Original Article

Effects of Flipped Classroom Learning in Acquisition and Retention of Cardiopulmonary Resuscitation Skills among Entry-Level Health Professional Students: A Single-Blinded Randomized Controlled Trial

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Abstract

Context: Inhospital cardiac arrests are provided with immediate life support care, but outhospital cardiac arrest does not receive bystander resuscitation immediately. These delays are due to several reasons; education and type of training received are among them. **Objective:** The objective of this study was to evaluate the effects of flipped classroom learning (FCL) in the acquisition and retention of knowledge and skills of cardiopulmonary resuscitation (CPR) among health professional students. **Methods:** A randomized control trial was performed among entry-level health professional students with no background knowledge and skills on basic life support (BLS) and CPR who were equally divided into the flipped classroom (intervention group) and lecture-based classroom (LC) (control group). The BLS and CPR were taught through didactic lectures and hands-on practice to both the groups. The intervention group received the self-study material in a video module before the lecture and hands-on practice. The study was implemented in three phases – intervention phase, follow-up at 1 month, and 2 months. Knowledge was assessed using multiple-choice questions and skills through direct observation and a checklist throughout all the phases. **Results:** Sixty-one participants completed the study. Mean difference in scores for knowledge and skills between the LC and flipped classroom groups increased immediately after intervention but was not retained on follow-up at 1 and 2 months, and is not statistically significant. However, a significant difference was observed in knowledge and skill scores within the group across different phases ($P < 0.001$). **Conclusion:** We did not find an additional benefit of FCL over LC learning.

Keywords: Basic cardiac life support, cardiopulmonary resuscitation, flipped classroom learning, online learning, traditional learning

Introduction

Cardiac arrest occurs in both in-hospital and out-hospital setting, often with pre-monitory signs. It is characterized by a sudden loss of consciousness and breathing after cardiac output has ceased.[1] According to the statistical updates reported by the American Heart Association (AHA), the incidence of Out-hospital cardiac arrest (OHCA) in 2016 was 350,000, with an overall survival rate of 12%.[2] Survival rate of patients with OHCA can be enhanced by increasing the bystander response. In 2016, the rate of bystander cardiopulmonary resuscitation (CPR) received by OHCA cases was about 46.1%. Various factors are responsible for a lower rate of bystander CPR, including lack of training, legal implications, socioeconomic factors, and fear that can be mitigated and maintained using education.[3]

CPR can be provided by an individual who has acquired prior training; therefore, it is important to examine the training they

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Quick Response Code:

Website: www.ijrc.in

DOI: 10.4103/ijrc.ijrc_149_21

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How to cite this article: Reddy M, Unnikrishnan R, Ramachandran S. Effects of flipped classroom learning in acquisition and retention of cardiopulmonary resuscitation skills among entry-level health professional students: A single-blinded randomized controlled trial. Indian J Respir Care 2022;11:128-34.

Received: 02-12-2021 **Revised:** 19-12-2021

Accepted: 12-01-2022 **Published:** 08-04-2022

have received because the primary reason to initiate bystander CPR is the level and amount of education and training received. Therefore, well-structured educational programs must be provided to improve the attitude, cognitive, and psychomotor skills toward performing CPR.[3] In addition, psychomotor skills are needed to perform CPR because the quality of rescuer performance also depends upon these factors. Hence, one of the ways to improve the bystander response is by providing the knowledge of CPR in the most appropriate way.[4,5]

Currently, there are numerous formal and informal training programs. The approach of training provided by the AHA is a 3-day training program with an instructor-to-student ratio of 1:6.[5] This model expects the students to learn the skills and knowledge for providing resuscitation through videos and instructor-led hands-on practice. One of the limitations of this method is that the time provided for the learners is fixed; therefore, learners with a slow ability to learn the skills may find it difficult to acquire the required skills in a given time. Therefore, teaching strategies must be designed so that learners are encouraged to observe, analyze, express an opinion, look for a solution, and discover knowledge by themselves.

