological actions of medications. Sometimes teachers are forced to conduct laboratory activities in crowded groups, or they can undertake demonstrational activities instead of practical ones because of equipment limitations, time constraints for the topic, or inadequate laboratory circumstances. This application is opposed to the underlying constructivist theory of laboratory technique which accepts that knowledge can be learned by human experience and observation [5]. Finding suitable alternatives becomes inevitable when taking these limits into account. Using educational technologies, particularly computers to complement laboratory methods, can be a sensible solution among these [7].

The educational process has been transformed in many ways with the application of digital technology. The effective integration of digital technology into teaching methods has revealed beneficial effects. Learning has been made more interactive with digitalization in the teaching process [8] . Digitalization in education has made it easier for learners to access the wealth of knowledge from digital libraries. In addition, the learner can have personalized learning experiences as it can be tailored to the students' pace and requirements [7].

The practical sessions and hands-on training are key components of psychomotor learning and these facilitate the comprehension of complex concepts of the intended learning outcomes. The experiences gained in the laboratory are a vital component of scientific education [9, 10]. For the better understating of the practical sessions, the virtual simulation-based learning could be a good option, as it revealed to be a valuable tool in facilitating the learning process [11]. The virtual laboratories could be a good choice, particularly in terms of safety, cost-effectiveness, and space. The academic performance of the students who were trained on computer-based simulations was better than those who were not [12].

For medical students to achieve higher academic performance, it would be beneficial to use digital technology in medical education. The evaluation of the digital teaching techniques, the students' feedback would be necessary as it could help the teachers to further improve the process of learning. In the present study, practical experiments conducted in the virtual pharmacology laboratory would be evaluated in the light of students' feedback regarding their impact on the learning environment and learning process, and the impact of the virtual laboratory on their performance.

2. Materials and Methods

The current study was conducted via a structured questionnaire, followed by modifications [11]. The questionnaire was composed of 14 questions which covered three areas. The first section was composed of eight questions and it covered the students' feedback regarding the pharmacology virtual laboratory classes. The second section was composed of four questions covering the effect of the virtual classes on the students' performance in the course. The third section was composed of two questions to evaluate the students' attitude toward virtual laboratory classes. Responses were prepared based on the 5-point Likers scale, which included five responses as follows: strongly agree (scored as 5), agree (scored as 4), neutral (scored as 3), Disagree (scored as 2), and strongly disagree (scored as 1). The questionnaire was validated via distribution to 15 students to be sure regarding clarity of the questions to be self-administered. Data about responses to the validation sample were not included in the final data analysis. The questionnaire was distributed among the second-year students in May 2024. All students from both the male and female sections from the Faculty of Medicine, Northern Border University who have completed the pharmacology course in the academic year 2023-2024 were enrolled in the study. Students from different class years and programs were excluded in the final data analysis.

2.1. Sample Size

OpenEpic sample size calculator was used to estimate the minimum required sample size of participants for robust data. As the total numbers registered for pharmacology course was 204, a total of 134 medical students from both the male and female sections was considered a statistically representative sufficient sample. The sample size has been calculated based on confidence level of 95%, margin of error 5%, and the number of medical students who have completed the pharmacology course.

2.2. Ethical Considerations

Ethical approval to conduct the study was obtained from the local bioethics committee of Northern Border University, Arar, Saudi Arabia (Decision number 99/24/H in 6/9/2024). The questionnaire proceeded with

a brief explanation of its purpose and aims, as well as a reminder that participation is completely voluntary. All responses were kept secure and confidential through all phases of the research project.

2.3. Statistical Analysis

The data were analyzed using the Statistical Package for Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY). Response data were collected and examined for internal consistency using Cronbach Alpha. The responses were then studied by column statistics for frequency distribution, means of responses, standard deviation, standard errors, and 95% confidence intervals for both means' higher and lower levels. Chi-square test was used to study contingency tables of male and female participants' data. Significance was considered with $p<0.05$.

3. Results

A total of 152 responses were received with a 74.5% response rate. The number of female and male participants were 78 (51.3%) and 74 (48.7%), respectively. The responses' consistency for the entire questionnaire was assessed by Cronbach Alpha with an estimated value of 0.92 with satisfactory good level of data validity. As shown in Table **1**, the overall answers of the respondents were satisfactory for the different sections with an overall average score of 3.4 (ranging from 3.3 to 3.47).

Table 1: Summary of the participants' responses to the questionnaire questions.

