

Virtual and Traditional Learning in Undergraduate Radiology Education: A Cross-sectional Comparative Study from Saudi Arabia

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Abstract

Background: The coronavirus pandemic (COVID-19) resulted in disruption in the traditional teaching methods and lead to a wider adoption of virtual teaching. However, there is a lack of comparative studies regarding the use of either or the mixed mode for teaching radiology to undergraduate students.

Objective: This study aimed to determine the barriers, performance, and overall satisfaction of undergraduate medical students and instructors undertaking virtual and traditional radiology learning across Saudi Arabia.

Methodology: This cross-sectional questionnaire study included undergraduate students and instructors from across Saudi Arabia who had undertaken radiology either traditionally, through E-learning, or both in the 2019-20 academic year. The questionnaire elicited information regarding attendance, teaching methods, difficulties, knowledge acquisition, and satisfaction. Association between variables was assessed using Chi-square, in addition to a univariate analysis.

Results: A total of 404 undergraduate students from 28 universities of Saudi Arabia responded, in addition to 20 instructors. Students preferred E-learning for the quality of the course and the time and effort spent as well as obtained higher grades than those in traditional learning. Traditional education was favored over E-learning for clarity of instructors' voice, ease of understanding image description by the instructor, and lack of technical barriers such as poor Internet connection. The form of education was significantly correlated with grades obtained ($P < 0.001$) but not with overall satisfaction ($P = 0.067$). The majority of the instructors (60%) considered E-learning to be helpful in balancing their workload and teaching responsibilities ($P = 0.029$) and would recommend it as a standard teaching method for radiology (85%).

Conclusion: E-learning has potential advantages over traditional learning for teaching radiology to undergraduate medical students. However, further optimization is required to overcome the current deficiencies of this mode.

Keywords: E-learning, radiology teaching, traditional education, virtual education

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INTRODUCTION

Virtual education provided an effective alternative to traditional learning when the onset of COVID-19 pandemic dramatically disrupted the regular delivery of medical education and clinical practice.^[1] However, for students, this transition was not without technical difficulties impacting their learning outcomes and raising concerns about lack of clinical exposure.^[2,3] In addition, there is a lack of strong evidence in the literature that demonstrates that E-learning has substantial benefits over traditional learning, which could also be due to the absence of theoretical foundations that can accurately measure learning outcomes.^[4] Therefore, the usefulness of adopting online education as a standard method across different medical domains remains unclear.^[2]

In radiology education, interruptions at the reading rooms and the reporting of clinical cases often impair faculty members' teaching–work balance.^[5] For overcoming such issues, E-learning is a potentially useful tool in radiology education, as it allows for authentic image manipulations that help students understand the three-dimensional relations between anatomical and pathological structures.^[6] This potential is highlighted in the findings of a study published in 2016, wherein participants receiving E-learning training in addition to traditional formal radiological education demonstrated an improvement in knowledge and skills in X-ray interpretation compared to students who only received traditional learning.^[7] Similarly, a low-powered study found that after receiving E-learning education, there was an increase in the radiological image assessment abilities of students who had no previous experience in the interpretation of radiographs.^[8]

In Saudi Arabia, for the 2019-20 academic year, university students received traditional face-to-face learning from September 2019 up until the end of March 2020, following which all university classes were moved onto the virtual mode based on the directive of the Ministry of Education. A study from the country that assessed undergraduate medical students' perceptions regarding the effectiveness of online learning after the switch found that it was well-accepted, though with difficulties. In fact, most preclinical students stated a preference for online learning over traditional learning even for the upcoming academic years.^[9] Similarly, another study found that most students preferred virtual learning over traditional learning in radiology clerkship due to the cost-effectiveness, time, effort and improved radiological image resolution during classes.^[10]

The previous studies from Saudi Arabia regarding the perception of virtual learning of radiology only included students from two institutions, and thus its repetitiveness is limited. In addition, understanding the perception of instructors undertaking the radiology courses would provide additional evidence for developing robust learning plans. Therefore, the current study was conducted to determine the barriers, performance, and overall satisfaction of undergraduate medical students and instructors undertaking virtual and traditional radiology learning across Saudi Arabia.

METHODOLOGY

Study design and participants

This cross-sectional web-based questionnaire study included undergraduate students and instructors from Saudi Arabia who had undertaken radiology courses during the 2019-20 academic year. All responses were collected between September 15 and December 31, 2020. The Unit of Biomedical Ethics at King Abdulaziz University, Jeddah, Saudi Arabia, approved the study.

