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Research Article

# Students' perspective on the online delivery of radiography & medical imaging program during COVID-19 pandemic

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## ABSTRACT

**Introduction:** The COVID-19 pandemic has led to significant changes to academic program delivery worldwide. Face to face (traditional teaching) lectures were replaced with online, recorded, or live sessions; however, online systems are not an efficient substitute for clinical or laboratory courses. The purpose of this study is to evaluate the imaging student's perspective on COVID-19 awareness to ensure they are prepared for clinical training and laboratory education, and to evaluate the teaching quality of the online radiography program delivery.

**Methods:** An online survey was conducted with radiography and medical imaging students of two female campuses in the United Arab Emirates (UAE). Knowledge and awareness level of COVID-19, such as symptoms and diagnostic tests, were evaluated using multiple choice questions. The Likert scale (1-5) was used to evaluate the teaching quality of the online learning of radiography, such as critical thinking and communication skills. Open-ended questions were included for students to provide comments and feedback.

**Results:** Out of 305 female students, 212 participants (71%) responded and were included in the study. The average age was 20 years, and respondents were from different study levels (year 1-year 5), with 47% and 53% of the participants from Al Ain campus and Abu Dhabi campus, respectively. Seventy percent of the respondents reported a Bachelor degree, while 30% were higher Diploma participants. The overall COVID-19 awareness level mean score was acceptable (70%). Senior students with a Bachelor degree and clinical experience scored higher than other students (72% vs. 65%,  $P < 0.05$ ). The mode value of the Likert scale for the teaching factors assessment (1-5) for most

of the respondents showed average (mode=3) response value. However, the mode for the stress factor was high (mode=5). The overall online radiography teaching satisfaction for the teaching quality factors was less than 50%. However, more than half of the respondents (52%) recommended delivering the radiography program using the online learning system.

**Discussion:** COVID-19 imposed several challenges to the educational systems worldwide, requiring implementation of effective strategies to improve the current online teaching. Effective communication between instructors and students, engaging students with case studies discussion, and encouraging students to think critically and to be creative are important strategies.

**Conclusion:** Online delivery of the radiography and medical imaging program imposes challenges for laboratory and clinical courses. It is recommended that academic institutions implement state of art technology to bridge the gap between traditional and online learning methods during the pandemic. Students are suggested to be mentally prepared to accept the shifting of the teaching mode to relieve stress and gain knowledge and practical skills more efficiently.

## RÉSUMÉ

**Introduction:** La pandémie de COVID-19 a entraîné d'importants changements dans la prestation des programmes universitaires dans le monde entier. Les cours magistraux en face à face (enseignement traditionnel) ont été remplacés par des sessions en ligne, enregistrées ou en direct; cependant, les systèmes en ligne ne constituent pas un sub-

Ethical approval: Informed consent was obtained from all participants. This survey study was approved by the research ethical committee of the institution to be conducted among Radiography and imaging students of two female campuses belonging to the college.

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stitut efficace aux cours cliniques ou de laboratoire. L'objectif de cette étude est d'évaluer le point de vue des étudiants en imagerie sur la sensibilisation à la COVID-19 afin de s'assurer qu'ils sont préparés à la formation clinique et à l'enseignement en laboratoire, et d'évaluer la qualité de l'enseignement du programme de radiographie en ligne.

**Méthodologie:** Une enquête en ligne a été menée auprès d'étudiantes en radiographie et en imagerie médicale de deux campus féminins des Émirats arabes unis (EAU). Le niveau de connaissance et de conscience de la COVID-19, comme les symptômes et les tests de diagnostic, a été évalué à l'aide de questions à choix multiples. L'échelle de Likert (1-5) a été utilisée pour évaluer la qualité de l'enseignement de l'apprentissage en ligne de la radiographie, comme la pensée critique et les compétences en communication. Des questions ouvertes ont été incluses pour permettre aux étudiantes de fournir des commentaires et des réactions.