A recently introduced novel educational model called flipped learning or flipped classroom, also known as a backward, inverted, or reverse classroom, was developed, which requires classwork to be done before class, while what used to be homework was done in the scheduled class.[6] It is student-centered learning allowing the students to learn at their own pace and comfort. Studies have shown that the flipped classroom can provide students more flexibility for self-paced learning, help to promote content retention, and promote students' interest in learning. However, the overall effectiveness of the flipped classroom approach in medical education is still being debated. Therefore, it is important to evaluate the effectiveness of the flipped classroom each time that it is applied to a new setting.[7] This study aims to determine the effects of flipped classroom learning (FCL) strategy and traditional classroom strategy on the acquisition and retention of knowledge and skills of CPR.

Methods

Study objectives

The study's primary objective was to assess the scores obtained in acquisition and retention of the knowledge and skills of basic life support (BLS)/CPR of the participants through different types of training. The secondary objective was to compare the scores obtained in knowledge and skill acquisition and retention between the control and interventional groups at different phases.

Study design

A single-blinded randomized controlled trial was conducted comparing the effects of FCL and lecture-based classroom (LC) learning on medical skills. This study was performed after obtaining ethical clearance from the institutional ethical committee (419-2018) and registering in the Clinical Trials Registry of India (2018/08/015426). The study was performed in a medical simulation center (MSC) located on our university campus.

Study population

We enrolled undergraduate students of the health professional program studying in our institute, aged 18–25 years, who did not have any prior knowledge of any lifesaving skills for the study. Participants with clinical deformities restricting them from performing medical skills and previous knowledge of BLS or CPR were excluded from the study.

Randomization

Block randomization was used. Twelve sequences with a block size of six were generated. Blocks were created using the two alphabets "A" and "B." Each sequence was unique from another. All the sequences were concealed and kept in an opaque envelope. The sequences were opened at the time of recruitment by the primary investigator. Participants were allotted into the interventional group – FCL and the control group – LC. Only evaluators were blinded to the group of participants and the type of intervention received.

Study interventions

Informed consent was obtained from each participant. A total of 72 participants were recruited for the study. Before allocation into different groups, all 72 participants who volunteered for the study underwent a pretest using a multiple-choice questionnaire (MCQ) to assess their knowledge on BLS and CPR during the first meeting. The MCQ used in this study was reproduced from the National Health Care Provider Solutions, BLS Practice Test Questions with permission. The questionnaire contained 13 questions covering the algorithm of adult BLS [Table 1]. Each question was awarded one mark, accounting for a total of 13 marks, and there were no negative markings for incorrect answers.

After completing the pretest, participants were randomized into intervention and control groups. The intervention group received the self-study material in a scripted video module before the didactic lecture and hands-on practice as a flipped classroom strategy. The reference materials were uploaded to the Google classroom 1 week before the scheduled didactic lecture. The participants in the intervention group were instructed to log in to the online classroom through their e-mail for access to the video-based learning module. The steps of BLS and CPR were scripted to supplement the video-based learning module. The scripted video module was locally developed with the help of an experienced and qualified cardiac life support instructor at our MSC and shared in the Google classroom as embedded video with view option only. This prevents the students of flipped classroom from downloading or forwarding the video link to other students.

On the other hand, the control group received only the didactic lecture and hands-on practice on BLS and CPR. The students in the control group did not have access to the

Table 1: Multiple choice questions for assessing knowledge level on adult basic life support

Questions
1. You are alone when you encounter a patient who collapsed in-front of you. What are the first three steps you should take to stabilize the patient? Check for danger, _____, and send for help
2. Where should you attempt to perform a pulse check in an adult?
3. You assess that the patient still has a pulse, what is the next step in managing this case?
4. You are a day-care provider and find a 50-year-old woman unresponsive. You secure the scene, you are by yourself, what is the next step in managing this case?
5. The initial BLS steps for an adult are
6. The compression to ventilation for one rescuer giving CPR to an adult individual is
7. The five steps in adult chain of survival include all of the following except
8. The 2015 AHA guidelines for CPR recommended BLS sequence of steps are
9. In an adult with an advanced airway in place during 2 - rescuer CPR, how often should a breath be delivered?
10. The critical characteristics of high-quality CPR include which of the following?
11. The proper steps for operating an AED are
12. The AED indicates shock advised. What is the next step?
13. After delivering a shock, what is the next step in caring for this patient?