The academic year chosen for the study provides a unique opportunity, wherein students from some universities would have undergone radiology learning in the traditional learning mode (i.e., before the pandemic restrictions were imposed), while others would have undergone the learning entirely in the virtual mode or both due to the onset of the COVID-19 pandemic. Therefore, undergraduate students of any year of study were considered eligible if they attended any medical school in Saudi Arabia and had attended radiology courses during the chosen academic year as a traditional lecture (Group A), on an E-learning platform (Group B), or both (Group C). Similarly, radiology instructors who conducted lectures in the year in either or both modes were considered eligible. Students of only a specific year of study were not chosen because of differences in the academic curriculum between medical schools.

Sample size and sampling method

A non-probability convenience sampling was used for the study. Data were distributed and collected using Google Forms. The study targeted undergraduate medical students of 40 different universities across Saudi Arabia through the help of data collectors. The authors and data collectors shared the Google Forms link through WhatsApp and Gmail platforms and other social media mediums; the link was only shared with the targeted population.

The number of undergraduate medical students per batch in Saudi Arabian universities ranges from

approximately 200 and 400 (median: 300). Using this median value and considering that 40 universities offering medical courses were targeted for the study, the total student population across Saudi Arabia was estimated as 12,000. From this, the sample size predicted using the Qualtrics calculator with a confidence level of 95% was 372 undergraduate medical students. For instructors teaching radiology, the sample size was similarly estimated and found to be 80.

Study questionnaire

For students, a 27-item questionnaire was developed in English considering the existing literature. At the start of the questionnaire, the aim of the study was explained, the estimated time for questionnaire completion was stated (estimated as 3–5 mins based on the pre-testing) and an informed consent was obtained. Here, the respondents were informed that participation is voluntary with no incentive being offered and their anonymity and data protection was assured. The questionnaire comprised the following six sections: demographics (5 items), percentage of attendance and benefit (3 items), learning method experience (7 items), difficulties and barriers to each teaching method (5 items), knowledge gained and assessment scores (2 items), and satisfaction (5 items).

The same format of the questionnaire was adopted for developing a 19-item, 6-section questionnaire for instructors. In addition to demographics (3 items), attendance of both instructors and students based on the teaching method experienced were considered (4 items). Then, data were elicited regarding the teaching method taught (and if any training was received) (3 items), difficulties and barriers experienced (3 items), student performance and interaction (2 items), and instructor satisfaction (4 items).

In both questionnaires, response to all questions were made mandatory for submitting the response, and a “Not applicable” field was available for selected questions. In addition, respondents could review their responses before submission by going back to their answers and making any changes.

The internal consistency of both questionnaires was measured using Cronbach’s alpha and was 0.7 for the students’ and 0.8 for the instructors’ questionnaire. The questionnaires were pre-tested by administering it to two university academics and 10 undergraduate medical students. No changes were considered necessary based on the responses received, and the data of those involved in the pre-testing were not used in the full-scale study

data analyses. The face validity of the questionnaires were determined to be adequate by the respondents.

Outcome measures

The primary outcome measured in the study is the percentage of students’ and instructors’ satisfaction with each teaching method (traditional and E-learning). Secondary outcomes included barriers and difficulties faced, knowledge acquisition, and overall performance with each learning method.

Statistical analysis

Responses were automatically collected by Google Forms, then stored on Microsoft Excel and sent to SPSS statistics for Windows version 23.0 (IBM, Armonk, NY, USA) for statistical analysis. The data were only accessible to the authors. Association between variables was identified using Chi-square, and a univariate analysis was done. All *P* values were based on two-tailed tests of significance and <0.05 was deemed statistically significant.

RESULTS

Demographics and mode of learning

A total of 404 students responded, of which 244 (60.4%) were female and the mean age was 22.7 years. The respondents belonged to 28 of the 40 targeted universities across Saudi Arabia; however, 21% of respondents were from a single university: King Abdulaziz University, Jeddah. Regarding the mode of learning, 223 (55.2%) were from Group A, 102 (25.2%) from Group B, and 79 (19.6%) from Group C, as shown in Table 1. Table 2 shows the platforms used in the virtual learning experience.

In terms of instructors, only 20 responded, of which 15 were female (75%) and 14 (70%) were from King Abdulaziz University. Most of the course instructors (11, 55%) taught lectures traditionally, 3 (15%) taught virtually only and 6 (30%) taught using both methods.

Table 1: Number of students in each mode of radiology course (N=404)

Mode of learning	Frequency, <i>n</i> (%)
Traditional	223 (55.2)
E-learning	102 (25.2)
Traditional and E-learning	79 (19.6)

Table 2: Platforms used for attending virtual radiology lectures (n=102)

Application	Number of students, <i>n</i> (%)
Google classroom	55 (53.9)
Zoom	14 (13.7)
Blackboard	29 (28.4)
Others	4 (3.9)

Students' learning experience

Details of student attendance are shown in Table 3. Students felt more comfortable asking questions in traditional rather than virtual classes (62% vs 37.1%, respectively). Regarding the instructors' voice clarity, 76.2% and 64.7% of Group A and B students, respectively, found the instructors voice to be clear. In terms of understanding images described by the instructor, Group A students were more satisfied than those in Group B (70.4% vs. 60.8%, respectively) [Table 4]. The environment in which the lecture was attended was considered helpful for learning by both groups (about 68% for both).