**Résultats:** Sur 305 étudiantes, 212 participantes (71%) ont répondu et ont été incluses dans l'étude. L'âge moyen était de 20 ans, et les répondants appartenaient à différents niveaux d'études (année 1 - année 5), avec 47% et 53% des participants du campus d'Al Ain et d'Abu Dhabi, respectivement. Soixante-dix pour cent des répondantes ont déclaré être titulaires d'une licence, tandis que 30 % étaient titulaires d'un diplôme supérieur. Le score moyen global du niveau de sensibilisation à la COVID-19 était acceptable (70%). Les étudiantes plus âgées ayant un diplôme de licence et une expérience clinique ont obtenu un score plus élevé que les autres (72% contre 65 %,

*Keywords:* Radiography; COVID-19; Teaching; Online; Imaging; Students

## Introduction

Based on our experience at this institution, the COVID-19 pandemic has led to significant changes to academic program delivery. Face to face theory lectures were replaced with online, recorded, or live sessions conducted through videoconference platforms such as Blackboard, Teams, and Zoom. However, a lack of physical interactions, tutorials, group discussion, and actual attendance in class is thought to limit the achievement of program learning outcomes. The usual perception is that traditional teaching is more effective in terms of delivering information to the students. Close contact with students, active participation, and using the class board for demonstration are all considered powerful approaches for student learning [1].

Online delivery of theory courses can be a successful experience since the study materials can be uploaded and provided to students in PowerPoint or multimedia formats. Students are required to spend more time on self-study, and they can post questions to the instructors using available discussion and chatting tools. However, online systems cannot substitute for clinical or laboratory courses efficiently. Practical courses are core components of the radiography and imaging curricula worldwide. A lack of physical training in clinical settings to practice imaging techniques, handle real patients, and interact with other health professions will negatively impact the quality of the graduates. Sadly, since the beginning of the pandemic and

$P < 0,05$ ). La valeur modale de l'échelle de Likert pour l'évaluation des facteurs d'enseignement (1-5) pour la plupart des répondants a montré une valeur de réponse moyenne (mode=3). Cependant, le mode pour le facteur de stress était élevé (mode=5). La satisfaction globale de l'enseignement de la radiographie en ligne pour les facteurs de qualité de l'enseignement était inférieure à 50%. Cependant, plus de la moitié des répondantes (52%) recommandent d'offrir le programme de radiographie à l'aide du système d'apprentissage en ligne.

**Discussion:** La COVID-19 a imposé plusieurs défis aux systèmes éducatifs du monde entier, nécessitant la mise en œuvre de stratégies efficaces pour améliorer l'enseignement en ligne actuel. Une communication efficace entre les instructeurs et les étudiants, l'engagement des étudiants dans des discussions sur des études de cas, et l'encouragement des étudiants à penser de manière critique et à être créatifs sont des stratégies importantes.

**Conclusion:** La prestation en ligne du programme de radiographie et d'imagerie médicale impose des défis pour les cours de laboratoire et les cours cliniques. Il est recommandé aux établissements universitaires de mettre en œuvre une technologie de pointe pour combler le fossé entre les méthodes d'apprentissage traditionnelles et en ligne pendant la pandémie. Il est suggéré aux étudiants d'être mentalement préparés à accepter le changement de mode d'enseignement afin de soulager leur stress et d'acquérir des connaissances et des compétences pratiques plus efficacement.

until recently (approximately 5 months, from March to August 2020), trainees were requested to stop the clinical training and to study from home to avoid contacting COVID-19 from patients.

In response, exams were administered online using proctoring programs such as lockdown browser and Respondus monitor. Although the institution's library prepares and circulates a mock quiz using Lockdown Browser and Respondus Monitor (camera) to students prior to live exams, such programs can cause stress, high tension, and can overwhelm the students since they do not feel comfortable due to the constant webcam monitoring. This program reduces the chances of cheating; however, students can get distracted and their performance might be affected. Moreover, deferred and repeated exams as a consequence of technical issues encountered during the exams due to internet connection interruptions and sick leave cases have increased the anxiety burden on students—and the instructors, as well.

