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Undergraduate Pharmacy student's perspectives and attitudes toward the online teaching of analytical chemistry courses: A cross-sectional study

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ABSTRACT

Background: Online learning has become a valuable tool that when properly implemented, shows beneficial results compared with in-class teaching. However, several factors impact its beneficial effects, such as students' acceptance, knowledge, and perception, and thus should be studied. This study aimed to assess students' attitudes toward online analytical chemistry learning; to identify the challenges that they face during their online learning; and to assess their academic and attendance performances and compare them with their face-to-face performance.

Methods: By using Google Forms, a cross-sectional survey was conducted to collect information from undergraduate pharmacy students who studied online analytical chemistry courses.

Results: The survey indicated that the students had good knowledge about online resources. The data showed that the students had satisfactory feelings toward online teaching and gained good knowledge. However, the data revealed that the students faced challenges, especially with the practical sessions of the analytical chemistry courses. The results showed a statistically significant difference in academic performance between the first and second terms and between the online and in-class sessions ($P < 0.0001$ for all).

Conclusion: A high percentage of the participants reported that they had good knowledge of e-learning tools and were satisfied with online learning. However, challenges such as Lack of training on the instrumental and experimental aspects of the laboratory and the lack of social interaction should be considered to improve the overall online learning process.

Keywords: distance learning, pharmacy, mobile learning, analytical chemistry.

INTRODUCTION

Analytical chemistry is a required subject for undergraduate pharmacy students at Umm-Al-Qura University (UQU). The subject is given 6 credits, which is divided into 3 credit units for each course. At the Faculty of Pharmacy, UQU, analytical chemistry courses are offered to third-year students. Analytical Chemistry I is provided in the first term, with 3 credit units, and Analytical Chemistry II is provided in the second term, also with 3 credit units. The objective of the two courses is focused on advancing students' knowledge of the principles and analytical techniques used in analytical chemistry; validation methods; the application of mathematical tools to calculate concentration; the descriptions of the basic principles of separation, identification, and sample extraction; critical thinking and analysis skills to solve complex spectroscopic problems; and quality control management and its application in the analytical

laboratory in the pharmaceutical industry. Knowledge of various subjects from other courses such as organic chemistry and pharmaceutics is also essential for learning analytical chemistry. The 6 credits given to lectures in the two courses are divided into 8 parts: part I, the principle of analytical chemistry and classification of the analytical method; part II, quality control and method validation; part III, basic calculations in analytical chemistry; part IV, titrimetric analysis; part V, physiochemical properties of drug molecules; part VI, spectroscopy (atomic absorption, infrared, nuclear magnetic resonance, and mass spectrum); part VII, chromatography; and part VIII, bioanalysis and extraction techniques. The major teaching approach used in analytical chemistry courses is face-to-face teaching using in-class active learning activities that provide direct feedback and enhance students' engagement in the frequent practice of critical thinking and problem-solving skills.[1,2,3] However, online learning has become important worldwide, as it provides a more flexible learning environment and inspires students to take on more responsibility for their attainment of knowledge.[4,5,6] A well-designed online learning course can significantly impact students' satisfaction, motivation, and learning. [7,8]

The educational system is an important sector that Saudi Arabia intends to improve through investment and transformation through the Saudi Vision 2030.[4,9] Approximately 36 and 31 governmental and private higher education systems, respectively, were available for students to enroll in.[10] As part of this transformation, Saudi Arabia is trying to implement more online learning programs and platforms, so UQU has implemented the Blackboard learning platform. Digital learning is a teaching strategy delivered through the web using online tools such as videos, discussion boards, and platforms for learning.[11,12] At the Faculty of Pharmacy of UQU, online teaching was not applied for analytical chemistry courses until the onset of the COVID-19 pandemic. At that time, all educational institutions were closed, and in-class teaching was shifted to online education.[13,14] Fortunately, UQU was among the academic institutions that had previously applied groundbreaking e-learning programs that could help during emergencies.[15]

