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The Effect of Online Learning on Students' Practical Assessment Results During the COVID-19 Lockdown Period

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Abstract

Purpose: **Online education was an inevitable approach during the COVID-19 lockdown period. We aimed to determine the effect of online learning on assessment results in courses containing practical learning objectives delivered during the pandemic.**

Method: **A retrospective analysis was performed on the assessment scores in courses conducted during the lockdown and on-campus years. Accumulative and objective structured practical examination scores were used as outcome measures for academic performance. Courses were categorized into pure practical, theory + practical, and pure theory.**

Results: **This study showed that online education increased student scores as evidenced by a higher P-value in theoretical (<0.0001) than pure practical courses (0.033).**

Discussion.: **High scores indicate the effectiveness of the implemented online learning and assessment approach. However, potential confounders, such as exam validity, reliability, and misconduct, require further investigation to ensure an optimum and legitimate learning experience in future unforeseen situations. In addition, learning gaps in complex and technical learning objectives (e.g., prepare, perform, and operate) were identified and integrated in the following academic year.**

Keywords: COVID-19, Pandemic, Online learning, Laboratory learning, Practical learning

1. Introduction

After being identified in late 2019, coronavirus disease, officially named COVID-19, rapidly spread across borders. COVID-19 is caused by the severe acute respiratory syndrome coronavirus type 2. The number of infected individuals and relevant deaths was soaring, forcing the World Health Organization to declare a state of a pandemic on March 2020 [1]. During this period, no effective therapeutic regimens or vaccines were available, and different non-pharmaceutical interventions and preventive measures were implemented. These controls include wearing masks, social distancing, and self-isolation for disease carriers and suspects. Several quick and drastic global actions were taken, including universities' closure, which severely disrupted the everyday educational routines [2]. Such protective measures aimed to slow down the spread of the disease.

Saudi Arabia has imposed a nationwide lockdown with strict restrictions on social gatherings to combat the spread of COVID-19. Thus, online learning was nationally adapted to deliver the remaining curriculums. This new learning method revealed various challenges, such as the availability and readiness of infrastructure, skills, mindset, and other supporting factors. Accordingly, different academic institutions have developed contingency plans based on available resources.

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Several studies have shown that COVI-19 related closures negatively affected student achievement in primary and secondary education (Reviewed by Hammerstein et al., 2021) [3]. Relatively similar challenges were also evident in medical education necessitating the development of innovative teaching and assessment methods [4–8]. Studies have shown that medical students' academic performance, motivations, and mental health indicators have remained relatively high during the pandemic [9–11].

Our Clinical Laboratory Sciences (CLS) program [12] has adopted online learning during the complete lockdown period. The CLS program aims to educate and equip future laboratory technologists with the knowledge, skills, and attitudes. Thus, they can provide clinical laboratory information and services to diagnose and treat diseases. Program learning outcomes cover basic skills and competencies aligned with the national qualification framework. Each academic year is divided into two semesters, each of which is subdivided into different course blocks. Each block delivers focused content to prepare students with the skills and competencies in the fields of clinical chemistry, hematology, immunology, immunohematology and transfusion medicine, microbiology, molecular genetics, cytogenetics, histopathology, and other emerging diagnostics, laboratory management, and operations. In courses with laboratory-based learning methods, students perform various tests, ensure the quality of test results, demonstrate laboratory tests' significance, evaluate new methods, investigate tests' effectiveness, etc.

Following the mandatory nationwide lockdown, courses with theoretical learning objectives were shifted to online learning delivery and assessment utilizing available infrastructure and resources. Challenges were prominent for courses requiring onsite hands-on learning and assessment, particularly those designed for pure practical delivery methods and theoretical and practical learning objectives. Practical learning objectives were virtually delivered via virtual lectures, videos, pictures, elongated discussions, and virtual laboratories. The summative assessment included midterm exams, quizzes, assignments, final written exams, and the objective structured practical examination (OSPE). Assessment of practical learning objectives mainly relied on the online OSPE. The online OSPE was conducted via the blackboard learning platform and contained multiple-choice questions, modified essay questions, and short essays targeting the higher domains of Bloom's taxonomy. These questions were grouped into different stations, which were timed and shuffled across examinees to minimize misconduct and recapitulate onsite OSPEs. However, certain learning objectives cannot be measured through online OSPE and therefore were formatively assessed through group discussions.

The sudden shift to online learning has revealed many benefits as well as challenges. Few studies have reported their experience with virtual learning and assessment of practical skills during the COVID-19 pandemic [5,7,13,14]. Sharing knowledge about the impacts of digital technology integration on learning delivery and assessment will help to pinpoint areas for improvement to prepare for future unforeseen situations. Accordingly, this study aimed to assess the effect of online learning on student assessment results in courses with practical learning objectives.