This is concurrent with radiography students' experience in Singapore. In a study by Teo et al, students experienced frustration, fear, and anxiety because of the teaching shifting to online mode [2]. They also experienced the negative impact of ceased clinical training. However, they adapted to the new system and recommend a blended learning model, so both online and traditional teaching can be included in the radiography curriculum [2]. A study by Adams et al suggests a new radiology curriculum design for COVID-19 mitigation using a virtual

rotation curriculum to maintain the educational process of the radiology medical students [3]. Likewise, solutions for clinical imaging training were suggested by Alvin et al.[4] Since chest imaging is important diagnostic tool for COVID-19, an additional course of chest image interpretation to the radiology curriculum can improve the student's skills. For patient care and interactive activities, protective personal equipment (PPE) availability should be considered carefully for the safety of the trainees. Additionally, Darras et al found that online simulation software such as virtual dissection of computed tomography (CT) data, virtual three-dimensional radiology, and virtual dissection anatomy, are valuable tools for online learning [5].

Clinical practice requires implementing health infection control measures to ensure the safety of the trainees. Therefore, specific strategies have been recommended, such as applying the safe distance between trainees, reducing groups gathering across the treatment rooms, and preparing lists of staff and students to ensure training continuity [6].

Radiology workstation training areas represent a major challenge for students. A study by McRoy et al has reported a new developed approach for the first-year radiology students based on a remote learning method. This application can be used as a workstation simulation software for distance learning purposes [7].

There is a scarce literature regarding radiography students' perspective on the online delivery of imaging programs. Such studies could help to address the challenges faced by the students, including advantages and drawbacks of distance learning. Therefore, this study was conducted firstly to evaluate the COVID-19 awareness among imaging students to ensure they have adequate understanding of the disease following orientation sessions in the clinical settings and in the college in terms of applying the precautions, safety measures, and using PPE for patient's imaging and laboratory training. Secondly, to highlight their perspective about the online delivery in terms of the achieved learning outcomes such as critical thinking and communications skills, as well as the quality of the online delivered theory, laboratory, and clinical courses.

## Methods

This survey study was approved by the Research Ethical Committee of the institution to be conducted among radiography and imaging students of two female campuses belonging to the college. In this study, a questionnaire regarding COVID-19 awareness, achieved learning outcomes such as critical thinking and communication skills, and the teaching quality of different types of courses was developed based on relevant published literature [8–16].

The questionnaire was made available online and sent to the participants to be filled and submitted electronically. The questionnaire was divided into 4 sections (Appendix A). The first section is the consent form to explain the research purpose and objectives to the participants, to obtain their approval to proceed and complete the questionnaire. The second section is to collect demographic information, such as gender and age.

Table 1

Mean scores of different study level.

Year level	N	Mean	Std. Deviation	P value
Year1	84	0.67	0.15	0.095
Year2	35	0.68	0.18	
Year3	24	0.71	0.16	
Year4	37	0.72	0.20	
Year5	32	0.76	0.21	
Total	212	0.70	0.18	

The third section includes multiple choice questions regarding the knowledge and awareness level of COVID-19 disease, such as symptoms and diagnostic tests. The fourth section evaluates student satisfaction with the online teaching of the radiography and imaging program on a Likert scale (1–5; 1 for the lowest value and 5 for the highest value). An open-ended question was included at the end of the questionnaire for further suggestions and recommendations from the students.

For statistical analysis, the value of 1 was assigned to the correct answer and 0 for the wrong answer. Then, the mean scores were calculated and compared between different groups. ANOVA and Student's t tests were used to compare the significant difference between the groups. The P-value was calculated using two-tailed test with 95% level of confidence at the 0.05 significance level. Categorical variable such as gender, job and degree were expressed as proportions. For the Likert scale analysis, the mean, the median and the mode of the responses (1–5) were used. The analysis was performed using SPSS (Statistical package for the social sciences) software.