Online learning allows for more flexible solutions for busy universities and for students to be more independent and disciplined to finish their courses and gain skills.[8,16] When intended correctly, online education has been demonstrated to be equally or more effective than in-class learning.[17,18] Many studies have shown that when traditional learning was shifted to e-learning, students achieved higher exam scores.[3] However, when e-learning replaced traditional learning, unique challenges and learning experiences emerged. However, online teaching is a suitable learning method in certain circumstances such as pandemics and natural crises. The COVID-19 pandemic forced universities to shift to e-learning, which allowed for evaluating students' perspectives of distance learning and the identification of future approaches to online teaching.

This study was conducted at the College of Pharmacy of UQU. To identify the factors that influenced the use and acceptance of online learning, third-year pharmacy students who had completed online learning of analytical chemistry during the pandemic were targeted. The study aimed to assess students' perception and acceptance of online learning of analytical chemistry courses and to analyze the challenges that students face during their online learning journey. Four main areas were evaluated in the study: first, the students' attitudes and feelings toward online education; second, the challenges that the students faced during the online transition; third, the student's academic and attendance performances during their online learning; and fourth, the students' online performances compared with their in-class performances. Therefore, this study may help organizations conduct future research to improve information delivery to students and to help implement the most appropriate online technology platforms.

MATERIALS AND METHODS

Study design

A cross-sectional online survey was conducted from September 4, 2022, to January 8, 2023. The target population was male and female undergraduate third-year pharmacy students (N = 145) who had experienced online learning of analytical chemistry during the COVID-19 pandemic (2019–2020) at the College of Pharmacy of UQU in Makkah, Saudi Arabia. We excluded all other undergraduate students in the first, second, fourth, fifth, and sixth years, as analytical chemistry courses were given to third-year pharmacy students. We contacted the participants via WhatsApp, as it was the most common communication method used by the students.

Ethical approval was obtained from the Biomedical Research Ethics Committee of UQU (identification number: HAPO-02-K-012-2023-01-1366). The study participants provided consent to participate in the study and received an electronic link to the survey on Google Forms, along with a cover letter stating the study title and objectives, participants' rights, length of the survey, confidentiality of the data, and the primary investigator's name. Participation was voluntary, and the questionnaires were anonymous. An electronic link to the survey was sent to the leaders (both men and women), who then sent messages to the students to participate.

Questionnaire development

The survey consisted of six items that focused on the following domains: (1) three demographic questions (age, gender, and marital status); (2) six questions on the respondent's knowledge of e-learning tools; (3) six questions on the benefits that the student gained from online tools; (4) seven questions on the student's attitude and feelings toward e-learning; (5) challenges that the student faced during e-learning; and (6) questions on academic performance (first- and second-semester scores and attendance in addition to the comparison with the in-class results).

Validity and reliability of the instrument

The survey items were selected based on a literature review and interviews with pharmacy students. The validity and reliability of the questionnaire were assessed by five experts in the field of pharmacy education. The instrument was then piloted among 20 randomly selected students at UQU. As no changes were made to the questionnaire, 20 piloted responses were included in the analysis database.

Statistical analysis

The collected data were downloaded, entered, and analyzed using Microsoft Excel. Demographic and background information were described in percentages. The students' responses on their understanding, benefits, and attitudes toward e-learning were measured using a 5-point Likert scale ranging from strongly agree (1) to strongly disagree (5). The distribution of the scale scores, the challenges that the students faced during e-learning, and the student's academic performances at the end of each semester were presented as percentages. The students' scores were translated to grades as follows: 90–100%, a grade of A; 80–89%, a grade of B; 70–79%, a grade of C; 60–69%, a grade of D; and 0–59%, a grade of F. Attendance was measured as the number of classes attended by the participants in each semester and represented as a percentage. The unpaired *t-test* in GraphPad Prism 10 was used to compare the student's academic performances between the first and second terms and between the online and face-to-face examinations. A P value of <0.05 was considered statistically significant.