Question	Mean	Std. Dev.	Std. Error	Lower 95% CI	Upper 95% CI
Section (1): Feedback regrading virtual classes					
The software of the virtual pharmacology laboratory is easy to use	3.39	1.37	0.11	3.17	3.61
It is very convenient to perform practical in the virtual pharmacology laboratory	3.34	1.34	0.11	3.12	3.55
The performance of practical in the virtual pharmacology laboratory is less stressful as compared to traditional laboratories	3.30	1.43	0.12	3.07	3.53
The simulated practical yield clear results / findings of the medicines that are used in the practical	3.39	1.32	0.11	3.18	3.61
There is less waste of time in the performing of the practical in virtual lab.	3.38	1.34	0.11	3.16	3.59
The software application of virtual pharmacology laboratory is excellent for the repeated practice of practical	3.47	1.29	0.10	3.27	3.68
The scientific content of the practical of virtual pharmacology laboratory is sufficient to cover the learning outcomes	3.43	1.32	0.11	3.22	3.64
The practical of pharmacology in the virtual lab are well organized	3.43	1.32	0.11	3.22	3.64

Table 1: Continued.

Question	Mean	Std. Dev.	Std. Error	Lower 95% CI	Upper 95% CI
Section (2): The effect of virtual classes on the students' performance					
The software application of virtual pharmacology laboratory is useful in understanding the topics of subject	3.38	1.33	0.11	3.16	3.59
The virtual lab makes the classroom more interesting for the learning purpose	3.41	1.32	0.11	3.20	3.63
This learning resource helped me in obtaining better exam grades	3.30	1.29	0.10	3.09	3.50
The use of virtual lab has improved my scientific thinking ability	3.36	1.35	0.11	3.14	3.57
Section (3): Participants attitude toward the virtual classes					
I would prefer this teaching strategy over the traditional one	3.39	1.31	0.11	3.18	3.60
I would prefer to have such virtual labs in the other subjects	3.38	1.37	0.11	3.16	3.60

Data were further analyzed by comparison between the male and female sections by paired t-test. There was a significant difference between male and female responses ($p<0.0001$). Male participants showed higher levels of satisfaction in all questions with an average response of 3.7 while the female participants showed an average satisfaction level of 3.1 (Table **2**).

Table 2: Differences in response to the questionnaire based on gender.

Question	Gender	Mean	Std. Dev.	Std. Error	Lower 95% CI	Upper 95% CI
Section (1): Feedback regrading virtual classes						
The software of the virtual pharmacology laboratory is easy to use	Female	3.14	1.36	0.15	2.84	3.45
	Male	3.66	1.35	0.16	3.35	3.97
It is very convenient to perform practical in the virtual pharmacology laboratory	Female	2.97	1.30	0.15	2.68	3.27
	Male	3.72	1.28	0.15	3.42	4.01
The performance of practical in the virtual pharmacology laboratory is less stressful as compared to traditional laboratories	Female	3.01	1.45	0.16	2.68	3.34
	Male	3.59	1.35	0.16	3.28	3.91
The simulated practical yield clear results / findings of the medicines that are used in the practical	Female	3.08	1.30	0.15	2.78	3.37
	Male	3.73	1.26	0.15	3.44	4.02
There is less waste of time in the performing of the practical in virtual lab.	Female	3.10	1.32	0.15	2.80	3.40
	Male	3.66	1.31	0.15	3.36	3.96
The software application of virtual pharmacology laboratory is excellent for the repeated practice of practical	Female	3.21	1.33	0.15	2.90	3.51
	Male	3.76	1.19	0.14	3.48	4.03
The scientific content of the practical of virtual pharmacology laboratory is sufficient to cover the learning outcomes	Female	3.18	1.31	0.15	2.88	3.47
	Male	3.69	1.28	0.15	3.39	3.99
The practical of pharmacology in the virtual lab are well organized	Female	3.10	1.34	0.15	2.80	3.41
	Male	3.77	1.21	0.14	3.49	4.05

Table 2: Continued.

Question	Gender	Mean	Std. Dev.	Std. Error	Lower 95% CI	Upper 95% CI
Section (2): The effect of virtual classes on the students' performance						
The software application of virtual pharmacology laboratory is useful in understanding the topics of subject	Female	3.13	1.34	0.15	2.83	3.43
	Male	3.64	1.27	0.15	3.34	3.93
The virtual lab makes the classroom more interesting for the learning purpose	Female	3.14	1.37	0.16	2.83	3.45
	Male	3.70	1.20	0.14	3.42	3.98
This learning resource helped me in obtaining better exam grades	Female	2.87	1.22	0.14	2.60	3.15
	Male	3.74	1.21	0.14	3.46	4.02
The use of virtual lab has improved my scientific thinking ability	Female	2.99	1.32	0.15	2.69	3.29
	Male	3.74	1.27	0.15	3.45	4.04
Section (3): Participants attitude toward the virtual classes						
I would prefer this teaching strategy over the traditional one	Female	2.99	1.27	0.14	2.70	3.27
	Male	3.81	1.21	0.14	3.53	4.09
I would prefer to have such virtual labs in the other subjects	Female	2.96	1.30	0.15	2.67	3.26
	Male	3.82	1.30	0.15	3.52	4.12

