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Original Article

Computer-Based Clinical Examination (CCE) in Surgery: Would It Complement or Replace the OSCE in the Post-COVID-19 Era?

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Abstract

Objectives: Surgical clinical assessment of medical students is confronted by many challenges particularly the increasing numbers of students with limited resources, and pandemics. The search for new tools of assessment continues.
Our objectives were: (1) To develop a computer-based clinical exam (CCE) and identify its characteristics (2) To assess its acceptability of the students.
Method: The study was conducted at the Surgical Department, Alzaiem Alazhari University (AAU) between February and August, 2017. We used the modular object-oriented dynamic learning environment (MOODLE) program as a platform to upload and deliver the exam. The exam consisted of 45 questions (stations). Each consisted of a clinical scenario accompanied by a photograph (of a patient or investigation) or short video followed by multiple choice questions (MCQs).
A questionnaire was designed to get the students' feedback.
We analyzed the questionnaire and scores obtained by the students and compared them to their performance in other tools of the surgical exam, using SPSS statistical program.
Results: The study included 188 final year medical students. There was a highly significant correlation of the CCE scores of each student with their final result (r= 0.67), and with other tools of the surgery exam particularly the objective structured clinical examination (OSCE). Students' acceptability was high.
Conclusion: The CCE is valid and practicable. It saves time and is popular with the students and tutors. It complements the OSCE in the assessment of clinical competency and allows wide coverage of the curriculum. It is expected to gain importance and popularity in the post-COVID-19 era.

Keywords: computer-based clinical examination (CCE), video-projected structured clinical examination (ViPSCE), objective structured clinical exam (OSCE), COVID-19 pandemic, assessment of medical students, MOODLE

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1. Introduction

Assessment of medical students in clinical competencies, particularly in surgery, still poses many challenges. These include increasing numbers of students every year, increasing costs, and reduced resources especially manpower and time. Recently, the COVID-19 pandemic has imposed new challenges to both teaching (training) and assessment of medical students. Because of the lockdown and social distancing, universities were forced to depend on E-learning.

The main objective of this study was to improve the computer-based clinical examination (CCE) used to assess our students to be fully computerized. The CCE was developed by our faculty in 2011/2012 and was used for a number of years in the assessment of medical students in surgery [1]. The CCE itself was a computer version developed from the video-projected structured clinical exam (ViPSCE), which was created to replace the oral (viva) exam some years earlier [2, 3]. We needed to identify the characteristics of this *new* format of the CCE particularly its validity. In order to make the CCE fully computerized we had to change its question format from short-structured answer questions (SSAQs) to multiple choice questions (MCQs) of the single best answer (SBA) style. We also aimed to assess the acceptability of the students for this new test.

The SSAQs of the former CCE version were printed on paper. Students wrote the answers on the same sheet. The process of correcting this exam manually was time consuming especially with the increasing numbers of students each year. Each paper took 10–15 minutes to correct with model answers given to each correcting examiner. This problem induced us to try using a computer program to speed the process. We chose the modular object-oriented dynamic learning environment (MOODLE), which is a free web-based computer program that can be used as a platform to deliver the exams. It gives many options for assessment. It can be free downloaded from these websites [4, 5]. It has many advantages, such as providing the scores and their analysis automatically and immediately.

Our MBBS surgery examination consists of three parts: (i) written (theoretical) and (ii) clinical exam, and (iii) continuous assessment (CA). They contribute 40%, 50%, and 10% of the total scores of the surgery, respectively.

The written exam consists of two parts: (i) MCQs of the SBA style. It accounts for 20% of the marks and assesses higher knowledge; (ii) problems in the form of short-structured questions. These assess the problem-solving capability of the students and are allotted another 20% of the total marks.

The clinical part of the exam includes the following two tools, both accounting for 50% of the total marks in surgery:

1. Objective-structured clinical examination (OSCE): It accounts for 35% of the total marks. The OSCE consists of 12 stations. We have increased the number of stations from 7 to 12 after moving into a larger facility that allowed the expansion of stations. We use the OSCE to assess the skills, such as skills of history taking, clinical (physical) examination, surgical (procedural) skills, and communication skills. Therefore, all the stations are interactive and manned. The OSCE is presently the only tool to assess these skills.