## Results

### Demographic information

This study was conducted in a college that admits female students only. Out of 305 total students, 212 (71%) agreed to participate in our study. The age of the participants ranged from 17 to 26, with a mean value of 20. Among them, 53% came from the Abu Dhabi campus and 47% came from the Al Ain campus. The study comprised 40% year 1 level, 17% year 2 level, 11% year 3 level, 17% year 4 level and 15% year 5 level students. Regarding the program degree, 70% of the respondents reported a Bachelor degree while 30% were higher Diploma students. For practical/clinical courses, half of the participants reported that they have taken clinical courses. Slightly more than half of the participants reported that they prefer the online teaching (52%), while the other students did not recommend this type of teaching.

### Study level's scores of COVID-19 awareness section

According to the study level of the participants, the scores of year 5 students were higher than the other levels, while year1 level scored the lowest. There was no significant difference among the groups ( $P > 0.05$ ) as shown in Table 1.

Table 2  
Mean scores of different study degrees.

COVID-19 Awareness score	Imaging Program degree	N	Mean	Std. Deviation	P value
	Diploma	64	0.65	0.16	0.007
	Bachelor	148	0.72	0.18	

Table 3  
Mean scores of campuses.

COVID-19 Awareness score	Campus	N	Mean	Std. Deviation	P value
	Al Ain	100	0.67	0.18	0.06
	Abu Dhabi	112	0.72	0.17	

Table 4  
Mean scores of respondents regarding registered clinical courses.

COVID-19 Awareness score	Have you taken any clinical courses?	N	Mean	Std. Deviation	P value
	No	107	0.68	0.15	0.141
	Yes	105	0.72	0.20	

#### Program degree's scores of COVID-19 awareness section

According to the program degrees of the participants, the Bachelor level scored higher than the other Diploma level and the difference was significant ( $P < 0.05$ ) as shown in Table 2.

#### Campus scores of COVID-19 awareness section

Students in Abu Dhabi and AL Ain campuses scored similar results about 70% for the COVID-19 awareness section without significant difference ( $P > 0.05$ ) as shown in Table 3.

#### Practical/clinical courses' scores of COVID-19 awareness section

Participants who registered practical/clinical courses scored (70%) higher than participants who did not register (68%). However, there was no significant difference between the groups ( $p > 0.05$ ) as shown in Table 4.

#### Radiography online program delivery assessment

Students were requested to evaluate the online program delivery based on different aspects using a scale 1–5; 1 for the lowest and 5 for the highest value. The mode was 3 (average) in most of the responses. The mode of the stress level was 5 (above average) for the for the online program. Using the mean value of the scores, the required number of the self-study hours and the stress level are above average (3.4, 3.5, respectively). Most of the teaching quality factors such as analysis skills, critical thinking and class interaction were below average (2.8, 2.7, 2.7, respectively). However, most of the responses agree that the program learning outcomes and course outcomes can be achieved through online program delivery method. The results are summarized in the Table 5. The mean stress level value was higher for the Diploma and junior students in comparison to Bachelor and senior students. The results are summarized in the Tables 6 and 7.

Overall online program delivery satisfaction

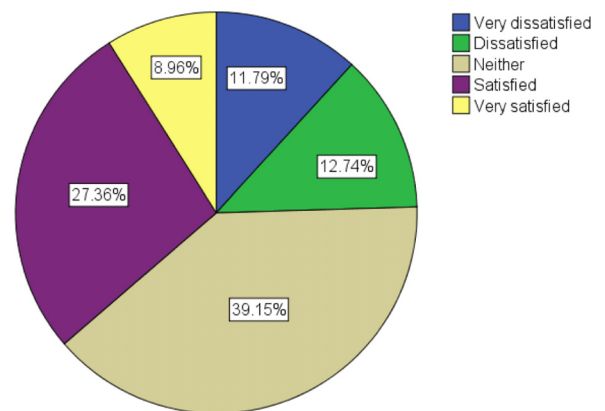


Fig. 1. Online imaging program satisfaction

#### Overall Radiography online program satisfaction

Overall, the total percent of satisfied and very satisfied students about the program is about 36% and higher than the total percent of dissatisfied and very dissatisfied students (25%), as shown in Fig. 1.