Students' barriers

In terms of training received for using E-learning systems, 33.3% of Group B students were trained by their university compared to 54.4% of Group C students. In terms of barriers to E-learning, both Group B and C students similarly experienced internet issues of varying degrees (i. e., strongly or moderately agreeing) (76.5% and 69.7%, respectively) and had lack of devices (39.2% and 30.4%). For Group A and Group C, traffic and transporting were the main barriers to traditional learning (52.6% and 62.0%). The vast majority of Group A and Group C students (87.5% and 84.8%, respectively) considered E-learning as beneficial in overcoming these transportation barriers.

Students' knowledge acquisition and overall satisfaction

About 74% and 67.6% of Groups A and B students, respectively, were confident of transferring the knowledge from the courses to clinical practice. However, a larger proportion of students belonging to Group B (79.4%) scored $\geq 90\%$ in the radiology course than Group A (43.9%) [Figure 1]. The student scores were self-reported. The study found a significant correlation between the form of education studied and the grades obtained ($P < 0.001$).

The overall satisfaction with the course was 70.8% and 73.5% for Group A and B students, respectively. However,

Table 3: Students who attended >75% of radiology course

Mode of learning	Frequency, n (%)
Traditional (n=223)	176 (78.9)
E-learning (n=102)	83 (81.4)
Traditional + E-learning (n=79)	41 (51.9)

Table 4: Ease of understanding images described during lectures

Scale	Traditional, n (%)	E-learning, n (%)
Strongly disagree	4 (1.8)	6 (5.9)
Disagree	6 (2.7)	13 (12.7)
Neutral	56 (25.1)	21 (20.6)
Agree	83 (37.2)	34 (33.3)
Strongly agree	74 (33.2)	28 (27.5)

no correlation was found between the form of education and the overall satisfaction ($P = 0.067$). Of all students, 63.9% preferred learning through traditional classes and 67.8% were more focussed and attentive while attending it. Nonetheless, 80.0% considered E-learning as a valuable tool to save time and effort and that it is less stressful academically (61.9%) than traditional learning.

Instructors' attendance, teaching methods and difficulties

Instructors of both forms of education faced occasional difficulty in conducting their respective classes (25.0%). Group A instructors owed this to traffic and workload, while Group B owed this to workload. Instructors reported that more students belonging to Group A attended >75% of the classes than those in Group B (50% vs. 35%). There was also a significant correlation between the form of education and attendance ($P < 0.001$). Regarding the mode where instructors had more time to take queries from students, about 50% of the instructors allocated similar times for addressing their students' questions, while 35% stated that traditional classes allowed them more time. Of the six instructors conducting classes in both forms, 33.3% voted for more time to answer questions virtually, and an equal 33.3% voted for more time to answer questions traditionally.

Only 33.3% of the instructors had difficulties with Internet connection and considered technical difficulties as barriers to E-learning. Regarding background environment and recording for explaining lectures, 66.7% believed their environment was suitable for recording and explaining lectures and did not consider this to be a hindrance to teaching.

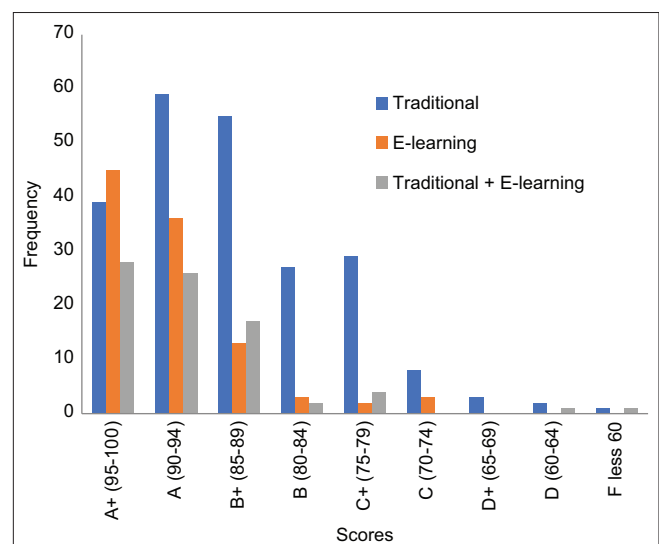


Figure 1: Student scores across the different modes of learning

Instructor-rated student performance

Most instructors (75.0%) reported that their students were more interactive during traditional classes [Table 5]. However, 40% of the instructors reported that the mode of learning did not affect the grades obtained by either group, while 35% reported that students attending only E-learning had higher grades than those attending traditional lectures; all grades were reported from course reports.