2. Methods

This study was approved by the institutional review board at King Abdullah International Medical Research Center (SP21R/435/10). A retrospective analysis of student assessment results was conducted for academic years 2018–2019 (on-campus), 2019–2020 (online), and 2020–2021 (on-campus). The analysis focused on courses affected by the lockdown period (from March 2020 to May 2020) and delivered to third- and fourth-year CLS students (107 students) attending the King Saud bin Abdulaziz University for health sciences. These courses are divided into three different types: pure practical (molecular diagnostics laboratory), theory + practical components (microbiology, blood bank, and immunology clinical education courses), and pure theoretical courses (molecular diagnostics, parasitology, and laboratory medicine seminar). These courses ran simultaneously in all campuses (central, western, and eastern regions) and went through the different academic years (on-campus, online, and on-campus, respectively) while maintaining the same learning objectives. Encrypted assessment results (OSPE and accumulative scores) were obtained from the College of Applied Medical Sciences' assessment units for all students in the above courses and years. Data from on-campus academic years 2018–2019 and 2020–2021 were combined for comparison. The main objective was to compare the scores of groups attending online only with groups attending on campus. Course accumulative and OSPE scores were used as outcome measures for academic performance. Students' accumulative and OSPE scores in all courses were evaluated. The performance scores of OSPE were re-scaled, ranging from 0 to 100. The theoretical

courses were removed from the analysis of OSPE scores. Means and standard deviations were used to describe outcome measures. General linear models' analysis of variance was used where the total score and OSPE score are the dependent variables. Here, the model of interest explores whether learning delivery methods predict student performance. The model fit is evaluated using the adjusted R^2 value. The regions are the source of noise or variation in performance. Although all campuses follow a common format for course delivery, differences in course applications between the three campuses cannot be avoided; therefore, it was controlled to reduce any potential variation in the dependent variables. Then, the impact of the differences in learning delivery methods on the accumulative and OSPE scores of each course was evaluated separately. Course type, delivery methods, and the interaction between the course type and delivery method were considered to evaluate the differences between different course types. A p-value <0.05 was statistically significant. Data were analyzed using JMP, version 15 (SAS Institute Inc., Cary, NC, 1989–2021).

3. Results

The study included data from 649 scores collected from three campuses: central (n = 253, 39%), western (n = 100, 15.4%), and eastern campus (n = 296, 45.6%). The accumulative grade performance of students enrolled in the desired courses was collected for online (2019–2020) and on-campus offerings (2018–2019 and 2020–2021). Table 1 presents the details of students' performance measured in total scores and OSPE scores for courses and modes of learning delivery.

The group of students taking online courses had statistically significantly higher accumulative scores than those students taking on-campus courses (Table 2). Our models for predicting the total student scores as a function of learning delivery methods explained approximately 22%–35% of the variability in the performance depending on the course type. Results also show that the group of students who had online courses had statistically significantly higher OSPE scores than those taking on-campus courses.

Our models for predicting students' OSPE score as a function of learning delivery methods explained approximately 6%–26% of the variability in the performance depending on the course type (Table 3).

4. Discussion

Practical application of skills is essential for developing the robust performance of healthcare professionals. Courses with practical components

Table 1. Descriptive statistics of students' performance (total scores and OSPE scores).

Course type	Delivery method	Region	n	Total score		OSPE score	
				Mean	Std. Deviation	Mean	Std. Deviation
Theory	On campus	Central	47	78.9	12.0	–	–
		Western	14	89.6	5.3	–	–
		Eastern	46	90.2	6.6	–	–
		Total	**107**	**85.2**	**10.7**	**-**	**-**
	Online	Central	24	94.3	5.7	–	–
		Western	11	96.3	2.7	–	–
		Eastern	23	88.4	2.7	–	–
		Total	**58**	**92.4**	**5.3**	**-**	**-**
Theory + practical	On campus	Central	84	79.7	10.7	68.2	17.8
		Western	32	91.5	5.7	89.2	8.1
		Eastern	102	86.1	7.1	77.3	16.5
		Total	**218**	**84.5**	**9.5**	**75.5**	**17.5**
	Online	Central	43	91.2	11.6	80.8	7.6
		Western	18	95.1	2.6	87.9	12.1
		Eastern	46	87.3	5.2	81.2	13.0
		Total	**107**	**90.2**	**8.6**	**82.2**	**11.2**
Practical	On campus	Central	36	78.3	10.2	68.2	14.1
		Western	18	89.9	7.1	86.8	12.5
		Eastern	56	88.4	6.2	83.0	9.3
		Total	**110**	**85.3**	**9.2**	**78.8**	**13.8**
	Online	Central	19	84.9	9.9	73.5	20.9
		Western	7	93.1	2.5	92.9	8.1
		Eastern	23	93.7	4.6	87.4	8.6
		Total	**49**	**90.2**	**8.1**	**82.8**	**16.3**

Table 2. General linear model analyses.