#### Students' opinions and comments

Most of the comments support the traditional teaching way (face to face). Comments such as "For clinical placement course students must go to the clinical for better learning" and "Radiology is best taught while being in class because it's easier to interact more with the instructors" clearly indicate the need for the traditional way of teaching. However, there are some opinions support the online teaching such as "Use of online modality simulators by students in online lab classes" and "No, it's excellent". Below is the full list of student comments in Table 8.

Table 5  
Likert scale results of the online imaging program assessment.

Factor	N	Mean	Std. Deviation	Median	Mode
Online learning difficulty level	212	3.02	1.21	3.00	3
Required Self-study hours	212	3.37	1.01	3.00	3
Online study Stress level	212	3.49	1.32	4.00	5
Online Theory Learning quality level	212	3.02	1.06	3.00	3
Online laboratory learning quality level	212	2.49	1.09	3.00	3
Online Clinical learning quality level	212	2.59	1.19	3.00	3
Interaction and engagement level	212	2.73	1.04	3.00	3
Online study Flexibility level	212	2.83	1.15	3.00	3
Analysis skills level	212	2.8	1.10	3.00	3
Critical thinking level	212	2.72	1.04	3.00	3
Communication skills level	212	2.75	1.20	3.00	3
Online examination quality	212	2.96	1.14	3.00	3
Achieving course outcomes	212	3.25	1.11	3.00	4
Achieving Program outcomes	212	3.25	1.06	3.00	4
Overall online program delivery satisfaction	212	3.09	1.10	3.00	3

Table 6  
Comparison between student's degrees for online imaging program assessment.

Factor	Imaging Program degree	N	Mean	Std. Deviation	P value
Online learning difficulty level	Diploma	64	3.16	1.07	0.298
	Bachelor	148	2.97	1.27	
Required Self-study hours	Diploma	64	3.31	0.90	0.599
	Bachelor	148	3.39	1.04	
Online study Stress level	Diploma	64	3.67	1.22	0.191
	Bachelor	148	3.41	1.36	
Online Theory Learning quality level	Diploma	64	2.92	1.01	0.383
	Bachelor	148	3.06	1.08	
Online laboratory learning quality level	Diploma	64	2.55	1.22	0.625
	Bachelor	148	2.47	1.04	
Online Clinical learning quality level	Diploma	64	2.84	1.17	0.045
	Bachelor	148	2.49	1.18	
Interaction and engagement level	Diploma	64	2.70	1.03	0.799
	Bachelor	148	2.74	1.05	
Online study Flexibility level	Diploma	64	2.77	1.12	0.568
	Bachelor	148	2.86	1.17	
Analysis skills level	Diploma	64	2.69	1.09	0.344
	Bachelor	148	2.84	1.11	
Critical thinking level	Diploma	64	2.66	0.91	0.550
	Bachelor	148	2.75	1.10	
Communication skills level	Diploma	64	2.75	1.15	0.970
	Bachelor	148	2.74	1.23	
Online examination quality	Diploma	64	2.97	0.97	0.925
	Bachelor	148	2.95	1.20	
Achieving course outcomes	Diploma	64	3.28	0.86	0.789
	Bachelor	148	3.24	1.209	
Achieving Program outcomes	Diploma	64	3.27	0.85	0.922
	Bachelor	148	3.25	1.14	
Overall online program delivery satisfaction	Diploma	64	3.06	0.90	0.815
	Bachelor	148	3.10	1.18	

## Discussion

This study was conducted among female imaging students to evaluate their COVID-19 awareness and to highlight their perspective on the online delivery in terms of the achieved learning outcomes such as critical thinking and communication skills as well as the quality of the online delivered theory, laboratory and clinical courses.