2. CCE: It accounts for 15% of the total marks. This is the focus of our paper. We developed the CCE from the ViPSCE. This tool allows covering much of the clinical curriculum horizontally (i.e., more subjects can be included in the assessment) and vertically (i.e., more depth in each subject can be assessed). Both the CCE and its predecessor ViPSCE are used to assess the higher knowledge and problem-solving competencies of the students in various clinical scenarios. Within the context of a clinical scenario/ problem, we use photographs of patients/lesions, or short videos of patients, procedures, management charts, and investigations such as X-rays, CT scans, contrast radiology, blood test results, and so on. This is followed by a question which in the newly developed CCE is of the MCQ single/best answer type.

3. CA: It accounts for 10% of the total marks. This is composed of a midterm exam (5%) using the CCE, as well as seminar MCQs (3%) and clinical assessment by tutors (2%) during the clinical rounds and tutorials. This CA is currently under review.

2. Methods

The study was conducted at the surgical department, Alzaiem Alazhari University between February and August 2017.

Ethical approval was obtained from the Research and Ethics Committee at the school of medicine to allow the use of the students' marks data in this study. Informed consents were also taken from the students/participants who were also asked to complete an evaluation form at the end of the exam.

2.1. Exam preparation

The CCE was prepared according to a blueprint, thus allowing us to cover the whole curriculum. The questions were in the form of a clinical scenario accompanied by a photograph, investigation, or a short video for further illustrating the clinical problem. This was followed by SBA type MCQ (Figure **1**). The questions and correct answers were uploaded in the MOODLE program. We made sure that the photos or videos of the patients did not show their identities. It is to be noted that one photo can generate so many questions. The question example cited could be altered to assess knowledge of the function of the nerves, rather than their names. The department slowly but progressively compiled a bank of photographs, investigations, and videos.

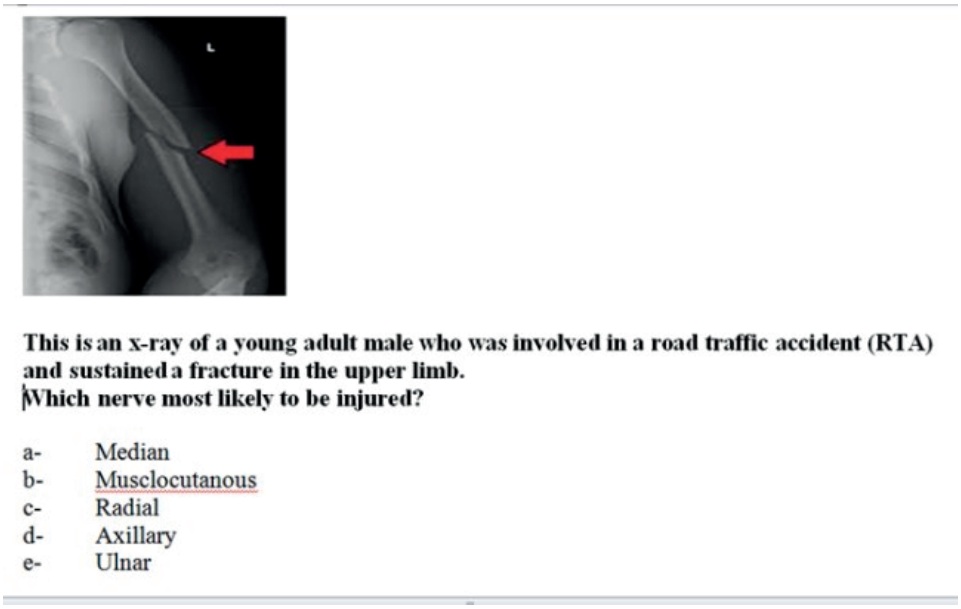
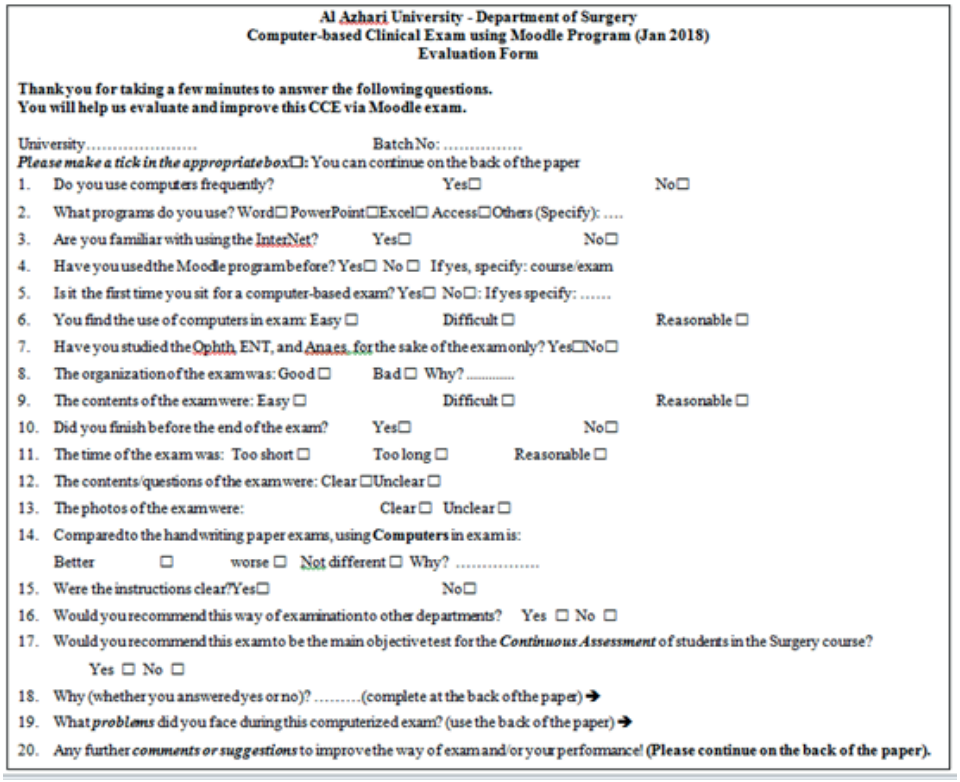


