ORIGINAL ARTICLE
Volume 17 Issue 2 2025

DOI: 10.21315/eimj2025.17.2.7

ARTICLE INFO
Submitted: 30-08-2024
Accepted: 17-03-2025
Online: 30-06-2025

Teaching and Learning of Advanced Life Support through a Totally Remote Online Learning to Undergraduate Medical Students: A Randomised Controlled Study

Ismail Mohd Saiboon[1], Mohd Hisham Isa[1], Muhamad Hafiq Ab Hamid[1], Shiraaj Zainul Abiddin[1], Alias Mahmud[2], Amirudin Sanip[1], Harwati Hashim[3], Michelle A Kelly[4]

[1]Department of Emergency Medicine, Faculty of Medicine, Universiti Kebangsaan Malaysia, Selangor, MALAYSIA

[2]Faculty of Technology and Applied Sciences, Open University Malaysia, Selangor, MALAYSIA

[3]Research Centre of Innovation in Teaching and Learning, Faculty of Education, Universiti Kebangsaan Malaysia, Selangor, MALAYSIA

[4]Clinical and Health Sciences, University of South Australia, Adelaide, AUSTRALIA

To cite this article: Mohd Saiboon I, Isa MH, Ab Hamid MH, Zainul Abiddin S, Mahmud A, Sanip A, Hashim H, Kelly MA. Teaching and learning of advanced life support through a totally remote online learning to undergraduate medical students: a randomised controlled study. Education in Medicine Journal. 2025; 17(2): 85–100. https://doi.org/10.21315/eimj2025.17.2.7

To link to this article: https://doi.org/10.21315/eimj2025.17.2.7

ABSTRACT

Cardiac arrest is the leading cause of death worldwide. Although there were several studies showing that advanced life support (ALS) can be taught through a blended approach, the practical aspect of ALS is still conducted in a classroom manner. We set out to evaluate an alternative approach to teaching ALS through a totally online remote learning (ORL) approach to a group of undergraduate medical students. A cluster-randomised controlled study was undertaken between the intervention ORL and control (conventional classroom teaching, CCT) groups. The intervention group undergoes a fully interactive online asynchronous approach (provided with a self-directed-learning package), synchronous online team practice of ALS, and debriefing. While the control group undergoes a physical face-to-face teaching with pre-reading material, lectures, and hands-on practice. Participants were evaluated at pre- and post-test on knowledge, decision-making, simulated cardiac arrest performance, and confidence level. A total of 124 participants were involved, with 62 participants in each group. Both groups demonstrated significant improvement between pre- and post-test scores in knowledge, decision-making, and performance assessment. In the assessment of knowledge and decision-making between groups, no significant differences were observed at the pre- and post-test. However, in performance assessments, the post-test mean score for the intervention group (ORL) was significantly higher than that of the control group with regard to shockable rhythms (80.6±2.7 vs 72.3±4.7; $p < 0.001$) and non-shockable rhythms (80.6±4.1 vs 67.4±12.0; $p = 0.002$), respectively. There was no significant difference in confidence levels between the two groups. These findings suggest that a well-designed online approach can be a viable alternative to standard teaching methods for ALS among medical students.

Keywords: *Online learning, Remote learning, Simulation, Debriefing, Advanced life-support*

CORRESPONDING AUTHOR

Ismail Mohd Saiboon, Department of Emergency Medicine, Faculty of Medicine, Universiti Kebangsaan Malaysia, Jalan Yaacob Latif, Bandar Tun Razak, Cheras, 56000, Kuala Lumpur, Malaysia

E-mail: ismailms@ukm.edu.my; fadzmail69@yahoo.com.my

INTRODUCTION

Online remote learning (ORL) is an approach that offers flexible open access and multiple modes of learning where resources and interactive ways of engagement become the central features of the learning experience (1). ORL is flexible because it allows learners access to materials from anywhere, at a time and place convenient to them (2). Multiple modes of delivery and a range of learning resources are the usual features of ORL.

Technology advancements have led to the use of ORL in many educational fields, including medical education (3). Several studies have demonstrated the effectiveness of ORL, particularly in cognitive domains, including cardiac resuscitation (4, 5). Using a blended teaching approach, Abdullah and colleagues (4) compared the effectiveness of e-learning advanced life support (ALS) training against conventional classroom teaching (CCT), demonstrating that the blended approach was as effective as the CCT technique and received positive acceptance from the students. Thorne et al. (5) found a similar result in their observational study conducted in the United Kingdom (UK), where ALS MCQ scores from e-learning were compared with CCT ALS courses. The result demonstrated that e-learning for ALS was as effective as CCT, with increased candidate autonomy, cost-effectiveness, decreased instructor burden, and improved standardisation of course material (5).

Research has also demonstrated the effectiveness of exclusive ORL for training individuals in basic clinical skills (6, 7). However, teaching and learning a more complex algorithm that combines theoretical knowledge, decision-making, procedural skills, and team dynamics, such as during cardiac arrest resuscitation or ALS, is yet to be fully validated using a remote online approach. Currently, conventional face-to-face classroom teaching is the standard method used to teach ALS to undergraduate medical students. However, when face-to-face classroom sessions become challenging, as they did during the COVID-19 pandemic, a total ORL should be offered as an alternative.