Overall satisfaction of instructors

The majority of the instructors (60%) considered E-learning to be helpful in balancing their workload and teaching responsibilities ($P = 0.029$). The majority also considered that teaching through the E-learning mode required less time and effort (80%) and that they would recommend it as the standard teaching method for radiology to undergraduate medical students (85%). In terms of the overall satisfaction, 30% of the instructors each were satisfied and dissatisfied with conducting radiology lectures through E-learning, while 20.0% were neutral.

DISCUSSION

This study found that in undergraduate medical students who undertook radiology course in the 2019-20 academic year, the form of education did not impact the overall satisfaction or the hypothetical ability to transfer knowledge to clinical practice. However, virtual learning was revealed to result in lower academic stress and more control over time and effort, while in traditional learning, students found it easier to focus and interact with the instructor. The findings of this study are coherent with that of a previous study's observation that altering the form of education will not likely show an immediate drastic change in the performance or practice of medical students,^[11] but given that there is no need for direct patient contact, the practicality of virtual learning may be useful.

A notable finding of the study was that most students (62.9%) preferred traditional learning over virtual learning, which is in contrast to the findings of Khalil *et al.*^[9] The reason for this discrepancy may also be because the vast majority of the students who undertook virtual learning did not receive formal training. Students being more comfortable interacting with their instructor in traditional learning could

Table 5: Instructor's opinion of higher student interaction during the course (n=20)

Mode of learning	Frequency, n (%)
Traditional	15 (75)
E-learning	2 (10)
Equal interaction in both	3 (15)

also be attributed to the lack of virtual learning training or to the newness of the platform as well.

The study found that a significantly higher percentage of students who undertook virtual learning scored $\geq 90\%$ in their radiology course. While the authors were unable to account for confounding variables for this parameter, this finding is similar to that observed by Salajegheh *et al.*, where students who were provided virtual learning in addition to traditional learning demonstrated higher knowledge, skills, and assessment scores in interpreting radiographs than those who only undertook the traditional course.^[7] Similarly, in one study where dental radiology was taught either traditionally or using a web-based approach, final examination results revealed significantly higher scores in those who studied using the web-based approach.^[12] Traditional education can be one-dimensional and vary in teaching style, whereas E-learning is more dynamic. This difference may be a contributing factor for the higher information retention rates and scores reported in the literature.^[13]

In our study, the instructors reported that students were more attentive and interactive in traditional education, which is similar to the findings of several studies in the literature. A study postulated that this may be because students are unable to skip content as they could in E-learning,^[14] while another argued that the quality of teaching may vary using E-learning and the lack of motivation provided by a real-life educator may hinder the incentive for students to learn.^[15] Despite this, most of our instructors preferred E-learning over traditional education, as it saved more time and allowed balancing workload and teaching responsibilities. A study performed early in 2021 concluded synchronous E-learning to be as effective as traditional education and could bridge the gap of impaired interaction.^[10] The effectiveness of isolated synchronous E-learning could be investigated in comparison to combined virtual and traditional classes. Integrating E-learning with traditional education would help build on the advantages of both teaching environments while also allowing students to individualize their learning approach. This teaching strategy was found to have the most weighted impact on performance by a group of researchers from Germany.^[11]

Limitations

This study has a few limitations. One limitation is the study design, wherein all data, including scores, are being self-reported by participants. In addition, there is a likeliness of recall bias due to difference in timelines when the lectures were attended/conducted throughout the sample. Similarly, the course content and assessment methods

across the universities may have differed, and thus affected the findings. The number of instructors who participated in the study were much lower than the required sample size and the majority (70%) belonged to a single institution. Therefore, the data regarding instructors in our study is both underpowered and not representative of instructors across Saudi Arabia. Nonetheless, these provide an insight that can be used for developing future studies that elicit instructor experience from a larger sample and teaching methods.

CONCLUSION

The study found that in undergraduate radiology education, the form of learning was not associated with the students' overall satisfaction or confidence in transferring knowledge to clinical practice. However, those who undertook E-learning showed significantly better academic performance and considered this mode to lower their academic stress and provide them more control over time and effort. In addition, a significant proportion of the radiology instructors reported that virtual training was helping in work–teaching balance and that they would recommend it as a standard teaching method for radiology to undergraduate medical students.

Ethical considerations

The study was approved by the Unit of Biomedical Ethics at King Abdulaziz University, Jeddah, Saudi Arabia (Reference number: 169-21). All participants were assured of data anonymity and provided informed consent before answering the questionnaire. The study adhered to the principles of the Declaration of Helsinki, 2013.

Data availability statement

The datasets generated during and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Peer review

This article was peer-reviewed by three independent and anonymous reviewers.

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Conflicts of interest

There are no conflicts of interest.

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