Figure 1: An example of a question in the CCE.

The new CCE consists of 45 SBAs. In the old version of CCE, the exam consisted of 15 questions of the short-structured answer questions (SSAQ). We had decided to increase the number of questions to 45 in order to keep the high validity of the exam.

The MOODLE program has the ability of shuffling the order of the MCQs as well as shuffling the order of the answer choices within each question. This has the advantage of making cheating difficult.

A questionnaire was prepared to get the students' feedback for the evaluation of the exam (Figure **2**).



Al Azhari University - Department of Surgery
Computer-based Clinical Exam using Moodle Program (Jan 2018)
Evaluation Form

Thank you for taking a few minutes to answer the following questions.
You will help us evaluate and improve this CCE via Moodle exam.

University..... Batch No: .....
***Please make a tick in the appropriate box*☐: You can continue on the back of the paper**

1. Do you use computers frequently? Yes☐ No☐
2. What programs do you use? Word☐ PowerPoint☐ Excel☐ Access☐ Others (Specify): ....
3. Are you familiar with using the InterNet? Yes☐ No☐
4. Have you used the Moodle program before? Yes☐ No☐ If yes, specify: course/exam
5. Is it the first time you sit for a computer-based exam? Yes☐ No☐: If yes specify: .....
6. You find the use of computers in exam: Easy ☐ Difficult ☐ Reasonable ☐
7. Have you studied the Ophth, ENT, and Anaes. for the sake of the exam only? Yes☐No☐
8. The organization of the exam was: Good ☐ Bad ☐ Why? .....
9. The contents of the exam were: Easy ☐ Difficult ☐ Reasonable ☐
10. Did you finish before the end of the exam? Yes☐ No☐
11. The time of the exam was: Too short ☐ Too long ☐ Reasonable ☐
12. The contents/questions of the exam were: Clear ☐ Unclear ☐
13. The photos of the exam were: Clear ☐ Unclear ☐
14. Compared to the hand writing paper exams, using **Computers** in exam is:
    Better ☐ worse ☐ Not different ☐ Why? .....
15. Were the instructions clear? Yes☐ No☐
16. Would you recommend this way of examination to other departments? Yes ☐ No ☐
17. Would you recommend this exam to be the main objective test for the ***Continuous Assessment*** of students in the Surgery course?
    Yes ☐ No ☐
18. Why (whether you answered yes or no)? .....(complete at the back of the paper) ➔
19. What ***problems*** did you face during this computerized exam? (use the back of the paper) ➔
20. Any further ***comments or suggestions*** to improve the way of exam and/or your performance! **(Please continue on the back of the paper).**

Figure 2: Evaluation questionnaire for students' feedback.

2.2. Exam administration

The students were comfortably seated in the computer lab. Each student had a computer and was seated at a reasonable distance from the next (Figure **3**a). During the COVID-19 pandemic, wearing masks was obligatory (Figure **3**b).