We proposed a replicable and totally online approach for learning complex clinical skills of ALS through a project called Online Remote-based Immersive Teaching with Simulation and Debriefing (ORBITS-DeBRIEF), which was funded by an institutional grant. ALS cardiac arrest resuscitation, being part of the undergraduate medical curriculum, is a complex process that combines knowledge, psychomotor skills, teamwork, and decision-making. The primary objective of this study was to assess the effectiveness of this innovative approach in teaching undergraduate medical students the ALS resuscitation code compared to the CCT. The secondary aim was to determine students' confidence and perception towards this different approach to learning. We hypothesised the online, remote-based approach could be as effective as the classroom approach in teaching and training undergraduate medical students to perform ALS-simulated cardiac arrest resuscitation. We also hypothesised the students would welcome this new approach to learning and have similar or higher levels of confidence in performing ALS compared with CCT.

Theoretical Framework

The theoretical framework underpinning this study was the community of inquiry model for designing and evaluating effective online learning experiences that incorporate social, cognitive, and teaching presence (8). A combination of social constructivist learning theory (9), principles of Education 4.0 (10), small group learning strategies for cognitive and psychomotor procedures (11), and the importance of interactivity in e-learning (12) was advocated. Social constructivism espouses the collaborative processes and knowledge development from individual learner interactions within the context of culture and society.

Education 4.0 encompasses the elements of personalised and flexible learning regardless of space and time, with the assistance of digital technology (13). Interaction and learning within small groups are effective in refining psychomotor skills, for example, via self-instructional video (SIV) (11), and the element of interactivity is essential to enhance e-learning (14). Debriefing was added to this repertoire of learning approaches because it is widely regarded as a cornerstone of the experiential teaching-learning approach (15).

During cardiac arrest resuscitation, we assume students should possess the requisite knowledge of individual psychomotor skills as well as the ability to work within a team and make appropriate clinical decisions. To ensure that these four elements were present in novice medical students, we incorporated self-learning through screen-based simulation (SBS) applications and self-practiced procedural skills via SIV. Debriefing was conducted to consolidate learners' understanding and to improve sense-making across the learning activity. To maximise interactivity, a combination of asynchronous and synchronous sessions was used.

METHODS

This is a single-blinded, clustered-randomised study conducted between January and August 2022. The study took place in the simulation laboratory of a medical faculty in Klang Valley, Malaysia. This study was approved by the Medical Research and Ethics Committee (MREC No: JEP-2021-378) of Universiti Kebangsaan Malaysia (UKM) and was conducted in accordance with the ethical standards of the Helsinki Declaration.

Participants

All final-year undergraduate medical students from a single public university in Klang Valley, Malaysia, were invited to participate in this study. Consent was obtained from the participants prior to the study, which included assurances of participants' data privacy. Those who had undergone ALS training within one year of the study period were excluded.

Intervention

The intervention group received the learning materials through an online link. This included a web URL (https://www.classmarker.com/#tests) to a SBS application of a cardiac arrest code and a Google Drive link (https://tinyurl.com/SDLP-ORBITS) to nine SIVs of procedures required during cardiac arrest resuscitation code.

The researchers developed the SBS using the ClassMarker web application (ClassMarker Pty Ltd, Sydney, New South Wales, Australia). These scenarios covered the basic principles of resuscitation, pharmacology, rhythm recognition, and decision-making in cardiac arrest. In the SBS, the participants assumed the role of a medical doctor managing a code. For the SIVs, all nine videos were also self-developed by the researchers. The nine SIV focused on (a) the opening airway manoeuvre (head-tilt-chin-lift [HTCL] and jaw trust); (b) insertion of an airway adjunct: oropharyngeal airway (OPA), nasopharyngeal airway (NPA); (c) insertion of a supraglottic airway – laryngeal mask airway (LMA); (d) performing endotracheal intubation; (e) performing manual chest compression; (f) performing manual defibrillation; (g) use of an automated external defibrillator; (h) team resuscitation codes-shockable rhythm; and (i) team resuscitation codes-non-shockable rhythm.

Sampling and Randomisation

The study utilised cluster sampling, where 124 (n = 124) final-year medical students were allocated into four clusters. Each cluster underwent a two-week hospital emergency medicine rotation at different times. From these four clusters, the medical students were randomly assigned to the intervention group (n = 62) and the control group (n = 62). Participants within each group were further subdivided into smaller sub-groups, consisting of 5–6 participants per subgroup. A supervisor was allocated to each subgroup.

Study Protocol

A pre-test to determine baseline knowledge, decision-making, and resuscitative performance was administered to all participants prior to the randomisation (Figure 1). Following randomisation, the intervention group received an online briefing. Each subgroup then received links to the SBS programme and the nine SIVs. All participants then completed the asynchronous teaching session, followed by the synchronous teaching session.