RESULTS

Demographic data

A total of 103 students participated in the study, most of whom were female (approximately 73%). Their mean age was 22 years. Of the participants, 5% were married and 95% were single (Table 1).

Table 1: Demographic data (characteristics) of the respondents (N = 103)

Characteristic	Total	Number of Respondents n (%)
Gender Male Female	 69 80	 28 (27) 75 (73)
Age (mean, SD)	-	22.2 ± 0.5035
Marital status Married Single	 -	 5 (5) 98 (95)

SD: standard deviation

Respondent's knowledge of e-learning tools

Table 2 shows the percentages of the respondents' knowledge about e-learning tools as assessed on the Likert scale. Almost all participants responded that they were aware of the tools used for e-learning, such as mobile electronic devices, links, videos, audio recordings, and discussion boards. Approximately 85% of the respondents either strongly agreed (49.5%) or agreed (35%) that they had adequate knowledge about e-learning and e-learning tools such as Blackboard. However, approximately 64% of the respondents were not aware of the online assessment of their knowledge using computer-based testing.

Table 2: Respondents' knowledge of e-learning tools

Questions	Response n (%)				
	SA	A	N	D	SD
You know that mobile learning allows students to use mobile electronic devices to access online content.	77 (74.8)	23 (22.3)	3 (2.9)	0 (0)	0 (0)
You know that links allow students to access other resources, videos, audio recordings, course notes, and presentations.	76 (73.8)	22 (21.4)	5 (4.9)	0 (0)	0 (0)
You know that discussion boards (Blackboard) allow participants to communicate and learn.	59 (57.3)	23 (22.3)	15(14.6)	4 (3.9)	2 (1.9)
You have adequate knowledge about e-learning and how to access an e-learning system such as Blackboard.	51 (49.5)	36 (35)	14 (3.6)	2 (1.9)	0 (0)
You know that videos of analytical chemistry laboratory experiments are available.	58 (56.3)	23 (22.3)	14 (13.5)	6 (5.8)	2 (1.9)
You know that you can assess your knowledge via computer-based testing.	15 (14.5)	17 (16.5)	5 (4.8)	53 (51.4)	13 (12.6)

SA: strongly agree; A: agree; N: neutral; D: disagree; SD: strongly disagree; n: number of respondents; (%): percentage of respondents

Benefits the respondents gained from e-learning tools

Table 3 shows the percentages of the benefits the students gained from online learning as assessed on the Likert scale**.** Most responses showed that the students strongly agreed they gained good knowledge from online classes, discussion boards, and electronic resources (74.8%, 73.8%, and 72.8%, respectively).

More than half (57.3%) of the students strongly agreed that they gained excellent knowledge from the links. By contrast, more than half of the students strongly disagreed that they had gained knowledge from the videos of laboratory experiments. However, 33% and 23% of the students strongly agreed and agreed, respectively, that they gained excellent knowledge from e-assessment.

Table 3: Benefits the respondents gained from e-learning tools

Questions	Response n (%)				
	SA	A	N	D	SD
You gained excellent knowledge from online classes.	77 (74.8)	23 (22.3)	3 (2.9)	0 (0)	0 (0)
You gained excellent knowledge from discussion boards.	76 (73.8)	22 (21.4)	5 (4.9)	0 (0)	0 (0)
You gained excellent knowledge from the provided links.	59 (57.3)	23 (22.3)	15(14.6)	4 (3.9)	2 (1.9)
You gained excellent knowledge from videos of the practical part of the course.	10 (9.7)	11 (10.6)	2 (1.9)	59(57.3)	21(20.3)
You gained excellent knowledge from the e-assessment.	34 (33)	24 (23.3)	20 (19.4)	19(18.4)	6 (5.8)
You gained excellent knowledge from electronic resources.	75 (72.8)	16 (15.5)	10 (9.7)	2(1.9)	0 (0)