The students were gathered in a classroom and briefed about the exam before it began. The number of exam rounds depended on the number of students and computers available. In our institution there are currently 4 computer labs each has 25 working computers. So a single round can accommodate a 100 students. When a class has more than a 100 students, the students are divided into 2 groups or more. Every effort is made to avoid communication between the groups. This involves taking away their mobile (cell) phones.

The exam time is 1 hour, giving about a 75 second per slide. The students had the freedom to answer the questions in any order they found suitable. In the end, they pressed the 'submit' button.

Each question (station) scores 1 mark, so the total score of the 45 questions is 45. This is divided by 3, so that the total score of the CCE is computed out of 15

Figure 3: a: Seating before COVID-19, b: Seating during COVID-19.

The MOODLE program gives the results immediately and provides some useful statistics on the exam questions. This information helps determine the minimum pass level (MPL) for each question.

3. Results

The CCE was used to assess188 final-year medical students.

3.1. Test statistics

The scores of the students were normally distributed (Figure **4**).

Table 1 shows the CCE statistics. The mean score was 7.42 (SD 1.32) out of 15. The skewness of the curve was -0.19 and kurtosis 0.006. The minimum score was 4 and the maximum was 11.3 giving a range of 7.3.

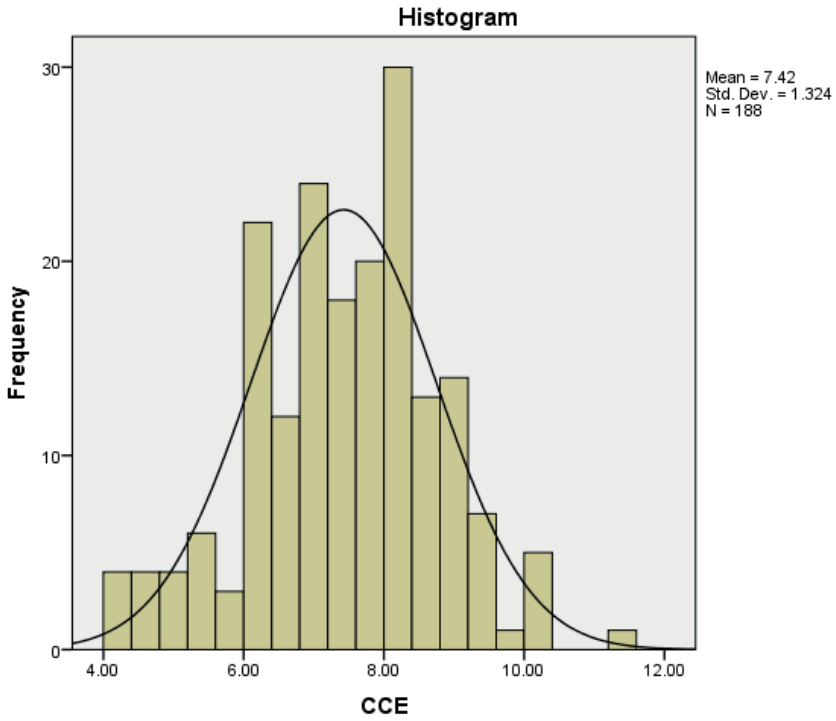


Figure 4: A histogram of the CCE results of 188 students showing normal distribution.

When the CCE result of each student was correlated with their total performance (mark) in surgery, the Pearson coefficient was (r=0.67) signifying high correlation at the 0.01 level.

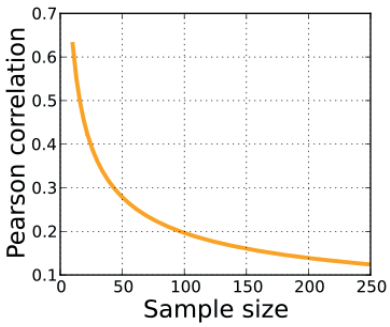
The correlation coefficients of the CCE with other tools of the surgery exam were as follows: total clinical (r=0.7), OSCE (0.46), and MCQs (0.51). All the correlations were significant at the 0.01 level using both SPSS calculations (Table 2), and Skbkekas graph which takes into account the sample size (Figure **5**).

Table 1: The statistics of the CCE scores of 188 students.