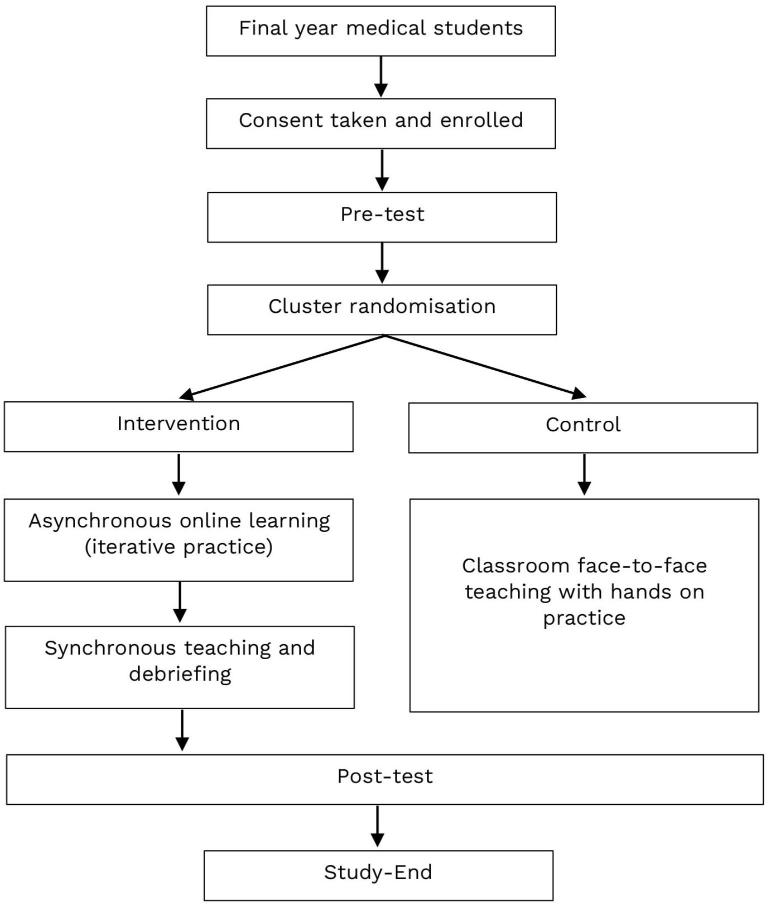

Figure 1: Study flow chart of the randomised online remote learning on advance life support.

Participants in the asynchronous session had five days to complete the SBS and practice the SIV procedures independently, without the assistance of a tutor or facilitator. A Telegram® (Telegram Messenger LPP, London, United Kingdom) group was created for each subgroup to support communications. The participants were to practice all seven procedures (minus the two resuscitation codes) shown in the SIVs unsupervised in the simulation lab in their own time.

The participants video recorded the procedures they performed, which were then sent to the supervisors for feedback. Repetition of the procedures was required if their earlier performance was deemed unsatisfactory against a standard checklist. Resubmission of video was required until the seven procedural skills were deemed satisfactory. Through the Telegram®, participants could ask the supervisor questions about the topic and receive feedback. Supervisors were prohibited from meeting or organising any synchronous sessions with the participants during the asynchronous period.

The subsequent synchronous session was divided into two sessions: (a) a one-hour session on Day 6 and (b) a two-hour session on Day 7 of the study period. During the synchronous session, the subgroup members had an online meeting with their supervisor to clarify any issues. On Day 7, the subgroup members, under the online supervision of their respective supervisors, practised the resuscitation code for shockable and non-shockable cardiac rhythms for two hours. Each participant's performance was telecast using WhatsApp® (Facebook Inc., Mountain View, California) through a smartphone to the supervisor. In contrast, a tablet device was used to allow participants to remotely view the electrocardiogram (ECG) rhythm changes set by the supervisor. Debriefing was performed at the end of each code scenario using the DeBRIEF technique (16). The total synchronous session time was kept to three hours to match the three-hour standard CCT method. During the synchronous session, supervisors were located remotely in their home workspaces. The supervisors were advised against meeting the participants physically during the synchronous session.

On the other hand, after the briefing of the study, the control subgroups received the usual preparation, that is, notes about cardiac arrest to read before a three-hour face-to-face teaching session. In the three-hour session, they attended a one-hour lecture followed by a two-hour practical session. Each subgroup was allocated one facilitator, and students practised all nine procedural skills under the watchful eyes of their respective facilitator until they achieved satisfactory competency based on the same standard checklist used with participants in the intervention group.

Students from both groups were also free to access the simulation lab throughout the two-week emergency department (ED) rotation. All the participants from both groups were assessed for knowledge, decision-making, and psychomotor skills in a post-test at the end of the two-week ED rotation.

Data Collection

Data sources used in this study included a questionnaire and a performance checklist. The questionnaire consisted of four parts: Part 1 examined demographics and prior training, and Part 2 consisted of 20 multiple-choice questions (MCQs) assessing the basic knowledge and clinical decision-making in cardiac resuscitation. Part 3 consisted of five questions, each with a 5-point Likert scale, asking participants to rate their confidence level in performing tasks during resuscitation. Part 4 was related to the perception of undertaking this activity via remote learning. Parts 1, 2 and 3 of the questionnaires were given to both groups, while Part 4 was only given to the intervention group. The performance assessment of team resuscitation was conducted through an objective structured clinical examination (OSCE) checklist.

The questionnaire and performance checklist were developed for this study by a panel of experts in cardiac resuscitation using a modified Delphi technique (17). Content and construct validation was carried out for the questionnaire and the performance checklist by a panel of senior emergency physicians. Face validity was carried out by a group of 10 medical students who were not involved in this study. Reliability testing of the questionnaire was conducted to assess its internal consistency.

In the questionnaire regarding confidence in performing cardiac resuscitation, ratings were as follows: 1 = not confident at all, 2 = slightly confident, 3 = somewhat confident, 4 = fairly confident, and 5 = completely confident. Each participant's response score was then summed to obtain a final score. The five aspects of confidence focused on initiation of chest compression, the decision to use cardiac defibrillation, ordering resuscitation drugs, diagnosing an arrest rhythm, and leading a resuscitation team. The perception questionnaire also requested 5-point Likert scale responses and evaluated participants' perceptions of the feasibility and relevance of learning using the intervention approach.

Raters' Calibration

Three raters were randomly selected from a group of emergency physicians, senior lecturers, and American Heart Association Advance Cardiovascular Life Support (AHA ACLS) instructors to determine inter-rater reliability. Rater training was provided using the frame-of-reference (FOR) approach (18). The calibration process began with a brief briefing and an explanation of the validated checklist to be used. This was followed by observing several simulated live performances of the cardiac resuscitation code, which included some errors. The raters scored the performance individually but reviewed the scoring together and discussed discrepancies to set the performance standards. They repeated the process until the scoring difference between all the raters was +/- 1 point. Towards the end of the session, the scores were compared, revealing good reliability between raters. The raters' training and calibration process was led by the lead researcher.