For further data analysis, frequency distribution statistics were conducted, and responses were compared between male and female responses. Data revealed that gender significantly affected the outcome. Male participants were significantly more satisfied with the convenience of virtual classes (p=0.0052) with clearer results and findings (p=0.0094), improved time management (p=0.045), and better classes organization (p=0.033). Also, male participants reported significantly higher satisfactory levels regaining the effect of virtual classes on their performance in the areas of better topic understanding (p=0.025), improved grades (p=0.0007), and improved scientific thinking abilities (p=0.0058). Also, both questions regarding attitude showed that male participants had a significantly better attitude toward virtual classes (Table **3**).

Table 3: The effect of gender on participants' responses.

Question	Gender	Response										Chi square
		Strongly disagree		Disagree		Neutral		Agree		Strongly agree		
		n	%	n	%	n	%	n	%	n	%	
Section (1): Feedback regrading virtual classes												
The software of the virtual pharmacology laboratory is easy to use	Female	15	19.2	6	7.7	25	32.1	17	21.8	15	19.2	P=0.1496 X^2=6.752, 4
	Male	9	12.2	4	5.4	17	23.0	17	23.0	27	36.5	
It is very convenient to perform practical in the virtual pharmacology laboratory	Female	17	21.8	7	9.0	23	29.5	23	29.5	8	10.3	P=0.0052** X^2=14.78, 4
	Male	8	10.8	3	4.1	16	21.6	22	29.7	25	33.8	

Table 3: Continued.

Question	Response											
	Gender	Strongly disagree		Disagree		Neutral		Agree		Strongly agree		Chi square
		n	%	n	%	n	%	n	%	n	%	
The performance of practical in the virtual pharmacology laboratory is less stressful as compared to traditional laboratories	Female	21	26.9	3	3.8	23	29.5	16	20.5	15	19.2	*P*=0.2479 X^2=5.408, 4
	Male	9	12.2	4	5.4	22	29.7	12	16.2	27	36.5	
The simulated practical yield clear results / findings of the medicines that are used in the practical	Female	15	19.2	8	10.3	20	25.6	26	33.3	9	11.5	*P*=0.0094** X^2=13.43, 4
	Male	7	9.5	4	5.4	17	23.0	20	27.0	26	35.1	
There is less waste of time in the performing the practical in virtual lab.	Female	13	16.7	11	14.1	23	29.5	17	21.8	14	17.9	*P*=0.0452* X^2=9.729, 4
	Male	9	12.2	3	4.1	16	21.6	22	29.7	24	32.4	
The software application of virtual pharmacology laboratory is excellent for the repeated practice of practical	Female	13	16.7	8	10.3	22	28.2	20	25.6	15	19.2	*P*=0.1145 X^2=7.438, 4
	Male	6	8.1	3	4.1	18	24.3	23	31.1	24	32.4	
The scientific content of the practical of virtual pharmacology laboratory is sufficient to cover the learning outcomes	Female	14	17.9	5	6.4	25	32.1	21	26.9	13	16.7	*P*=0.1113 X^2=7.509, 4
	Male	8	10.8	4	5.4	15	20.3	23	31.1	24	32.4	
The practical of pharmacology in the virtual lab are well organized	Female	14	17.9	11	14.1	19	24.4	21	26.9	13	16.7	*P*=0.0327* X^2=10.51, 4
	Male	6	8.1	4	5.4	16	21.6	23	31.1	25	33.8	
Section (2): The effect of virtual classes on the students' performance												
The software application of virtual pharmacology laboratory is useful in understanding the topics of subject	Female	14	17.9	10	12.8	19	24.4	22	28.2	13	16.7	*P*=0.0248* X^2=11.16, 4
	Male	8	10.8	2	2.7	23	31.1	17	23.0	24	32.4	
The virtual lab makes the classroom more interesting for the learning purpose	Female	14	17.9	10	12.8	21	26.9	17	21.8	16	20.5	*P*=0.1106 X^2=7.525, 4
	Male	5	6.8	7	9.5	16	21.6	23	31.1	23	31.1	
This learning resource helped me in obtaining better exam grades	Female	16	20.5	7	9.0	34	43.6	13	16.7	8	10.3	*P*=0.0007*** X^2=19.42, 4
	Male	6	8.1	2	2.7	23	31.1	17	23.0	26	35.1	
The use of virtual lab has improved my scientific thinking ability	Female	16	20.5	9	11.5	24	30.8	18	23.1	11	14.1	*P*=0.0058** X^2=14.50, 4
	Male	8	10.8	3	4.1	14	18.9	24	32.4	25	33.8	
Section (3): Participants attitude toward the virtual classes												
I would prefer this teaching strategy over the traditional one	Female	15	19.2	9	11.5	25	32.1	20	25.6	9	11.5	*P*=0.0009*** X^2=18.64, 4
	Male	6	8.1	2	2.7	20	27.0	18	24.3	28	37.8	
I would prefer to have such virtual labs in the other subjects	Female	16	20.5	8	10.3	28	35.9	15	19.2	11	14.1	*P*=0.0007*** X^2=19.38, 4
	Male	8	10.8	2	2.7	15	20.3	19	25.7	30	40.5	