SA: strongly agree; A: agree; N: neutral; D: disagree; SD: strongly disagree; n: number of respondents; (%): percentage of respondents

Students' attitudes and feelings toward e-learning

Table 4 shows the different percentages of the participants' attitudes toward e-learning as assessed on the Likert scale. Approximately 64% of the respondents either strongly agreed (38.8%) or agreed (25.2%) that they had positive feelings during their online learning, 23.3% were unbiased, and only 13% had negative feelings. Nearly 44% of the participants found themselves totally engaged with the instructor and involved with their classmates, whereas 26% responded that they were not engaged, and the rest of them had neutral responses about engagement. In addition, 61.2% of the participants found themselves motivated and had a high degree of self-directness to finish, 16% reported that they were not encouraged, and 23.3% were neutral. On the other hand, 34% (strongly agreed, 17.5% and agreed, 16.5%) and 56% (strongly agreed, 34% and agreed 22.3) of the participants were overwhelmed and had no patience with the entire e-learning process. Furthermore, 75% strongly agreed (45.6%) and agreed (29.1%) that some topics had to be given in person. However, in general, 86% of the participants were satisfied with the online learning process.

Challenges the students faced during e-learning

Table 5 shows the different challenges that the participants faced during online learning and the percentages of their responses to each challenge. The greatest challenge the participants faced was a lack of training on the instrumental and experimental aspects of the laboratory (57.2%), followed by poor Internet speed (33%) and a lack of social interaction (23.3%). The remaining percentages of each challenge are listed in Table 5.

Table 4: Student's attitudes and feelings toward e-learning

Questions	Response n (%)				
	SA	A	N	D	SD
You feel that you have positive feelings about e-learning.	40 (38.8)	26(25.2)	24(23.3)	10 (9.7)	3(2.9)
You are totally engaged with the instructor and classmates during online teaching.	24 (23.3)	21 (20.4)	32 (31.1)	13 (12.6)	13 (12.6)
You found yourself motivated and had a high degree of self-directness to finish the course.	39 (37.9)	24 (23.3)	24 (23.3)	8 (7.8)	8(7.8)
You feel exhausted with the entire e-learning process.	18(17.5)	17 (16.5)	22 (21.4)	26 (25.2)	20 (19.4)
You have no patient while facing a minor technical issue.	35 (34)	23 (22.3)	18 (17.5)	17 (16.5)	10 (9.7)
You found that some topics had to be taken face-to-face.	47 (45.6)	30 (29.1)	13 (12.6)	7 (6.8)	6 (5.8)
In general, you are satisfied with the online learning process.	51 (49.5)	38 (36.9)	2 (1.94)	2 (1.94)	10 (9.7)

SA: strongly agree; A: agree; N: neutral; D: disagree; SD: strongly disagree; n: number of respondents; (%): percentage of respondents

Table 5: Challenges the students faced during e-learning

Challenge	Response, n (%)
Poor Internet speed	34 (33)
Lack of technical support	15 (14.6)
Lack of social interaction	24 (23.3)
Concerns about professional development	9 (8.7)
Lack of devices and programs	6 (5.8)
Lack of security	2 (1.9)
Confidentiality	10 (9.7)
Validity and applicability	2(1.9)
High cost	5 (4.9)
Inadequate quality	13(12.6)
Lack of focus and concentration	8 (7.7)
Lack of training on the instrumental and experimental aspects of the laboratory	59 (57.2)
Online education requires more study time than face-to-face education	12 (11.6)
Lack of a desktop computer	2 (1.9)
Other challenges	7 (6.7)

Respondent's academic performances

Table 6 lists the respondents' academic performances during online learning, including their first- and second-term test and attendance scores. The responses are presented as mean scores of the academic and attendance performances in each term. The second-term score was higher (mean ± SD, 86.03 ± 9.9159) than the first-term score (84.04 ± 10.1887). The mean second-term attendance score was higher (mean ± SD, 99.71 ± 1.362) than the first-term attendance score (99.12 ± 1.362).