Supervisor Training

Supervisors for the study were selected from lecturers and trainees in emergency medicine. The lead researcher selected and trained six supervisors in online teaching and evaluation techniques, providing feedback, and debriefing using the DeBRIEF technique.

Outcome

The primary outcome of this study was the level of knowledge, decision-making, and team performance in cardiac arrest resuscitation, as measured by the participants' pre- and post-test scores. The secondary outcomes were the confidence levels (between the control and intervention groups) and the perception towards the online approach (intervention group).

Blinding

This study used single blinding, where the assessors were blinded to the participant groups. In the OSCE, a live assessment was done with the assessor present in the OSCE room. Blinding was achieved as the assessors were not aware of the ALS teaching-learning method that participants undertook. Furthermore, the researchers were present at all times during the OSCE assessments to prevent assessors and participants from revealing their learning methods (online or face-to-face). The assessor group was different from the facilitator group. Blinding the participants would not be possible, as each would be aware of their own and others' grouping in the study during the training period.

The Development Cost

The research team did not use a proprietary simulation-based training programme to control costs. Instead, the research team self-developed most of the teaching tools, such as the screen-based simulation programme (Class Marker) and the SIVs, using the editing programme of Filmora 9 (Wondershare Co. Ltd., Sydney, Australia). The total cost to develop the teaching tools was MYR571.90 (USD127.65). For the asynchronous and synchronous teaching sessions, the web applications used were WhatsApp® and Telegram®, obtained free of charge.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, New York) was used for the analysis. Demographic data for the two participant groups was compared using descriptive statistics. Continuously distributed data was summarised using mean and standard deviation for normally distributed data or median and interquartile range (IQR) for data that was not normally distributed. Frequency and percentages were used for categorical variables. The 95% confidence interval was calculated for the mean scores. Tests of significance utilised the student t-test for normally distributed data, while the Mann-Whitney U and Wilcoxon signed-rank tests were utilised for non-normally distributed data. Differences between groups were significant when the p-value was less than 0.01.

RESULTS

There were 124 final-year medical students enrolled in the study, n = 62 in the intervention group (with 12 sub-groups) and n = 62 in the control group (with 12 sub-groups). The Cronbach's alpha score for the questionnaires was 0.79. For raters' reliability, the intra-class correlation coefficient (ICC) was 0.94.

Demographic Information

There were no significant differences between the groups in terms of age, gender, race, or previous cardiac resuscitation training (Table 1). The average age was 24 years, with 65% of the participants being female. The sample included 62 (50%) Malay, with the remaining 50% representing other race categories. Concerning prior resuscitation training, 57 (91.9%) in the intervention group and 59 (95.2%) in the control group had exposure to basic life support (BLS), but none had undergone ALS training before enrolment (p = 0.467) (Table 1).

Table 1: Participant demographic data (n = 62)

Factors	Intervention group n (%)	Control group n (%)	*p*-value
Age, median [IQR]	24 [0]	24 [0]	0.196
Gender			0.851
Male	22 (35.5)	21 (33.9)	
Female	40 (64.5)	41 (66.1)	
Race			0.799
Malay	31 (50.0)	31 (50.0)	
Chinese	14 (22.6)	12 (19.4)	
Indian	16 (25.8)	16 (25.8)	
Others	1 (1.6)	3 (4.8)	
Previous course/training for cardiac resuscitation			0.467
Yes	57 (91.9)	59 (95.2)	
No	5 (8.1)	3 (4.8)	

Knowledge scores of basic principles and decision-making of the intervention and control groups at pre- and post-test are shown in Table 2. The median knowledge score on basic principles showed similar improvement for both groups from the pre-test 8 (3) to the post-test 14 (2), with a p-value < 0.001. The median knowledge score for decision-making also showed a significant improvement for both groups, with a 2 (1) to 5 (1) score for the intervention group, while the control group recorded 1.5 (1) to 5 (1) ($p < 0.001$). There were no significant differences between the groups in either of the knowledge domain median scores, with the p-values for the pre-test and post-test being 0.96 and 0.56, respectively, as shown in Table 2.

Table 2: MCQ scores on basic knowledge principles and decision making related to ALS (n = 62)

Knowledge score		Intervention	Control	*p*-value[a]
		Median score [IQR]		
Knowledge score on basic principles in resuscitation	Pre-test	8 [3]	8 [3]	0.93
	Post-test	14 [2]	14 [2]	0.86
	Mean Δ score	6 [3]	6 [3]	0.92
	Pre- and post-test	p = 0.000[b]	p = 0.000[b]	
Knowledge scores on decision making in resuscitation	Pre-test	2 [1]	1.5 [1]	0.96
	Post-test	5 [1]	5 [1]	0.56
	Mean Δ score	3 [2]	3 [2]	0.80
	Pre- and post-test	p = 0.000[b]	p = 0.000[b]	

Notes: [a] Mann-Whitney U test; [b] Wilcoxon signed-ranks test; Δ the difference in the score between pre-test and post-test

In the performance assessment of shockable rhythm management, the intervention group's post-test mean scores were 80.6 (±2.7) compared with 72.3 (±4.7) for the control ($p < 0.001$), despite no significant difference between the groups at the pre-test (Table 3). For non-shockable rhythm team performance, the mean score for the intervention group was 80.6 (±4.1), while the control group recorded 67.4 (±12.0) with a p-value of 0.002 (Table 3).

