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Research Article

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Feasibility of Online Classes for Microbiology Courses: Lessons learned amid COVID-19 Pandemic

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Abstract: Universities and colleges worldwide have been closed following the novel coronavirus (COVID-19), and online learning has become an educational practice at once. Previous research showed many problems, including time management difficulties, technological devices, communication, engagement and assessment of students for both educators and students in online education. This research was formulated to understand whether online microbiology courses from different Saudi Universities are appropriate. It was a nationwide cross-sectional study among educators from multiple Saudi Arabian Universities during the whole month of June 2020. We distributed the survey link electronically through messages on the phone. A total of 134 Saudis participated in the study, and the majority of the respondents, i.e., 106 (79.10%) are between 36 to 55 years old, 17 (12.69%) are 56 years and above. A total of 65 (48.51%) respondents responded that shifting from in-classroom to online setup has impacted the teaching-learning process negatively, while 43 (32.09%) responded with a positive impact. The majority of the respondents (82%) disagreed that practical learning outcomes such as laboratory-based microbiology courses can be achieved online at the same level as regular-campus classes.Furthermore, more than half of the participants think that students' dishonesty or violation of academic integrity threatens institutions from offering online courses. Technology tools have brought a positive impact on the effectiveness of online microbiology education. This study illustrated that the shift to online microbiology classes has a positive impact on attention to academic integrity. However, in-person labs are still considered the optimal lab design. While pandemics have historically generated difficulties, recognizing these difficulties is the first step in turning them into possibilities.

Keywords: COVID-19; Learning activities; Microbiology; Online Pedagogy; COVID Awareness

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1. INTRODUCTION

Educational institutions are facing more difficulties due to the COVID 19 Pandemic. This crisis has illustrated many shortcomings and disparities within educational system-from internet connectivity and devices required for online learning to enabling learning environments and the misalignment of resources and requirements. The novel coronavirus disease or COVID-19 was declared a pandemic (the worldwide spread of a new disease) by the World Health Organization (WHO) on 11th March 2020. Most clinical manifestations present as an acute respiratory disease with fever, cough, and a sore throat; nevertheless, in moderate to severe patients, the infection advances to breathing troubles, respiratory distress, and extra-respiratory manifestations including cardiac and renal injury and even death.[1] Community transmission became an important issue where numerous countries announced progressive lockdown measures in response to the increasing number of COVID-19 cases. A person was only authorized to leave his home for work, buy food, or obtain or provide healthcare services. [2] Minimizing personal interactions to mitigate and control the spread of this Pandemic had pressurized Universities and colleges to evacuate their classrooms and retain the students away from the establishments. One of the most immediate modifications implemented has been the widespread cancelling of traditional face-to-face teaching methods, with most being replaced by online teaching with recorded lectures, live-streams, or a combination of online and regular teaching (blending). The blended approach classes include replacing part of the in-person interaction with online guidance.[3,4] In Saudi Arabia, most establishments have shifted to distance learning in the most accessible and convenient possible ways, such as conferencing platforms, emails, and mobile message systems. [5] A previous study evaluating online microbiology courses for non-science majors showed no statistical difference between face-to-face and online courses where both concepts were equally satisfactory. However, the laboratory and proctored tests persisted face-to-face.[6] For the microbiology curriculum, laboratories are essential for educators. In recent years, online laboratories have attracted attention from many medical institutions. Some educators developed an electronic guide for introductory microbiology skills. Students participating in the laboratory practices with an online guide scored statistically significantly higher than those not using the online guide.[7] Visual learning was the most prominent advantage of the online laboratory experience, where a past investigation reported a high score of online microbiology students in favour of visual learning (77%). Furthermore, online microbiology students reported access and utilization of the laboratory content more useful than the in-person group. In addition, online activities offer students the opportunity to try exercises many times, a feature for in-person labs that is too costly and strenuous.[8] Another study found that the opportunity to reattempt exercises was received favourably by students, further supporting its cost-effectiveness. [9-11] However, the low cost can be relative to the level of education and the field of coursework.[12] In some departments, higher levels of education may require more comprehensive, costly simulations. Regardless of these costs and benefits, the outcome of the study[12] argue that it is recommended that instructors use laboratories (online or in-person) as the primary method of learning for case discussion.[13] Under these circumstances, previous studies reported multiple challenges for both educators and students in online education, including difficulties with time management, use of technology devices, communication, interaction, and 'students' evaluation.[14] Furthermore, many students do not have access to laptops or a perfect internet connection. Also, educators, especially older teachers, have technophobia where they are concerned or not confident enough about dealing with computers and software in their classrooms. [15] In contrast, other commentators reported the beneficial impact of online and technology-enabled education as implementing technology into medical teaching would enable students to acquire collaborative abilities and enhance adjustability.[15] Even before the Pandemic, there was previously a high increase and selection of education technology. It was believed that online education is equally effective as traditional face-to-face learning.[16] In a recent study analyzing the impact of the COVID-19 Pandemic on online education in Saudi Arabia, most of the participants preferred mixing online with face-to-face guidance.[17] Furthermore, many studies have described that hybrid learning is getting more approval amongst academic institutions due to its combination of the best of both worlds.[17] Nevertheless, its effectiveness depends on various determinants, such as sufficient training and faculty support.[18] The novel coronavirus presently has a face for every student displayed during their occupations and lives. As students and faculty staff are adjusting throughout this Pandemic, it will be essential to investigate the volume to which the modifications are currently being introduced due to COVID-19. This questionnaire-based research has been constructed to understand better the suitability of delivering Microbiology Courses online in different Saudi Arabian universities.