For both campuses, the traditional teaching (face to face) for theory courses was conducted in classes using PowerPoint presentations, group discussion, and problem-solving methods. For laboratory courses, face to face demonstration using the imaging equipment including phantom imaging, imaging positioning, image quality evaluation, and lab reports were utilized to improve the practical skills of the students. For clinical

Table 7  
Comparison between student's study levels for online imaging program assessment.

Factor	Study level	N	Mean	Std. Deviation	P value
Online learning difficulty level	Year1	84	3.10	1.28	0.531
	Year2	35	3.23	1.41	
	Year3	24	3.04	0.85	
	Year4	37	2.86	1.08	
	Year5	32	2.78	1.18	
	Total	212	3.02	1.21	
Required Self-study hours	Year1	84	3.35	1.01	0.283
	Year2	35	3.57	1.06	
	Year3	24	3.50	0.83	
	Year4	37	3.08	0.95	
	Year5	32	3.44	1.07	
	Total	212	3.37	1.00	
Online study Stress level	Year1	84	3.71	1.26	0.001
	Year2	35	3.31	1.38	
	Year3	24	4.25	1.18	
	Year4	37	3.05	1.39	
	Year5	32	3.03	1.09	
	Total	212	3.49	1.32	
Online Theory Learning quality level	Year1	84	2.93	1.02	0.189
	Year2	35	3.37	1.19	
	Year3	24	2.75	0.98	
	Year4	37	3.08	1.09	
	Year5	32	3.00	0.98	
	Total	212	3.02	1.06	
Online laboratory learning quality level	Year1	84	2.52	0.98	0.017
	Year2	35	2.80	1.34	
	Year3	24	1.83	1.09	
	Year4	37	2.59	1.01	
	Year5	32	2.44	1.04	
	Total	212	2.49	1.09	
Online Clinical learning quality level	Year1	84	2.49	1.14	0.227
	Year2	35	2.77	1.21	
	Year3	24	2.96	1.23	
	Year4	37	2.68	1.24	
	Year5	32	2.31	1.14	
	Total	212	2.59	1.19	
Interaction and engagement level	Year1	84	2.63	1.11	0.028
	Year2	35	3.11	1.13	
	Year3	24	2.54	0.77	
	Year4	37	2.97	0.98	
	Year5	32	2.44	0.87	
	Total	212	2.73	1.04	
Online study Flexibility level	Year1	84	2.48	1.14	0.002
	Year2	35	3.11	1.43	
	Year3	24	2.83	0.70	
	Year4	37	3.30	1.05	
	Year5	32	2.94	1.01	
	Total	212	2.83	1.15	
Analysis skills level	Year1	84	2.55	1.16	0.009
	Year2	35	3.26	1.22	
	Year3	24	2.67	0.96	
	Year4	37	3.08	0.95	
	Year5	32	2.72	0.88	
	Total	212	2.80	1.10	
Critical thinking level	Year1	84	2.63	1.11	0.370
	Year2	35	2.94	1.02	
	Year3	24	2.50	0.83	
	Year4	37	2.89	0.99	
	Year5	32	2.69	1.06	
	Total	212	2.72	1.04	

(continued on next page)

Table 7 (continued)

Factor	Study level	N	Mean	Std. Deviation	P value
Communication skills level	Year1	84	2.57	1.23	0.076
	Year2	35	3.17	1.46	
	Year3	24	2.63	0.97	
	Year4	37	2.97	1.06	
	Year5	32	2.56	1.01	
	Total	212	2.75	1.20	
Online examination quality	Year1	84	2.75	1.18	0.180
	Year2	35	3.29	1.22	
	Year3	24	3.04	0.80	
	Year4	37	2.95	1.05	
	Year5	32	3.09	1.20	
	Total	212	2.96	1.14	
Achieving course outcomes	Year1	84	3.11	1.14	0.470
	Year2	35	3.49	1.17	
	Year3	24	3.29	0.75	
	Year4	37	3.38	1.03	
	Year5	32	3.19	1.28	
	Total	212	3.25	1.11	
Achieving Program outcomes	Year1	84	3.08	1.07	0.283
	Year2	35	3.54	1.09	
	Year3	24	3.29	0.62	
	Year4	37	3.35	1.01	
	Year5	32	3.25	1.29	
	Total	212	3.25	1.06	
Overall online program delivery satisfaction	Year1	84	2.95	1.16	0.604
	Year2	35	3.20	1.10	
	Year3	24	3.17	0.56	
	Year4	37	3.27	1.12	
	Year5	32	3.06	1.26	
	Total	212	3.09	1.10	