Table 3: Team-based psychomotor skill performance (OSCE) scores for shockable rhythm and non-shockable rhythm

OSCE		Intervention group (n= 12)	Control group (n = 12)	*p*-value[a]
		Mean score±SD		
OSCE score for shockable rhythm	Pre-test	20.1±8.6	21.0±7.1	0.760
	Post-test	80.6±2.7	72.3±4.7	0.000
	Mean Δ score	60.5±8.7	51.2±7.9	0.012
	Pre- and post-test	$p^a = 0.000$	$p^a = 0.000$	
OSCE score for non-shockable rhythm	Pre-course	15±8.1	14.8±4.0	0.920
	Post-course	80.6±4.1	67.4±12.0	0.002
	Mean Δ score	65.6±14	52.7± 0.0	0.002
	Pre- and post-test	$p^a = 0.000$	$p^a = 0.000$	

Notes: [a] student *t*-test; Δ the difference in the score between pre-test and post-test

Regarding confidence level during simulated cardiac arrest resuscitation, both groups showed significant improvement in all five areas in the post-test scores. In terms of frequency, there was no significant difference between groups in the five aspects of confidence assessed. However, based on the weighted cumulative score of the Likert scale, there was a significant difference in the median score [IQR] between the groups at post-test, where the intervention group recorded 18.5 [4] compared with the control group score of 17.0 [4] (Table 4).

Table 4: Confidence level in ALS

Confident statement on ALS		Intervention (n = 62)	Control (n = 62)	*p*-value[a]
		Number of students (%) who were confident in the cardiac resuscitation components		
I am confident in initiating high-quality CPR when witnessing cardiac arrest	Pre-test	22 (35.5)	18 (29.0)	0.44[a]
	Post-test	61 (98.4)	59 (95.2)	0.31[a]
	Pre- to post-test	$p < 0.001^b$	$p < 0.001^b$	
I am confident to decide on defibrillation/ shock when witnessing cardiac arrest with shockable rhythm	Pre-test	12 (19.4)	7 (11.3)	0.21[a]
	Post-test	60 (96.8)	60 (96.8)	1.00[a]
	Pre- to post-test	$p < 0.001^b$	$p < 0.001^b$	
I am confident to order drugs as necessary during cardiac arrest resuscitation	Pre-test	6 (9.7)	2 (3.2)	0.15[a]
	Post-test	59 (95.2)	59 (95.2)	1.00[a]
	Pre- to post-test	$p < 0.001^b$	$p < 0.001^b$	
I am confident to determine rhythm associated with cardiac arrest	Pre-test	5 (8.1)	5 (8.1)	1.00[a]
	Post-test	58 (93.5)	56 (90.3)	0.51[a]
	Pre- to post-test	$p < 0.001^b$	$p < 0.001^b$	
I am confident to lead cardiac arrest resuscitation	Pre-test	9 (14.5)	6 (9.7)	0.41[a]
	Post-test	54 (87.1)	50 (80.6)	0.33[a]
	Pre- to post-test	$p < 0.001^b$	$p < 0.001^b$	
		Median [IQR]	Median [IQR]	
Cumulative weighted confidence level score in all components of cardiac arrest resuscitation	Pre-test	8 [4]	7 [5]	0.33[a]
	Post-test	18.5 [4]	17.0 [4]	0.005[a]
	Median Δ score	10 [4]	9 [5.5]	0.31[a]
	Pre- and post-test	0.001[b]	0.001[b]	

Notes: [a] Mann-Whitney U test; [b] Wilcoxon signed-ranks test; Δ the difference of the median score between pre-test and post-test

For perception, participants agreed that the interventional approach made a substantial contribution to learning cardiac arrest resuscitation. Ninety-eight percent of participants agreed that the self-directed learning package (SDLP) delivered through the internet link was essential in preparing them for the assessment. Seventy-one percent agreed that the intervention approach could replace the CCT approach. Referring to Table 5, more than 96.0% agreed that the intervention helped familiarise them with the cardiac arrest algorithm, the choice of drugs to use, and decisions relating to defibrillation.

Table 5: Perception towards screen-based simulation with online debriefing among participants

Perception questions	Response	Frequency, n (%)
Q1. It is not essential to complete the self-learning package of ORBITS-DeBRIEF prior to assessment	Strongly disagree/disagree	53 (85.5)
	Neutral	4 (6.4)
	Agree/strongly agree	5 (8.1)
Q2. Completing the SDLP module was necessary to answer the post-course assessments	Strongly disagree/disagree	0 (0.0)
	Neutral	1 (1.6)
	Agree/strongly agree	61 (98.4)
Q3. The facilitators made a meaningful contribution during online debriefing and feedback sessions to connect the topics and help me prepare for the assessments	Strongly disagree/disagree	0 (0.0)
	Neutral	2 (3.2)
	Agree/Strongly agree	60 (96.8)
Q4. I was confident about my knowledge to address topics in the assessments after using the SBOD module	Strongly disagree/disagree	0 (0.0)
	Neutral	1 (1.6)
	Agree/strongly agree	61 (98.4)
Q5. SBOD module can replace classroom-based learning for the learning of simulated cardiac arrest resuscitation	Strongly disagree/disagree	3 (4.8)
	Neutral	15 (24.2)
	Agree/strongly agree	44 (71.0)
Q6. SBOD helped me to learn when to initiate CPR when witnessing a cardiac arrest	Strongly disagree/disagree	0 (0.0)
	Neutral	1 (1.6)
	Agree/strongly agree	61 (98.4)
Q7. SBOD helped me to familiarise to the algorithm of cardiac arrest resuscitation	Strongly disagree/disagree	0 (0.0)
	Neutral	2 (3.2)
	Agree/strongly agree	60 (96.8)
Q8. SBOD helped me to familiarise with the choice of drugs used during a cardiac arrest resuscitation	Strongly disagree/disagree	0 (0.0)
	Neutral	2 (3.2)
	Agree/strongly agree	60 (96.8)
Q9. SBOD helped me to familiarise to defibrillation options during cardiac arrest resuscitation	Strongly disagree/disagree	0 (0.0)
	Neutral	1 (1.6)
	Agree/strongly agree	61 (98.4)
Q10. SBOD helped me to recognise rhythm commonly associated with cardiac arrest	Strongly disagree/disagree	0 (0.0)
	Neutral	3 (4.8)
	Agree/strongly agree	59 (95.2)