1.1 Research Background

In the education of medical and microbiology around the world, e-learning has been increasingly used[1,7] or context, faculty members have already used technology to flip the classroom, accompanied in recent years by small-group discussions or experiences in colleges and universities.[8] Like many nations, the Kingdom of Saudi Arabia (KSA) has sponsored universities to change their curriculum. The Ministry of Education (MOE) of KSA, for instance, developed the National Centre for E-learning and Distance Learning (NCEDL)for the implementation of e-learning in education, especially in higher education institutions .

2. MATERIALS AND METHODS

We conducted a nationwide cross-sectional study among educators from different Saudi Arabian universities during the whole month of June 2020. We distributed the survey link electronically through social media such as Whatsapp and Facebook messages. Participation was voluntary, anonymity was guaranteed, and consent was obtained at the start of the survey. In order to simplify the distribution and improve reliability of data collection, student participants have been asked to complete the online self-reporting questionnaire. Individualized emails were sent to participants, including a connection to the questionnaire and a statement telling them that participation is necessary, but at the same time it is complete and that their identities will remain secret to the research team in order to preserve privacy and that their answers will be strictly confidential. The informed consent form that was attached to the first page of the survey contained extensive details on the intent of the research, costs, and benefits.

2.1 Data collection

After approaching all Saudi Arabia Universities (Numbers of total approached universities can be given), educators from 16 universities accepted to participate in the study. The questionnaire was developed using available literature, and after the initial pool of questionnaire items were written, 12 qualified experts reviewed the items and validated the questionnaire. It is composed of 3 categories: Preparation of demographic questions determine whether students were well trained to engage in online learning and whether the University was promoting online training before COVID-19 appeared. This area also demanded that students continue their education as a conventional approach in online learning. The students' convictions were obtained about the faculty's preparedness for online learning. Finally, there were few questions aimed at assessing the readiness of students to learn online in terms of history and technological know-how. The questionnaire also contained the demographic information of respondents such as Gender, Degree, and Affiliation. In addition, the questionnaire included questions about the experience of faculties in microbiology teaching. It will be helpful to analyze the faculty skills and their interaction with students. Attitude towards the online learning questions (a total of 16 questions/parameters) were more than preparations to identify the positive or negative experience of the student. The questions included student knowledge of this new experience, online learning quality, learning, and learning online as a new standard. Furthermore, this area also included the skills of pseudo-motors, such as ease of use and adoption to other tasks such as homework and assignment. Five questions were included to evaluate student attitudes towards the didactic in-class approach compared to the online learning approach in terms of interests, productivity and workload, to prevent questions leading to responses to surveys and to minimize bias. Finally, to investigate the integrity of online teaching and assessment, a total of 7 questions were used to identify the academic integrity of faculties and students, issues of student dishonesty during online class and violation of academic integrity, and whether students avail outside support to answer the questions in the examination.