4. Discussion

This study explored how Northern Border University medical students felt about virtual pharmacology practical classes (using Ex-Pharm online service). Our findings add to the growing body of research on this topic and offer valuable insight into student satisfaction.

Interestingly, our study found a gender gap in satisfaction. Male students reported being happier with various aspects of virtual pharmacology compared to females. These findings are similar to those in Serrano-Perez JJ et al., which states that in the level of satisfaction the difference between males and females was statistically significant (not displayed in the figures), where it is higher in female students enrolled in dentistry concerning Traditional Learning (TL), i.e. satisfaction with TL in females versus satisfaction with TL in males (Females: 3.87 $\pm$ 0.80; Males: 3.58 $\pm$ 0.86; Dentistry: t = −2.027, d.f. = 127, $p < .05$) [13]. It is also similar to a study that found female students' satisfaction are significantly lower than male students [11]. Also, the current findings agree with another study from Tanzania which revealed that female students performed better in a traditional chemistry class than the virtual laboratories in comparison to male students [14, 15].

Previous research has shown that virtual labs can improve understanding and practical skills in pharmacology [14, 16]. Our study supports this result, with students finding the virtual labs in their pharmacology classes easy to use, convenient, and providing clearer results.

The students, if provided with the software, can study at their own pace and practice as many times as he/she desires aligned with the result of Kamath [17]. These findings can be abstracted easily from our study which supports the same trends.

The most crucial advantages of using virtual learning style in the practical is that less biological variations are observed, results are reproducible, many students can perform the experiment at the same time, and cost of animal procurement is reduced similar to result of Santhanalakshmi P et al. [18].

4.1. Study Limitations and Future Research Direction

While our study offers valuable insight, it has its limitations. The findings might not apply everywhere because the study was conducted at a specific university (Northern Border University). Future research, as suggested by Tikoo and Gupta, could explore the effectiveness of virtual pharmacology education in different settings and with different student populations [19]. The observed gender gap emphasizes the importance of considering diverse student perspectives when designing and delivering virtual pharmacology education. Future research, as suggested by Al-Dahir et al., could explore ways to address these disparities and create a more inclusive virtual learning environment [20].

5. Conclusion

This study contributes to our understanding of virtual pharmacology education by highlighting student satisfaction and gender differences in perception. By considering previous research, we offer valuable suggestions for future research and practice in this field. Ultimately, the goal is to improve student learning and engagement in virtual pharmacology classes.

Acknowledgment

None.

Statement of Ethics

As the study involved human participants, it was planned, conducted, and reported in accordance with the World Medical Association (WMA) Declaration of Helsinki.

Conflict of Interest

All authors confirm that there is no conflict of interest.

Ethical Approval

Ethical approval to conduct the study was obtained from the local bioethics committee of Northern Border University, Arar, Saudi Arabia (Decision number 99/24/H in 6/9/2024).

Informed Consent Statement

Written informed consent was obtained from all participants to participate in the study.

Artificial Intelligence (AI) Disclosure Statement

AI-unassisted work.

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Author Contribution

All authors contributed to the idea conception and final draft approval. Bandar T. Alenezi, Elhassan Hussein Eltom, and Samah Gaafar Alshygi contributed to the questionnaire preparation, validation, methodology, and data collection. Rahma Hamayun contributed to statistical analysis and results tabulation. Muhammad Jan Syed Sajid Shah contributed to data interpretation and initial draft preparation. Ekramy Elmorsy contributed to the final draft preparation, deep data interpretation, communication with the journal during the manuscript submission, peer-review, and publication process.

Data Sharing Statement

All data sets are included in this published article.

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