Note: SBOD = Screen-based simulation with online debriefing

The two groups differed in the duration of their teaching-learning sessions. The mean teaching time in the control group and each sub-group was fixed at 180 minutes (3 hours), while in the intervention group and each sub-group was 223.56 minutes, accommodating the extra flexible 43.56 minutes of the asynchronous session. Considering a lecturer's basic pay of RM6,500 per month or RM216 per day (for 9 working hours per day); therefore, an extra 43.56 minutes would lead to only an extra RM19.62 for the intervention group compared to the control group since both groups had the same number of facilitators. However, this was a side consideration of the study.

DISCUSSION

This study revealed that final-year medical students could perform simulated cardiac arrest resuscitation codes either through the remote online learning (intervention) approach or the conventional face-to-face classroom (control) approach. Specifically, the study findings showed that a well-designed online approach could be effectively used to teach cognitive, complex psychomotor skills and team training and result in good levels of performance in cardiac arrest resuscitation. Both groups performed equally well in the areas of knowledge acquisition (basic principles) and decision-making. This is not surprising since many studies have produced similar results (19, 20).

In terms of performance, our study revealed the intervention group's performance was better than the control group, as indicated by the OSCE post-test score. This was an important finding, but it could be attributed to several factors. Teaching team resuscitation via an online approach is challenging, and differing strategies are required to ensure engagement and meaningful learning. In face-to-face teaching, the knowledge and skills were delivered simultaneously; however, with online teaching, the approach was to break down the key processes/components into small sections (deconstruction), identify the related usage of the components, and then pull together all the smaller sections or components as a final process. This online teaching approach requires time and planning. Just like in the scaffolding method of "I do, we do, you do." Another influence on the findings is that the intervention group had to practice, record, and send their performance to their supervisors for evaluation. The notion of having performance evaluated even during practice could be a motivating factor to perform better. In relation to the control group, even though they were allowed to practice until they were able to perform the skills competently, knowing they would not be tested during practice could have contributed to less motivation in the final performance (21).

In our study, both groups had the opportunity for deliberate psychomotor practice, reflecting the strengths and limitations of each learning approach. While participants in the intervention group had to perform their procedural skills until their supervisor deemed their performance was satisfactory, the control groups were guided by their facilitators in face-to-face sessions, enabling practice until competency was demonstrated within one session. Teaching methods for the control group were designed to mirror standard practices, allowing students direct, real-time interaction with facilitators. This naturally includes opportunities for iterative practice under supervision, which is typical in psychomotor skill training. Thus, while the methods for achieving mastery differed, both groups had clear paths to skill acquisition irrespective of group allocation.

The combination of synchronous and asynchronous sessions greatly enhanced participants' learning ability. Adding interactivity in both sessions overcomes the often-cited limitation of online learning, as highlighted by Franchi and colleagues (22). Telegram®, as a medium for discussion, allowed students to communicate faster to clarify and verify their performance. Students remarked that this approach felt like having a "personal tutor". Anastasiades (23) emphasised the importance of interactivity in student learning. Having participants perform and video record the procedures, and receive feedback from the supervisors strengthened their skill development even through this online approach. The recorded videos and supervisors' feedback were beneficial for the individual participant and for other members of the subgroup by allowing quick identification of mistakes to be avoided. This conferred a shorter learning curve for the participants (24, 25).

In this study, we applied the three aforementioned elements of community of inquiry to create a supportive and engaging learning environment to foster student learning and development. According to the community of inquiry, social presence refers to the ability of participants to work effectively in a team by identifying themselves and communicating purposefully in a trusting environment, thereby developing interpersonal relationships by projecting their personalities (8). The tenets of our study rely on the participants working together during both phases of learning, i.e., asynchronous and synchronous learning.

Cognitive presence is the extent to which students construct and verify meaningful learning through self-reflection and discourse (8). This was enabled by a small-group approach during the asynchronous learning of skills with SBSs and SIVs. Debriefing is a facilitated reflection by the supervisors to help the students develop meaningful learning.

Debriefing is noted as a mandatory component of learning (26). The incorporation of debriefing during synchronous sessions allowed participants and supervisors to interact actively. In this study, debriefing was conducted twice, first on Day 6, during the synchronous session, and again on Day 7 after the team resuscitation practice. The DeBRIEF technique (16) used in this study is a structured debriefing technique that explores participants' understanding of processes and presents hypothetical situations that require participants to think critically.

Finally, teaching presence stresses the design, and enables facilitation, and direction of the learning through the modules. The ORBITS-DeBRIEF approach was designed to ensure these elements were evident. For the online approach, we were mindful of keeping the cost as reasonable as possible. The ORBITS-DeBRIEF utilised readily available resources that were less expensive than proprietary tools, which in the current market cost between USD13,000 and USD40,000. In a low-budget setting, the cost of these technologies can easily become a significant burden. Furthermore, most proprietary tools were limited by their license requirements. By incorporating affordable technology into the ORBITS-DeBRIEF approach, the objective of providing a high-quality education is achieved, allowing students to receive a valuable learning experience.