3. STATISTICAL ANALYSIS

Reports were collected then coded and revised, and data was introduced on statistical software IBM SPSS version 22.0. All statistical analysis was done using two-tailed tests and an alpha error of 0.05. P-value less than 0.05 was considered to be statistically significant. Frequencies and percentages were used to describe the demographics and attitudes of study participants.

4. RESULTS

4.1 Sociodemographic characteristics

Table 1 presents the demographic information of participants. A total of 134 educators participated in the study, 73.13% of them were females. The majority (79.1%) had an age range of 36-55 years old, followed by 12.69% who were aged 56 years and above. Only 9 participants are working in a private university. A total of 18 educators were from Jeddah, 9 from Dammam, and 8 from Najran. Almost all of the participants had a Ph.D. degree (94.78%), and the rest had a 'master's degree. As for their specialization, 102 educators majored in Bacteriology, followed by 20 majors in Mycology and 12 in Virology. Among educators who specified their position, 18.6% were assistant professors, 10.45% were professors, and 4.48% were lecturers. Half of the participants (49.25%) had more than 15 'years' experience in teaching microbiology in a faculty, and 41.79% had 5 to 15 years of experience.

Table. 1 Demographics of Participants, N=134

Parameters	Participant Demographics	N	(%)
P1	**Gender**		
	Female	36	26.87
	Male	98	73.13
P2	**Age**		
	Less than 35 years old	11	8.21
	Between 36 to 55 years old	106	79.10
	56 years old and above	17	12.69
P3	**Affiliation**		
	Public (Governmental) University	125	93.28
	Private University	9	6.72
P4	**City ' '**		
	Abha	1	0.75
	Al Ahsa	6	4.48
	Al Bahah	1	0.75
	Al Hofuf	1	0.75
	Alkharj	5	3.73
	Almajmaah	2	1.49
	Almujmaea	1	0.75
	Alriadh	1	0.75
	Arar	2	1.49
	Assiut	1	0.75
	Buraydah	4	2.99
	Cairo	1	0.75

	Dammam	9	6.72
	Hafr Al Batin	2	1.49
	Hail	4	2.99
	Hofuf Al-Ihsa	1	0.75
	Jeddah	18	13.43
	Khafji	4	2.99
	Majmaah	5	3.73
	Makkah	2	1.49
	Medina	1	0.75
	Najran	8	5.97
	Rafha	1	0.75
	Riyadh	27	20.1
	Sakaka	16	11.9
	Taif	10	7.46
P5	**Degree**		
	PhD	127	94.78
	Masters	7	5.22
	Bachelors	0	0.00
P6	**Specialization**		
	Bacteriology	102	76.12
	Virology	12	8.96
	Mycology	20	14.93
P7	**Position (Optional)**		
	Assistant Professor	25	18.66
	Professor	14	10.45
	Lecturer	6	4.48
	Head of Department	3	2.24
	Researcher	2	1.49
	Did not identify	84	62.69
P8	**Number of Years of Experience in Teaching Microbiology as a Faculty:**		
	Less than five (5) years	12	8.96
	Between five (5) and fifteen (15) years	56	41.79
	More than fifteen (15) years	66	49.25
N indicates the participants and (%) shows the percentage of participants			