Table 6: Respondents' academic performances

Test score	Mean ± SD
First semester	84.04 ± 10.18
Second semester	86.03 ± 9.915
Attendance score	
First semester	99.12 ± 2.646
Second semester	99.71 ± 1.362

SD: standard deviation

Statistical comparison of the students' online and face-to-face examination performances

Table 7 shows the statistical comparison of the student's first- and second-term performances during their online and in-class learning. Figure 1 shows a statistical comparison of the student's first- and second-term academic performances during their online and in-class learning. The data show statistically significant differences between the first- and second-term scores in the in-class examination ($P < 0.01$) and between the online and in-class examinations in the first and in the second terms ($P < 0.0001$ for both comparisons). Finally, the comparison of the first- and second-term online and in-class examination performances showed statistically significant differences ($P < 0.0001$).

Table 7: Statistical comparison of the student's first- and second-term academic performances during online and in-class learning.

Academic year	*t* Test	*df*	P value
Online examination (first term versus second term)	1.440	204	0.1513
Face-to-face examination (first term versus second	2.667	326	**0.008**
First term (online versus face-to-face examination)	5.984	265	**<0.0001**
Second term (online versus face-to-face	5.268	265	**<0.0001**
Online versus face-to-face examination	4.803	476	**<0.0001**

Unpaired *t*-test. The numbers in bold are the statistically significant values.
df: degree of freedom

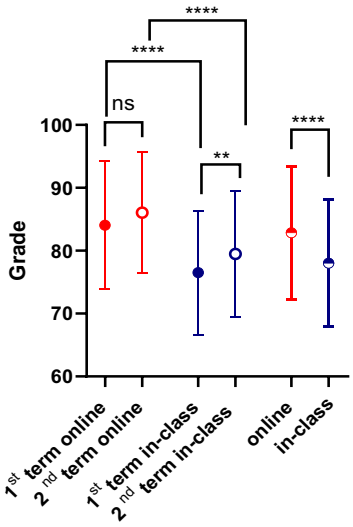

Figure 1: Statistical comparison of the pharmacy students' first- and second-term performances (examinations) during their online and in-class learning. The symbols represent the following: red with a closed circle, first-term online examination; red with an open circle, second-term online examination; blue with a closed circle, first-term in-class examination; blue with an open circle, second-term in-class examination; red with a half-closed circle, online examination; and blue with a half-closed circle, in-class examination. The comparison bars indicate the unpaired *t*-test scores, with no significant (ns) differences when the P value is >0.05; **P < 0.01, ****P < 0.0001.

DISCUSSION

One goal of Saudi Vision 2030 is world-class education, including the digital transformation of the educational system[19]. This goal was accelerated by the shift to e-learning during the COVID-19 pandemic.

Respondents' knowledge about e-learning tools

The study participants showed excellent knowledge of e-learning tools such as videos, audio, and discussion boards, which might be due to their previous experience with the use of these electronic tools. This finding is similar to that of a study conducted at UQU that investigated medical students' e-learning knowledge and demonstrated their fair knowledge of e-learning.[15] This is also in agreement with the study of Sud et al. which found that 85% of participants knew about e-learning.[20] However, this is in contrast to a study that assessed students' use and acceptance of emergency online learning. The study found that 70% of universities in Peru did not have previous experience with virtual courses.[4]

Benefits the respondents gained from e-learning tools

Our study demonstrated that a high percentage of respondents gained enough knowledge from online classes, discussion boards, links, and electronic resources. This is in agreement with several studies that found that online learning increases knowledge.[15,21] However, our study showed that students did not gain much knowledge from the videos of practical experiments that were sent to them. This might be because many practical analytical chemistry sessions require hands-on skills to be learned, such as weighing, titration, preparation of stock solutions, and dilutions. This could not be offered through videos of experiments.