Limitations

There are some limitations to the study. First, there is incomparability in the hands-on practice times for both groups. The control group had a structured hands-on practice time of 120 minutes, while the intervention group had an average cumulative hands-on practice duration of 223.56 minutes, which is almost double. This variation in exposure may have influenced skill acquisition and performance outcomes. Despite every effort to make the allowable two-week practice time for both groups equal, we only documented the individual practice time for the intervention group and not the control group. As students were free to practice in their own time, the total hands-on practice time may be more than the compulsory 120 minutes.

Second, the "contamination" of participants in this study can be very high because students might learn about cardiac resuscitation while they are on an anaesthesia or internal medicine clinical rotation and will often discuss their learnings with each other, even though they have been randomised to one or another group. Therefore, we used cluster or group randomisation to mitigate contamination of the participants within the same clinical rotation group. Each group attended the emergency medicine rotation at a different, dedicated time; therefore, the interaction between one group and the other was planned to be minimal. As students were required to interact closely with their group in completing their assignments, within-group randomisation was not an option to avoid bias.

Third, on some occasions, supervisors' feedback was delayed by a few hours after the students had submitted their performance. This was due to supervisors' busy clinical work schedules, which took priority. Hence, students sometimes felt frustrated due to the delay; however, as with any asynchronous learning approach, this is unavoidable. On the other hand, delay in feedback can also be an advantage because comments sent to one group member can benefit others and can act as a form of early remediation.

Fourth, despite efforts to ensure equal opportunities by providing the same facilitator-to-student ratios and access to the simulation laboratory, the different approaches resulted in slightly better opportunities for the intervention group to achieve skill mastery. The intervention group had to submit video recordings of their practical skills and repeat tasks until their supervisor was satisfied. In contrast, the control group received real-time, in-class instruction and performed the skills without necessarily reaching mastery level. Consequently, this difference might have introduced biases and contributed to improved OSCE performances in the intervention group.

Fifth, there were some technical limitations in the participants' video recording technique of their performance. As there was no written guide for students on how to record the technical videos, it led to difficulties in evaluating their techniques. Some had to re-record their performance, and although inadvertently, they offered an opportunity for more practice. Going forward, a sample on how to record the videos would mitigate this unforeseen error.

Finally, at times, the unreliability of internet access became a technical limitation. Some of the locations, either for participants or supervisors, lacked reliable internet access. Therefore, some of the videos took longer to download and review. Medical institutions that intend to use this approach should ensure strong and reliable internet coverage, which is essential in adopting this approach.

CONCLUSION

A total ORL through the mixed use of asynchronous and synchronous modes of learning, together with debriefing, facilitated a deeper understanding and skill retention that offers an effective alternative in gaining knowledge, making decisions, and performing ALS procedures for undergraduate medical students. Well-designed learning materials that combine screen-based simulations for cognitive learning and self-instructional videos for procedural learning, coupled with timely feedback from a supervisor, proved to be a good combination in our asynchronous learning approach. The ORL method seemed not only equivalent to the CCT in terms of knowledge acquisition and decision-making but was also shown to be superior for students' performance assessments. The practical aspects of team resuscitation, usually taught in a face-to-face classroom session, can also be successfully completed through an online synchronous format using readily available information and communication resources such as handphones and tablets or laptops. Medical students felt confident in performing the important aspects of ALS irrespective of the teaching and learning approach. Participants also perceived that the small-group learning approach of ORL contributed substantially to learning ALS as though it was like having a personal coach.

ACKNOWLEDGEMENTS

This research was funded by the Teaching and Learning Grant of Universiti Kebangsaan Malaysia (grant numbers PDI-2021-022). We would like to thank Associate Professor Dr. Johar Jaafar, Dr. Syed Mohammad and Mr. Ahmad Jailani for helping us with the data collection in this study. Also, to Dr. Muhammad Munawar for coordinating the medical student rotation in the Emergency Department. Finally, we would like to acknowledge all the medical officers from the Department of Emergency Medicine who have contributed to this study, either directly or indirectly.

ETHICAL APPROVAL

This study was approved by the Medical Research and Ethics Committee, Universiti Kebangsaan Malaysia (MREC No: JEP-2021-378).

REFERENCES

1. Malaysian Qualification Agency. Code of practice for programme accreditation: open and distance learning. 2nd ed. Cyberjaya: Malaysian Qualification Agency; 2019. p. 1–111.

2. Hatim F [Internet]. Johor: UTM; 2021 Jul 23 [cited 2022 Dec 29]. The 23rd Japanese University Consortium (JUC) meeting. Available from: https://news.utm.my/2021/07/the-23rd-japanese-university-consortium-juc-meeting/

3. Ahmady S, Kallestrup P, Sadoughi MM, Katibeh M, Kalantarion M, Amini M, Khajeali N. Distance learning strategies in medical education during COVID-19: a systematic review. J Educ Health Promot. 2021;10:421. https://doi.org/10.4103/jehp.jehp_318_21

4. Abdullah AA, Nor J, Baladas J, Hamzah TMAT, Kamauzaman THT, Noh AYM, Rahman A. E-learning in advanced cardiac life support: outcome and attitude among healthcare professionals. Hong Kong J Emerg Med. 2020;27(6):328–33. https://doi.org/10.1177/1024907919857666

5. Thorne CJ, Lockey AS, Bullock I, Hampshire S, Begum-Ali S, Perkins GD. E-learning in advanced life support – an evaluation by the Resuscitation Council (UK). Resuscitation. 2015;90:79–84. https://doi.org/10.1016/j.resuscitation.2015.02.026