4.2 Attitudes toward the conduct of online teaching

A total of 65 educators (48.51%) found that shifting from in-classroom to online (due to Covid-19) has negatively impacted the teaching-learning process, while 32.09% reported a positive impact. The majority of the participants (70.9%) stated that students and faculty members experienced the same difficulties of online teaching. Similarly, 62.69% of the participants reported that online microbiology teaching is suitable for senior and junior faculty. Only 9 educators thought that learning outcomes of Microbiology courses cannot be achieved through the online approach. More than half of the participants (67.91%) partially modified their courses in response to learning modification. The most useful teaching approach was on-time virtual classes (38.81%) followed by PowerPoint slides (36.12%), whereas assignments & student presentations were found least useful (47.01%). The majority (32.09% and 25.37%) (Please clear the numbers) agreed that online theoretical microbiology courses can be achieved at the same level as regular on-campus classes. However, for practical (lab-based) courses, the majority disagreed on its outcomes. Almost 40% of educators responded that online education is more appropriate for microbiology courses. More than half of the respondents agreed that online education issues and challenges can be resolved with time. Table 2 presents the questionnaire employed in the survey for collecting the responses related to attitude towards the conduct of online teaching. Figure 1 shows the graph of the highest number of responses collected through the survey questionnaire. More responses collected for parameter 5 indicates that both faculties and students focus on all the fields of microbiology.

Table 2. Distribution Response of 'Participants' Attitudes Towards the Conduct of Online Teaching, N = 134

Parameters	Questions and Response	N	(%)
P1	**Shifting from in-classroom to online (due to Covid-19) has impacted the teaching-learning process.**		
	· Positively	43	32.09
	· Negatively	65	48.51
	· No impact	26	19.40
P2	**Those who experience more difficulties in the shift to the online approach are:**		

	· Faculty members	12	8.96
	· Students	27	20.15
	· Both experienced the same difficulties	95	70.90
P3	**The online approach is more suitable for:**		
	· Introductory courses	57	42.54
	· Advanced courses	16	11.94
	· The same	61	45.52
P4	**Online teaching approach is more suitable for :**		
	· Senior faculty	27	20.15
	· Junior faculty	23	17.16
	· The same	84	62.69
P5	**The most challenging branch of Microbiology to go online is :**		
	· Bacteria	7	5.22
	· Viruses	1	0.75
	· Fungi	8	5.97
	· All the same	110	82.09
	· Don't know	8	5.97
P6	**Learning outcomes of Microbiology courses can be achieved through the online approach.**		
	· Yes	34	25.37
	· No	9	6.72
	· Partially	91	67.91
P7	**In response to the change of teaching strategies (due to the Pandemic),have you modified the course learning outcomes?**		
	· Yes (Major modifications)	27	20.15
	· No	21	15.67
	· Slightly	86	64.18
P8	**During the Covid-19 period, what was the teaching approach you found most useful?**		
	· PowerPoint Slides	35	26.12
	· Videos	18	13.43
	· On-time Virtual classes	52	38.81
	· Assignments & Students Presentations	19	14.18
	· Other: Discussion	10	7.46
P9	**During the Covid-19 period, what was the teaching approach you found less useful?**		
	· PowerPoint Slides	22	16.42
	· Videos	31	23.13
	· On-time Virtual classes	14	10.45
	· Assignments & Students Presentations	63	47.01
	· Other:	4	2.99
P10	**During the Covid-19 period, what was the Assessment Method you found most useful?**		
	· Assignments & Students Presentations	55	41.04
	· Quizzes	49	36.57
	· Virtual Verbal Exam	26	19.40
	· Other:	4	2.99
P11	**During the Covid-19 period, what was the most useful online teaching solution?**		
	· Blackboard or Moodle	90	67.16
	· Google Classroom	8	5.97
	· Zoom	36	26.87
	· Other:		
P12	**Theoretical learning outcomes of microbiology courses can be achieved online at the same level as regular in-campus classes.**		
	· Strongly Agree	34	25.37
	· Agree	43	32.09
	· Neutral	23	17.16

	· Disagree	28	20.90
	· Strongly Disagree	6	4.48
P13	**Practical learning outcomes (lab-based) of microbiology courses can be achieved online at the same level as regular in-campus classes.**		
	· Strongly Agree	2	1.49
	· Agree	11	8.21
	· Neutral	11	8.21
	· Disagree	57	42.54
	· Strongly Disagree	53	39.55
P14	**Hospitals and research centers are increasingly move towards automated microbiological procedures, Therefore, Microbiology courses should be automated (online education).**		
	· Strongly Agree	4	2.99
	· Agree	22	16.42
	· Neutral	40	29.85
	· Disagree	43	32.09
	· Strongly Disagree	25	18.66
P15	**As online education allows teaching all kinds of microorganisms in the same way regardless of their pathogenicity level. Therefore, online education is more appropriate.**		
	· Strongly Agree	8	5.97
	· Agree	33	24.63
	· Neutral	39	29.10
	· Disagree	41	30.60
	· Strongly Disagree	13	9.70
P16	**Current difficulties and challenges of the online education can be solved by time.**		
	· Strongly Agree	15	11.19
	· Agree	63	47.01
	· Neutral	39	29.10
	· Disagree	10	7.46
	· Strongly Disagree	7	5.22
N indicates the participants and (%) shows the percentage of participants			