BLS: Basic life support, CPR: Cardiopulmonary resuscitation, AHA: American Heart Association, AED: Automated External Defibrillator

Table 2: Check list for assessing the skills of adult basic life support

Check-list item	
Items with score 1	**Items with score 2 (critical skills)**
Scene safety	Response (tap and shout)
Compression depth	Activation of emergency response system
Breathing	Compression rate
Hand placement	
Chest recoil	
Minimizing interruptions	
AED placement	
Total score - 13	

AED: Automated External Defibrillator

scripted video module as the Google classroom restricts permission for invalid users.

On day 8, participants of both the groups were asked to attend the traditional lecture session, which was conducted in the MSC. Participants in the intervention group attended the morning session, and participants in the control group attended the lecture session in the afternoon. This was done to avoid any contact between the two groups. The lecture was conducted using PowerPoint facilitated by a cardiac life support instructor. After the 30 min of lecture session, all participants were divided into a group of six per instructor for 45 min of hands-on practice, and their doubts were clarified simultaneously. There were six instructors who were qualified trainers. All six trainers were health care professionals, mainly respiratory therapists, who specialized in adult respiratory care and completed their AHA BLS instructor courses. Hence, they were considered evaluators for the study. All participants were given the opportunity to practice on the manikin. After the hands-on practice was completed, they were given a 10-min break. They were then asked to attend a postintervention test (Phase I) to assess their knowledge through the same questionnaire.

Along with the knowledge, participants' CPR skill performance was also assessed on Little Anne CPR rescue manikin. The skills were evaluated using an expert validated checklist [Table 2]. Ten items were included in the checklist. Each item had a score of one except for the critical skill items which carried two marks, accounting for 13 marks. Skills evaluated were verifying scene safety, checking for a response, activating emergency response, chest compressions (rate and depth), providing rescue breath, use of AED. Among these, the critical skills were check for a response, activating emergency response, and compression rate. All the evaluators who assessed the skill performance were trained on using the checklist. Those participants who failed to perform the critical skills correctly were assessed and retrained on the same day.

After the teaching and evaluation sessions, all participants were given a feedback form to provide their views on the intervention and were also allowed to give suggestions and any other feedback. The feedback form contained three sections. Section 1 had items regarding the need for BLS knowledge to the society and the participants' confidence in providing CPR in times of need after attending the session. Section 2 included items regarding flipped classroom intervention, and Section 3 contained items regarding LC intervention.

At 1 month postintervention (Phase II), the participants were assessed only for knowledge retention using the same questionnaire sent as an online survey. Their responses were recorded since the participants were away from the campus for that particular period. Participants were again called for the face-to-face follow-up session at 2 months (Phase III) to evaluate their retention of knowledge and skills. The evaluation session was conducted in MSC. The same questionnaire and checklist were used. All the scores were recorded and then computed and analyzed.

Outcome measures

Our study had two outcomes. The primary outcome of

our study was acquisition and retention of the knowledge component of BLS and CPR, which was measured using the MCQ. The study's secondary outcome was acquisition and retention of BLS and CPR skills, which was measured using a validated checklist.