6. Saiboon IM, Jaafar MJ, Ahmad NS, Nasarudin NMA, Mohamad N, Ahmad MR, Gilbert JHV. Emergency skills learning on video (ESLOV): a single-blinded randomized control trial of teaching common emergency skills using self-instruction video (SIV) versus traditional face-to-face (FTF) methods. Med Teach. 2014;36(3):245–50. https://doi.org/10.3109/0142159X.2013.857013

7. Soar J, Mancini ME, Bhanji F, Billi JE, Dennett J, Finn J, et al. Part 12: education, implementation, and teams: 2010 international consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Resuscitation. 2010;81Suppl 1(1):e288–330. https://doi.org/10.1016/j.resuscitation.2010.08.030

8. Office of Teaching and Learning: Inclusive Teaching Practices [Internet]. Denver: University of Denver; c2025 [cited 2023 Jan 29]. The community of inquiry model. Available from: https://operations.du.edu/inclusive-teaching/community-inquiry-model

9. Zajda J. Social constructivism to improve students' motivation. In: Globalisation and dominant models of motivation theories in education. Cham: Springer Nature; 2023. p. 63–79. https://doi.org/10.1007/978-3-031-42895-1_5

10. Hussin AA. Education 4.0 made simple: ideas for teaching. IJELS. 2018;6(3):92–8. https://doi.org/10.7575/aiac.ijels.v.6n.3p.92

11. Saiboon IM, Musni N, Daud N, Shamsuddin NS, Jaafar MJ, Hamzah FA, Bakar AA. Effectiveness of self-directed small-group-learning against self-directed individual-learning using self-instructional-video in performing critical emergency procedures among medical students in Malaysia: a single-blinded randomized controlled study. Clin Simul Nurs. 2021;56:46–56. https://doi.org/10.1016/j.ecns.2021.02.006

12. Karageorgakis T. [Internet]. E-learning industry; c2011–2025 [cited 2022 Sep 28]. The importance of interactivity in eLearning programs. Available from: https://elearningindustry.com/interactivity-in-elearning-programs-importance on 28/9/2022

13. Fisk P. [Internet]. 2017 [cited 2022 Jul 26]. Education 4.0...the future of learning will be drastically different, in school and throughout life. Available from: https://www.peterfisk.com/2017/01/future-education-young-everyone-taught-together/

14. Wei HC, Peng H, Chou C. Can more interactivity improve learning achievement in an online course? Effects of college students' perception and actual use of a course-management system on their learning achievement. Comput Educ. 2015;83:10–21. https://doi.org/10.1016/j.compedu.2014.12.013

15. Eppich WJ, Hunt EA, Duval-Arnould JM, Siddall VJ, Cheng A. Structuring feedback and debriefing to achieve mastery learning goals. Acad Med. 2015;90(11):1501–08. https://doi.org/10.1097/acm.0000000000000934

16. Ismail MS. The role of simulation in shaping emergency medicine education in the era of education 4.0 [lecture]. Bangi, Selangor: Penerbit UKM; 2022.

17. Wicklein RC. Identifying critical issues and problems in technology education using a modified-Delphi technique. J Technol Educ. 1993;15(1):54–71. https://doi.org/10.21061/jte.v5i1.a.5

18. Feldman M, Lazzara EH, Vanderbilt AA, DiazGranados D. Rater training to support high-stakes simulation-based assessments. J Contin Educ Health Prof. 2012;32(4):279–86. https://doi.org/10.1002/chp.21156

19. Isa MH, Lim K, Jaafar MJ, Saiboon IM. The effectiveness of self-instructional video vs classroom teaching method on focused assessment with sonography in trauma among house officers in university hospital. Front Surg. 2021;8: 698774. https://doi.org/10.3389/fsurg.2021.698774

20. Saiboon IM, Qamruddin RM, Jaafar JM, Bakar AA, Hamzah FA, Eng HS, Robertson CE. Effectiveness of teaching automated external defibrillators use using a traditional classroom instruction versus self-instruction video in non-critical care nurses. Saudi Med J. 2016;37(4):429–35. https://doi.org/10.15537/smj.2016.4.14833

21. Burch VC, Seggie JL, Gary NE. Formative assessment promotes learning in undergraduate clinical clerkships. S Afr Med J. 2006;96(5):430–3. https://www.ajol.info/index.php/samj/article/view/135425

22. Franchi T, Magudia A, Rasheed A. Appropriate use of self-directed learning at medical school prepares students for future clinical practice. Med Educ Online. 2020;25(1):1752450. https://doi.org/10.1080/10872981.2020.1752450

23. Anastasiades PS. Blending interactive videoconferencing and asynchronous learning in adult education: towards a constructivism pedagogical approach – a case study at the University of Crete (E.DIA.M.ME.). In: Negash S, Whitman M, Woszczynski A, Hoganson K, Mattord H, editors. Handbook of distance learning for real-time and asynchronous information technology education. USA: IGI Global Scientific Publishing; 2008. https://doi.org/10.4018/978-1-59904-964-9.ch002

24. Templeton JJ. Learning from others' mistakes: a paradox revisited. Anim Behav. 1998;55(1):79–85. https://doi.org/10.1006/anbe.1997.0587

25. Weinzimmer LG, Esken CA. Learning from mistakes: how mistake tolerance positively affects organizational learning and performance. J Appl Behav Sci. 2017;53(3):322–48. https://doi.org/10.1177/0021886316688658

26. Fanning RM, Gaba DM. The role of debriefing in simulation-based learning. Simul Healthc. 2007;2(2):115–25. https://doi.org/10.1097/sih.0b013e3180315539