courses, students were assigned to different clinical settings to conduct their clinical training under the supervision of the college clinical instructor and the clinical setting preceptor. The imaging training areas for students such as X-ray, CT scan and MRI were selected based on the clinical courses' objective and the expected outcomes as well as the course study level.

For online teaching mode, theory courses were conducted using the Blackboard platform; live online classes were performed by uploading the teaching material and recording the teaching sessions. For laboratory courses, lab simulators such as MRI simulator and CT simulator were utilized for online demonstration. For clinical courses, clinical case studies of different imaging modalities such as US, MRI and CT, and clinical reports were used for the online clinical teaching.

The overall awareness level among the students of both campuses regarding the COVID-19 was acceptable, and most of the students scored over 70%. A similar study was conducted among university students and reported a good COVID-19 knowledge level of 80% [17]. However, Y5 level students with a bachelor's degree scored higher than the other students. Additionally, students with clinical experience scored higher than the other students. This can be related to the higher medical knowledge and the clinical experience of senior students in comparison to other students. A study by Dalky et al demonstrated that

knowledge of COVID-19 is significantly increased with higher clinical experience [18].

In addition, most of the students' comments supported the traditional teaching way (face to face). However, almost more than half of the participants reported that they prefer the online teaching (52%), while the other students did not recommend this type of teaching and the majority of the students were satisfied with the online delivery of the program.

Similarly, a study was conducted in Malaysia by Chung et al to evaluate online learning readiness among university students. The results indicated that degree students are more ready and scored higher than diploma students because of their longer experience. In addition, face to face learning is preferred if students were given the option to choose. However, most of the respondents preferred online learning using uploaded recorded classes to Google and YouTube [19].

The study results showed a high stress level and more required self-study hours for online learning. Likewise, a study by Elsaleem et al showed there is a negative effect of the online mode on the student stress level, especially for the exams [9]. In that study, different awareness programs have been suggested, such as sleep quality and physical activity, to help students adapt to the new system [9]. Moreover, it was recommended by Mukhtar et al to develop classes with less cognitive load and more interactivities [20].



Table 8  
Comments and suggestions results.

Do you have any suggestions/comments to improve the teaching of imaging (radiography) program?	Year level
• It should be in classroom	Y1
• The instructors must explain and try their best to make the content easy to the students not just reading the lectures.	Y3
• More practical courses than theory. And more clinical days. Radiographic Anatomy should be a priority.	Y5
• Teaching of imaging program should be in class	Y4
• Focusing on improving frequent errors within the program modules	Y3
• Everything goes well.	Y5
• Yes, I think that RMI student must study in reality	Y5
• Please we need to go to the college, 90% of student struggling with online classes... we don't understand most of the things... Our studying level is down, we can't do well in the exam.	Y1
• The professors should take in consideration that because the study is online the exams must be easy	Y3
• Increase time in exam and I hope the questions are put the sample like in campus because these circumstances and the reasons are not from us because Punishment in exam online is more difficult And please I hope put new instructions about finale exam in campus like other university and college	Y3
• Back to campus	Y1
• Going to the hospital and have training	Y4
• Go back to college	Y1
• I suggest that MRI student can go to the Campus	Y3
• No it's excellent	Y5
• Better to be In reality	Y3
• Radiology is best taught while being in class because it's easier to interact more with the instructors.	Y5
• Use of online modality simulators by students in online lab classes.	Y3
• Test timing is very limited. It's better to send email as reminder before test.	Y1
• To be honest since I've started studying online courses i didn't understand or get anything	Y2
• Wish we could go back to campus, at least year one students some of us are lost and confused.	Y1
• I suggest for year one student to go to the college	Y1
• For clinical placement course students must go to the clinical for better learning	Y5
• Only for clinical placement courses must attend in the hospitals to practice well.	Y5