Course type	Source	df	F	P-value
Theory	Delivery method	1	22.56	<0.0001
	Error	159		
	(Adjusted $R^2 = 0.35$)			
Theory + practical	Delivery method	1	28.87	<0.0001
	Error	322		
	(Adjusted $R^2 = 0.22$)			
Practical	Delivery method	1	11.71	0.001
	Error	153		
	(Adjusted $R^2 = 0.30$)			

Notes: "df" denotes degrees of freedom. The dependent variable used in the analysis is students' total score.

were difficult to deliver and assess during the complete lockdown period. These courses cover several essential skills and competencies, including communication skills, physical examination skills, clinical skills, and technical skills.

No empirical evidence evaluates learning objective outcomes of online learning compared with traditional learning approaches, particularly on teaching and assessing practical skills. Several randomized control trials have shown the effectiveness of distance learning on complex practical clinical skills with comparable learning outcomes and assessment [7,15–17]. For example, in a cardiopulmonary resuscitation course, the passing rate for students attending traditional classrooms was comparable with that for students using the video self-instruction method at the initial examination or re-examination after 1 year [17]. In another randomized control trial on undergraduate health professional students, different teaching methods for practical skills, such as pre-recorded video tutorials, student self-video, and traditional instructor-led methods, have shown comparable learning outcomes in the objective structured clinical examination; students perceived a higher educational value for the non-traditional methods [15]. A relevant study by Dolan et al. [16] also demonstrated the effectiveness of online learning on teaching the practical and theoretical skills required for resting electrocardiogram (ECG) electrode placement and interpretation, with comparable OSPE results. Thus, most aspects of the practical skill were similarly conveyed using the online teaching approach. However, another study has shown that students who learned online were less accurate at placing the ECG electrodes than their counterparts in the classroom-based group [18].

In a medical biochemistry course, cognitive and psychomotor learning domains were assessed using the electronic OSPE (e-OSPE) approach; results were reliable compared with the traditional OSPE [13]. However, the authors have highlighted numerous limitations to applying this approach for assessment. They include issues with slow Internet connectivity, misuse through unfair means, and challenges with assessing the affective domain. In addition, e-OSPE could not fully recapitulate real-life situations produced by the pressure of working under close observation in traditional OSPE. In addition, numerous studies have highlighted certain negative aspects of online learning, including poor student engagement, social isolation, lack of trust in peers' knowledge and expertise, technological difficulties, and employer perception of its credibility [19–23]. Therefore, an appropriate instructional design is required to overcome such obstacles [21,24].

Our CLS program has a unique teaching and learning environment, represented in the synergistic efforts of highly skilled full-time academicians, collaborative researchers from the attached research center, and joint appointed clinical practitioners from

Table 3. General linear model analyses.

Course type	Source	df	F	P-value
Theory + practical	Delivery method	1	13.69	<0.0001
	Error	322		
	(Adjusted $R^2 = 0.06$)			
Practical	Delivery method	1	4.6	0.033
	Error	153		
	(Adjusted $R^2 = 0.26$)			

Notes: "df" denotes degrees of freedom. The dependent variable used in the analysis is students' OSPE score.

the regional attached hospitals. The synergistic efforts are arguably an effective method for exposing students to various learning opportunities. Such opportunities support the overarching CLS program's mission in graduating highly skilled technologists capable of conducting research and performing community services. During the complete lockdown period, content experts designed online teaching and assessment activities, considering their appropriateness to the desired learning outcomes.

Our study has shown improved assessment results with the online learning delivery and assessment approach, suggesting that students' motivation has not been affected and they may have had more time to study during to the pandemic. However, it overlooked many potential skewers, such as gender, students' GPA, stress level, exam misconduct, exam reliability, and validity which may also explain the variability across studies. However, multiple pieces of evidence indicate the reliability of online teaching and assessment for practical skills in health education, which agrees with this study. In addition, the limitations of using the online learning approach for complex and technical practical skills and competencies must be considered. For our cohort of students, arrangements were made to remediate learning gaps in the next academic or internship years.

Ethical approval

This study was approved by the institutional review board at King Abdullah International Medical Research Center (SP21R/435/10).

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Other disclosure

None.

Conflict of interest

The authors have no conflict of interests to be declared in connection with this manuscript.

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