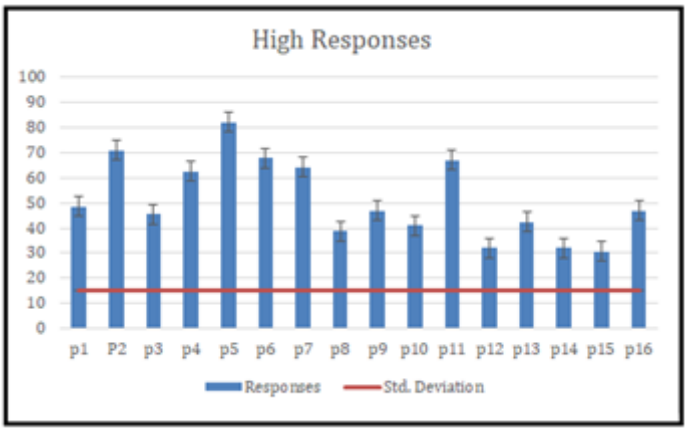

Fig 1: Attitudes Towards the Conduct of Online Teaching

4.3 Attitude on the academic integrity of online tests

A higher proportion of respondents (27%) (27% is not higher, the percentage for neutral is higher) agreed that academic integrity (for faculty and students) is assured in the online classroom setup, while 44.03% were neutral. More than half of the faculty confirmed that dishonesty is a significant issue of online classes and a threat to institutions offering this approach. The majority agreed that a)students consulting help from other people or b)the ones browsing the web opening and accessing notes or other sources without the teacher's consent while taking the exam, and c)even students asking someone to take the test on his or her behalf, are all form of dishonesty and problems in the conduct of online classes. Table 3 shows data related to the attitude on the academic integrity of online tests. Figure 2 illustrates the highest responses in table 3. All faculties and students agreed with P2 and P6.

Table 3. Distribution Response of 'Participants' Attitude on the Academic Integrity of Online Tests, N =134

Parameters	Questions and Response	N	(%)
P1	**Academic integrity (for faculty and students) is assured in the online classroom setup.**		
	· Strongly disagree	13	9.70
	· Disagree	26	19.40
	· Neutral	59	44.03
	· Agree	34	25.37
	· Strongly agree	2	1.49
P2	**Student dishonesty is a major issue in the conduct of online classes.**		
	· Strongly disagree	5	3.73
	· Disagree	11	8.21
	· Neutral	31	23.13
	· Agree	63	47.01
	· Strongly agree	24	17.91
P3	**Students' dishonesty or violation of academic integrity is a threat to institutions from offering online courses.**		
	· Strongly disagree	4	2.99
	· Disagree	13	9.70
	· Neutral	38	28.36
	· Agree	59	44.03
	· Strongly agree	20	14.93
P4	**Students consulting help from other people while taking the exam is a form of dishonesty and is a problem in the conduct of online classes.**		
	· Strongly disagree	2	1.49
	· Disagree	6	4.48
	· Neutral	21	15.67
	· Agree	57	42.54
	· Strongly agree	48	35.82
P5	**Students browsing the web while taking the exam is a form of dishonesty and is a problem in the conduct of online classes.**		
	· Strongly disagree	2	1.49
	· Disagree	6	4.48
	· Neutral	27	20.15
	· Agree	56	41.79
	· Strongly agree	43	32.09
P6	**Students opening and accessing notes or other sources without the teacher's consent is a form of dishonesty and is a problem in the conduct of online classes.**		
	· Strongly disagree	1	0.75
	· Disagree	5	3.73
	· Neutral	27	20.15
	· Agree	63	47.01
	· Strongly agree	38	28.36
P7	**Students asking someone to take the test on his or her behalf is a form of dishonesty and is a problem in the conduct of online classes.**		
	· Strongly disagree	3	2.24
	· Disagree	4	2.99
	· Neutral	21	15.67
	· Agree	49	36.57
	· Strongly agree	57	42.54