Test statistics	Value
Mean	7.4245
Std. error of mean	.09658
Median	7.3000
Std. deviation	1.32420
Variance	1.754
Skewness	–0.197
Std. error of skewness	0.177
Kurtosis	0.006
Std. error of kurtosis	0.353
Range	7.30
Minimum	4.00
Maximum	11.30
Sum	1395.80
N	**188**

Table 2: Correlation of the CCE results of 188 students with their total score and scores in other tools of the exam using Pearson's 2-tailed test.

Correlations with:	Total score	Clinical CCE+OSCE	OSCE	MCQs	SSEQs	CA
CCE	r= 0.67 (*P*<0.01)	r= 0.70 (*P*<0.01)	r= 0.46 (*P*<0.01)	r= 0.51 (*P*<0.01)	r=0.35 (*P*<0.01)	r=0.35 (*P*<0.01)



By Skbkekas - Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=9484334

Figure 5: A graph showing the minimum absolute value of Pearson's correlation coefficient that is significantly different from zero at the 0.05 level, for a given sample size.

3.2. Students' evaluation of the CCE

There was 97% response rate i.e., 180 out of 188 students. The analysis of this questionnaire showed that 82% of the students used computers frequently (Table 3). However, of the 18% of the students who use computers less frequently, (32-37%) were familiar with Microsoft PowerPoint and Word programs. Interestingly, 73% use the internet and 51% had some experience with using the MOODLE program.

A good proportion of both the groups commended the exam organization, clarity of photos, instructions, contents and time. It has been shown that students who are frequent computer users always have an edge and are happier than the less frequent users.

Most of the students (61%) admitted that computer-based exams are better than the paper-based exams. Upon analysis, 65% were found to be frequent computer users and 41% were less frequent users.

Most students from both the groups recommended CCE use in surgery as part of the CA and in other departments too. These were 67% versus 57% and 72% versus 59% of frequent and infrequent computer users, respectively.

TABLE 3: Comparing opinions of frequent vs less frequent computer users N=180.

Points of comparison	Frequent users	Less frequent
%	**82%** (n=148)	**18%** (n=32)
Using Word	48%	37%
PowerPoint	70%	32%
Excel	12%	8%
Access	19%	None
Familiar with internet	**93%**	**73%**
MOODLE	**55%**	**51%**
First computer exam	**47%**	**57%**
Use of computer in exam easy or reasonable	**82%**	**57%**
Organization of exam is good	**65%**	**57%**
Contents of exam: reasonable easy	**63% 16%**	**43% 24%**
Time of exam: reasonable	**64%**	**62%**
Finish before end	**63%**	**51%**
Photos and contents are clear	**78%**	**84%**
Instructions clear	**83%**	**76%**
Compared to paper exams computer exams are better Worse No difference	**65% 26% 9%**	**41% 46% 13%**
Recommend this test to other departments	**72%**	**59%**
Recommend as continuous assessment	**67%**	**57%**

4. Discussion

The statistics of the CCE and the normal distribution of the marks/scores have shown that it was a balanced exam. The strong correlation with the final marks in the surgery exam of each student was an evidence that the exam was valid, since it truly reflected the strength of the students. The proof that the CCE assesses the clinical competency was shown by the strong correlation with the OSCE as well. The CCE also assesses the

higher thinking and problem-solving capacities of the students as it correlates strongly with the problem (SSAQ) exam and MCQs. Although the correlation with the SSAQ written exam is strong, it is less than with the other exam tools. This can be explained by the fact that both exams assess different domains. The similarities between the CCE and our MCQs are that both use clinical scenarios and MCQs of the SBA style. The difference between them is that the CCE is more clinically oriented as it uses hospital (practice) based clinical images and videos.

One of the important CCE characteristics is that it allows covering the whole curriculum in such a way that the OSCE cannot do alone. The CCE complements the OSCE in such a way that we have dedicated the skills of history taking, clinical examination, and communication to the OSCE, while assessing higher thinking and problem-solving competencies to the CCE.

The change of the questions style from SSAQ to MCQs of the SBA type did not seem to affect its validity and strength as an exam tool.

The CCE complements the OSCE and avoids some of its disadvantages, such as being resource-intensive [6]. It doesn't require many tutors, patients, or simulated patients.

Computers have been used for assessment in medicine as early as the 1960s to test the knowledge and problem-solving skills [7]. Cantillon *et al*. carried out a survey of UK medical schools and found there was a great potential for the use of computer-based assessment for its high validity and candidates' acceptability [8]. In a limited-resources environment, it could be argued that computers are expensive to buy and computer labs are difficult to set up. The establishment of a class with computers may be expensive at the beginning but it is cost effective in the long run.