Students' attitudes and feelings toward e-learning

Our research found that students had adequate attitudes toward e-learning and were generally satisfied. More than half of them had positive feelings toward online teaching and found themselves motivated enough to be on track and to finish all requirements. Nearly half of the students were engaged with their instructors and classmates during online learning. This may be attributed to the pharmacy students' high degree of knowledge of e-learning tools. A lack of skills might lead to technological barriers that cause increases in anxiety and negative feelings toward online teaching. On the other hand, good skills and knowledge about online resources will enhance students' confidence and, consequently, their positive feelings toward e-learning. This is in line with several studies that found that students had positive feelings toward online learning.[15,22] Moreover, these results are in agreement with a study in Thailand that found that students had good attitudes toward the online teaching of medical chemistry courses.[18]

Challenges the students faced during e-learning

Online teaching can help students overcome the drawbacks associated with traditional learning. However, unique challenges can present with online teaching, such as a lack of training on the instrumental and experimental aspects of the laboratory. In addition, poor Internet speeds were reported, consistent with the reports in previous studies.[15,20,23] Other challenges were the concerns about professional development and social interaction, which are understandable because students are still adjusting to a new way of learning, whose outcomes are not yet well known.

Respondents' academic performance

In this study, one remarkable finding pertains to the students' academic performances. The students' academic grades, which were measured using examination and continuous assessment scores, were higher in the second term than in the first term. This is due to the multiple benefits of online learning, such as the various digital tools used that might improve the learning experience; better retention, as students are more engaged; less distraction from others; and more time for studying.[3] This finding was in agreement with Tashkhandi's study which found that students' second-term scores were higher than

their first-term scores. Moreover, this study found that the attendance rate was higher in the second term than in the first term, which is in agreement with previous studies.[15,24] This finding was due to the ease of access to online classes compared with on-campus classes. Moreover, this study compared the examination results of online and in-class examinations, and the findings proved the benefits of online learning, as the scores were higher in online than in in-class examinations. This is in agreement with the study of Zheng et al. which found that students' scores during online learning were higher than their scores during face-to-face classes.[3]

The strength of this study is that it is the first study to describe UQU pharmacy students' e-learning knowledge and to examine the effect of online teaching on students' academic performances. Moreover, it compared medical students from the same country and university, which allowed for obtaining more realistic findings.

Limitations

During the comparison of the students' performances in online and in-class examinations, this study used a control group from later years. Although the course materials were almost the same between the two-time points, there could be some changes in other aspects that impacted the students' performances. For example, some lecturers might be more flexible in assignment deadlines. In addition, individual variations between students, such as motivation, commitments, and previous knowledge, can have significant impacts on the student's scores. A further limitation is that because the data collected in this study were anonymous, we could not correlate the students' engagement in online teaching with their course grades. Finally, this study compared and assessed the data from one school and course, so it might not be comprehensive.

From a future perspective, further study should be conducted to correlate the students' apparent online engagement with their performance. Moreover, the assessment of students' attitudes and performance toward online teaching should be studied for other courses and schools to compare results. In addition, as this study examined students' feelings and challenges in e-learning, it is important to focus on the faculties to learn and assess online teaching from students' point of view.

CONCLUSION

This study showed that the pharmacy students had good knowledge of the different e-learning resources. Moreover, it indicated that the students gained excellent knowledge from online classes, links, and discussion boards, which is associated with better performance in online than in in-class classes. However, as online teaching could be used during pandemics and natural disasters, further research should be conducted to improve the outcome of digital education to enhance students' and faculty members' interests in being involved in e-learning programs.

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Conflict of Interest

The authors declare no conflict of interest relevant to this article.

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