N indicates the participants and (%) shows the percentage of participants

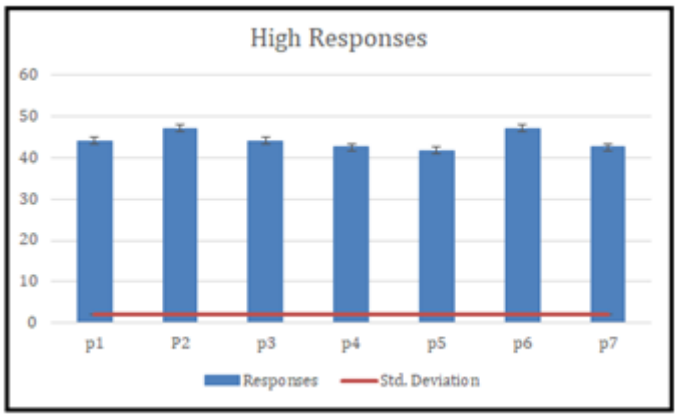

Fig 2: Attitude on the Academic Integrity of Online Tests

5. DISCUSSION

Currently, the novel coronavirus is disturbing routines in hospitals, medical institutions, and beyond. The health outcomes and fatality are already catastrophic, and medical teaching, including microbiology, is being adjusted in response to this international emergency. Almost all universities and colleges around the world have been closed, and online learning has immediately become an educational norm. The full impact of COVID-19 on education is yet unknown. Under these circumstances, educators and students may find the rapid shift to online education distracting and frustrating. Previous reports have predicted that it might take 5 to 10 years to recover from this crisis.[13] As a consequence, it is necessary to document and investigate the full extent of the modifications made in education services due to this global threat to simplify the recovery from this Pandemic. A reasonable number of faculty educators responded in this timely study to present their attitudes towards online classes for microbiology courses. Only 8.2% of the respondents aged less than 35 years, thus, older educators reported being not confident enough about dealing with computers and software in their classrooms[10] this may explain the disagreement of online teaching and learning by almost half of the study respondents. Almost half of the faculty respondents (48.51%) reported the negative impact of shifting the teaching-learning process from in-classroom to online education during the COVID-19 Pandemic, while 32.09% reported its positive effect. However, these findings did not align with a previous study conducted at the College of Medicine (COM) of AlFaisal University in Riyadh reporting a higher positive view of the Pandemic's impact, whereas 78.9% of faculty reported a positive impact of online education and only 13.2% reported a negative impact.[4] A recent study found that e-learning in an introductory course to Clinical Microbiology can positively improve examination performance.[14] It must be noted that integrating the skills needed for online education into application demands sufficient faculty professional improvement.[13]The results of this study support that the majority of the respondents (82%) disagreed that practical learning outcomes such as laboratory-based microbiology courses can be achieved online at the same level as regular on-campus classes. The existing studies reported that students preferred some in-person microbiology lab instruction and felt more involved in the learning process and physically interacting with an instructor. [7,15] Previous research work has primarily focused on comparing online and in-person microbiology labs, where students valued the hands-on practice of in-person laboratories but additionally admired the visuals unique to the online setup. Furthermore, online labs were found more convenient than in-person labs. [7,15,16] In contrast, when receiving the identical material in lecture format before the lab experience, online lab students felt that they encountered completely new material during their experience than the face-to-face lab students.[7] Given that more than half of the participants agreed that academic learning outcomes of microbiology courses can be achieved online similarly to in-person classes, the faculties may implement a combination of online (for theoretical courses) and regular teaching (lab practices), or what's called blending. The Microbiology and Cell Science Department at the College of Agricultural and Life Sciences at the University of Florida developed a blended curriculum in which some theoretical portions of the course were completely online, while laboratories and exams were in-person. After a long-period assessment, there was no difference between the experiences of program students and on-campus students.[17] Another study in Iran found that a blended approach (with e-learning) enhanced clinical skills in nurses.[18] The widespread dependency on the online education and appraisal platform raises the risk for academic integrity. The ease of accessing, duplicating, manipulating and adding knowledge in one's work adds issues of academic dishonesty, stealing and plagiarism and can lead to an insufficient understanding of the unethical nature of the use of online materials. It was important to see how the institution remained concerned with academic integrity, even though academic integrity (for teachers and students) is guaranteed during the online classroom structure. These study results showed over one-half of participants that online courses are a threat to institutions because of student dishonesty or breach of academic integrity. Recent research has also found that the major obstacle faced by participants (students and teachers) in online health education was interacting during the COVID-19 pandemic.[4] Online student evaluation, as stated in this review, and other technological challenges reported. These problems mimic those in online learning during non-emergency conditions. [8,9] The difficulties were identical. The present study was conducted in Saudi Arabia. Only faculty educators (Assistant Professors, Professors, Lecturers, Heads of Department, etc…) were invited to participate. Secondly, we did not capture or acquire the 'students' perception or attitude towards online microbiology learning. Thus, the primary limitation is the lack of generalizability of study results. Despite these limitations, the present study is the first in Saudi Arabia to provide relevant insights into attitudes towards online microbiology classes and academic integrity in the time of a public health crisis. During this international