The CCE saves time and cost of paper and examiners. It uses minimal numbers of tutors (invigilators) and one tutor could be enough per class. The CCE also saves correction time. It can definitely cater for the increasing numbers of medical students. According to the number of available computers, the class can easily be divided into groups and examined in one, two, or three sessions. Care must be taken to avoid communication between the examined and the waiting groups. The students are requested to switch off their mobile (cell) phones, and all forms of communication should be prohibited and warned against.

The characteristics and advantages of the MOODLE program include: (i) Shuffling the questions, so that question no.1 in one computer is not the same in the others. (ii) Shuffling the five answer options. These two characteristics prevent peeping or communicating the right answers between students. (iii) It gives the students the freedom to

move up and down the exam questions according to their wishes. (iv)The MOODLE also gives the result immediately and allows a quick feedback. It has the option of showing or hiding the result at the end of the exam. We elect not to show the result to prevent unnecessary stress to the student and make them look forwards to the next tools of the surgery exams.

The high response rate and high acceptability rate confirms what was shown before in our studies and others, that computer-based exams will become ever popular [1, 8, 9].

Although this study was done just before the COVID-19 year, the use of the CCE continued during the COVID period and was successful. The student sat with good distance from one another and apart from wearing masks and respecting social distancing during the gathering and seating, no major changes were required (Figure **3**b).

COVID-19 has posed new challenges, such as lockdown and social distancing. It has forced a change all over the world, in both under- and post-graduate education, from face-to-face to E-learning. Many medical and health schools around the world have shifted their teaching and assessment methods into remote learning platforms. There has been a surge in telemedicine, teleconferencing (tele-OSCE), virtual OSCE (VOSCE), and on-line OSCE [10–13]. Many platforms are in use, such as Zoom [10, 13], Microsoft Teams platform [11], and MOODLE [12]. We, therefore, expect the CCE to be a major tool in the post-COVID era.

Telemedicine, particularly online assessment, such as virtual OSCE (VOSCE), has its well-known challenges regarding the technology and the domains it assesses when it is changed from the classical mode to the virtual mode. The technology may not be available or if available there may be issues regarding its stability (net down, electricity cuts, camera, or microphone off) and cost, particularly in remote areas or in developing countries. Protecting the integrity of the VOSCE has been a critical issue particularly in high stakes exams [14]. The CCE has the advantage of the ability to be undertaken both locally (in a classroom), and remotely (on-line) just like other forms of telemedicine mentioned above, while we didn't face an integrity challenge.

There are, however, limitations and challenges to the CCE. There were three major issues that we had to face when carrying on this test in our set up. Most of these were, however, related to using computers, rather than the exam itself. These were: (i) the number of available computers (ii) electricity cuts, and (iii) poor net connection. Therefore, the success of the CCE (or any computer based exam) depends on the presence of enough number of computers, a good/quick internet and facilities to ensure the stability and continuity electricity supply. A dedicated generator may be of value

in areas prone to electricity cuts. These challenges are more obvious in developing countries with limited resources.

The limitation of the CCE as a tool of assessment is similar to that of the VOSCE. It cannot test or assess the clinical competency of physical examination in the same way as the classical OSCE does [15]. The CCE is, however, great in testing higher knowledge and problem-solving clinical competencies. Unlike the VOSCE -which has a smaller numbers of stations than the OSCE- the CCE has the potential to be expanded and its questions increased to assess a wider areas of the curriculum both in width and depth. In addition, it is easy to set an exam, and using the MOODLE does not require much training.

5. Conclusion

The CCE using the MOODLE program is a valid test of clinical problem solving and higher cognition and knowledge. It complements the OSCE which can be dedicated to assessment of clinical skills (history, examination, communication, and procedure). All non- interactive stations can be done using the CCE. This has the potential of increasing the depth and covering the spectrum of the surgical curriculum. The CCE is efficient and cost-effective as well as popular with the students. Its use is expected to gain great importance and popularity in the COVID and post-COVID-19 era.

Declaration Section

The authors declare that this manuscript has not been published or submitted for publication by another journal.

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Ethical Considerations

Ethical approval was obtained from the research and ethics committee at Khartoum North Teaching hospital.

Competing Interests

The authors declare that they have no competing interests.

Availability of Data and Material

Anonymous data are available.

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Informed Consent

Informed consent was obtained from all participants of the study at endoscopy. In addition, the study does not contain identifying information about participants.

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