Regarding the quality of the online clinical and laboratory learning, the score was below average. Accordingly, different studies have suggested using various technologies to overcome the issues of the online delivery of the practical courses such as virtual dissection of computed tomography (CT) data, virtual three-dimensional radiology, and virtual dissection anatomy for online learning [5]. Online teaching technologies such as lab simulators and clinical study cases studies were effective methods for online learning.

COVID-19 imposed several challenges to the educational systems worldwide that require implementing effective strategies to improve the current online teaching. Effective commu-

nication between instructors and students is one of the most important strategies. Instructors should focus on their voice quality while delivering the class since they are no longer using body language as in physical classes. Additionally, engaging students with case studies discussion will create more interactive classes. Moreover, students should be encouraged to think critically and to be creative through providing analytical materials and assignments. Technical issues during online learning are inevitable. Therefore, instructors should be more flexible with students in terms of time and assignment submissions deadlines. Finally, academic institutions should be fully equipped with the necessary technologies that required to de-

liver the program online such as videoconference programs. Also, infrastructure, information technology and internet connectivity should be well maintained and prepared to avoid poor online teaching experience [21].

In order to improve the quality of online teaching, a well-established information technology (IT) infrastructure to enhance online communication and to reduce technical connection issues is required. Additionally, alternative learning management systems must be considered in case of downtime or maintenance. Moreover, teaching staff require a proper comprehensive training on using online teaching resources, which can improve the communication skills on delivering courses and student assessments methods. Finally, students should be given the opportunity to be well trained on using online learning management systems through tutorials and mock exams. Additionally, the availability of online educational resources, such as laboratory simulators and clinical images cases and reports, will improve the online program delivery effectiveness.

This present study has several limitations. Although the teaching staff have the proper, relevant qualifications to conduct classes in a traditional way (face to face), they did not have enough experience in delivering online courses or using online learning management systems. The teaching method was shifted to online mode in a short period of time following the pandemic, without sufficient time for a proper training. Also, students did not have adequate tutorials on online learning due to the shortage of time. Therefore, student online program satisfaction might be influenced by the above mentioned factors. Additionally, all participants were female because of the campus admission policy. Including both males and females could improve the overall transferability of study findings. Although the institution is a multi-campus entity, investigating more colleges and universities will increase the power and the sample size of this study. Finally, including additional degrees, such as master and doctorate levels, will provide new insights into different students' experiences of the online delivery of the program and to identify advantages, challenges, and limitations of the online teaching of the radiography and imaging program. However, the current study can serve other investigators as a baseline for future related studies and for comparison purposes.

## Conclusion

The COVID-19 pandemic has changed teaching methods and led to new approaches in conducting classes and practical sessions. Virtual learning has advantages in terms of flexibility, in offering more time for self-study, and to comply with current safety measures. However, the level of stress and the study load were found to be high for online learning. Furthermore, the quality of online laboratory and clinical courses, and the general skills such as critical thinking and communication skills, were below average. Poorer engagement, flexibility, analytical skills, and critical thinking training via online instruction can lead to poorer outcomes for the laboratory and online clinical training. However, the quality of online theory learning, and achieving course and program outcomes via online teaching re-

ceived an acceptable rating by the students. Nevertheless, online teaching has become more popular among students over time, which requires more attention and preparation from institutions in applying technology for the effective delivery of online radiography teaching in the future.

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## Supplementary materials

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jmir.2021.07.009.

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