emergency, it is assumed that medical curricular adjustments should be flexible regarding delivery and administration, developing the present pedagogical design. The governance composition of the curriculum should be sustained to secure compliance with accreditation standards. It has been stated that the efficacy of online learning is equal or superior to that of in-person learning. [13, 14, 19] Students performed similarly in online and in-person laboratories in a recent study. However, the studies identified some benefits from online laboratories, such as decreased instruction time, decreased faculty/staff time, and greater intrinsic student motivation. [14] In microbiology, students who used either a wet-lab (in-person) or a virtual lab (online) experienced increases in understanding and self-efficacy. Comas – Quinn et al. found that, in addition to performing equally in online and in-person laboratories, the online lab was also an important part of the course by most students. [12] Other studies have also concluded the integrated learning format to be a superior learning method.[13–15, 18] Most faculty respondents said that e-learning is a valuable tool for their courses. Online learning is not limited to teaching and assessment, and thereby includes various schemes, such as students tracking progress, exchanging courses with colleagues and researchers.[18] Once again, the majority of faculty respondents have decided to use e-learning for teaching and education with enthusiasm and trust. Similarly, faculty members in Saudi universities demonstrated a constructive approach to using online learning.[9] Further studies have shown that educators enjoy positive e-learning interactions as well as the use of modern instruments.[14,17] The use of e-learning involves complex links between the personal characteristics of educators, their trust in their performance and their level of confidence.[13]

6. CONCLUSION

Our research indicates that the use of e-learning resources increased enormously after COVID-19 and offered Saudi colleges greater educational opportunities. In these colleges the implications of COVID-19 could change the future methods of education forever. The longer distant learning is, the greater the value of e-learning. Therefore, in the competitive age of technology COVID-19 can be regarded as "a dedication under cover." Although professors have shown positive attitudes to the use of e-learning, the institutional readiness as a workforce and infrastructural resources is significant. Teaching faculties must learn thoroughly about innovations and how e-learning is applied in their teaching practices. There is no doubt that teaching, learning, and communicating today have been dramatically changed because of the COVID-19 Pandemic. Also, our findings suggest that shifting the teaching-learning process from in-classroom to online education in microbiology courses might have a positive impact. However, that was not the case with practical learning outcomes such as laboratory-based courses. In addition, participants were concerned about academic integrity in the online classroom setup and the violations of academic integrity and other dishonest behaviours. While pandemics have historically generated difficulties, recognizing these difficulties is the first step in turning them into possibilities.

7. AUTHORS CONTRIBUTION STATEMENT

The Author read and approved the final version of the manuscript.

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9. CONFLICT OF INTEREST

Conflict of interest declared none.

10. REFERENCES

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