Sample size and statistical analysis

A total of 72 participants were recruited and divided into two groups (intervention and control) of 36 participants. The sample size was calculated using the power of 80%, confidence intervals of 95%, anticipated population standard deviation of 3.85, and magnitude of the expected difference of 3. Furthermore, considering the dropout rate of 20%, a sample size of 36 was estimated per group. All data were analyzed using IBM SPSS Statistics for Windows, Version 20.0. (Armonk, NY: IBM Corp), (Bengaluru, South Asia, India). Continuous variables (age and scores) are mean and standard deviation or median and interquartile range. Categorical variables (gender and class year) are described as *n* (%). Kolmogorov–Smirnov and Shapiro–Wilk tests were used to check the normality of the data. To compare scores between the two groups, Mann–Whitney *U*-test was used. For comparison of scores across different time points in the same group, Wilcoxon signed-rank test was used. MS Excel was used to derive the error line plot for enumerating the scores. $P < 0.05$ was considered to be statistically significant. Due to multiple tests performed, Bonferroni correction was used to obtain a new corrected $P < 0.01$.

Results

Study population

A total of 72 participants were recruited in this study, and they were randomized into two groups (36 each). All 72 participants attended the pretest assessment. Sixty-one (84.72%) reported for the study at Phase I, 37 (51.38%) reported at Phase II, and 51 (70.83%) reported at Phase III. Table 3 and Figure 1 provide the details of the participants who attended each phase of the study. Analysis of the scores was performed only for those participants who appeared for the assessments at different time points.

Table 3: Study participant details

	Control group	Interventional group
Sample size for each group	36	
Total participants reported for (*n*)		
Pretest	36	36
Phase I	29	32
Phase II	17	20
Phase III	24	27
Age (mean±SD)	18.3±0.62	18.3±0.69
Gender (%)		
Male	24	28
Female	76	72
Class year (%)		
1st year	83	80
2nd year	17	20

SD: Standard deviation

Study intervention

The mean score obtained for the knowledge component during pretest was 4.41 (±1.82) and 4.44 (±1.81), Phase I was 8.03 (±1.59) and 8.56 (±2.16), Phase II was 8.71 (±2.80) and 8.75 (±2.69), and Phase III was 10.67 (±1.88) and 10.70 (±2.09) for the control group and intervention group, respectively [Figure 2]. The mean score for the skill component at Phase I was 11.69 (±1.69) and 10.81 (±2.82) and Phase III was 9.42 (±1.88) and 9.37 (±2.35) for the control and interventional groups, respectively [Figure 3].

When analyzed between the groups at different time points, no significant difference was found in the MCQ scores, $P = 0.36$ at Phase I, $P = 0.93$ Phase II, and $P = 0.81$ at Phase III [Table 4]. The analysis of skill scores showed no significant difference when compared between the groups: $P = 0.24$ Phase I and $P = 0.74$ at Phase III. When the MCQ scores were compared within the groups at different time points (pretest, Phase I, Phase II, Phase III), There was a statistical difference between pretest and phase I & III and between Phase I and Phase III. However, there was no statistical difference observed for the time points between Phase I and Phase II ($P = 1.00$) in both the groups. In analyzing skill scores across different time points (Phases I and III) within the group, no significant difference was seen, $P = 0.004$ in the control group and $P = 0.034$ in the interventional group [Table 4].

Feedback analysis

Feedbacks provided by the students postintervention were obtained and analyzed. Ninety-five percent of the participants agree that all society members must be educated with BLS. Ninety-six percent of the participants came across the term "flipped classroom," and only a few participants (8%) were satisfied by teaching through the FCL technique. Participants of both the groups (100%) agree that a traditional classroom is better for teaching than the flipped classroom. Overall, all participants (100%) were satisfied with the intervention.

Discussion

Several studies have been performed to observe the influence of flipped classroom in various fields of education. Few studies demonstrated the potential benefit of the use of FCL in attaining cognitive knowledge and skills.[8-11] In our study, we found no statistically significant difference between LC and FCL in the acquisition and retention of knowledge and skills of CPR. Similar results were found in studies conducted by Junainah *et al*. and Nakanishi *et al*.,[6,10] demonstrating no significant difference between the flipped classroom and traditional classroom learning strategy. Chen *et al*.[12] conducted a systematic review of the effectiveness of flipped classroom in medical education. Based on the findings of the review, it was found that although having a positive perception toward the flipped classroom approach, it

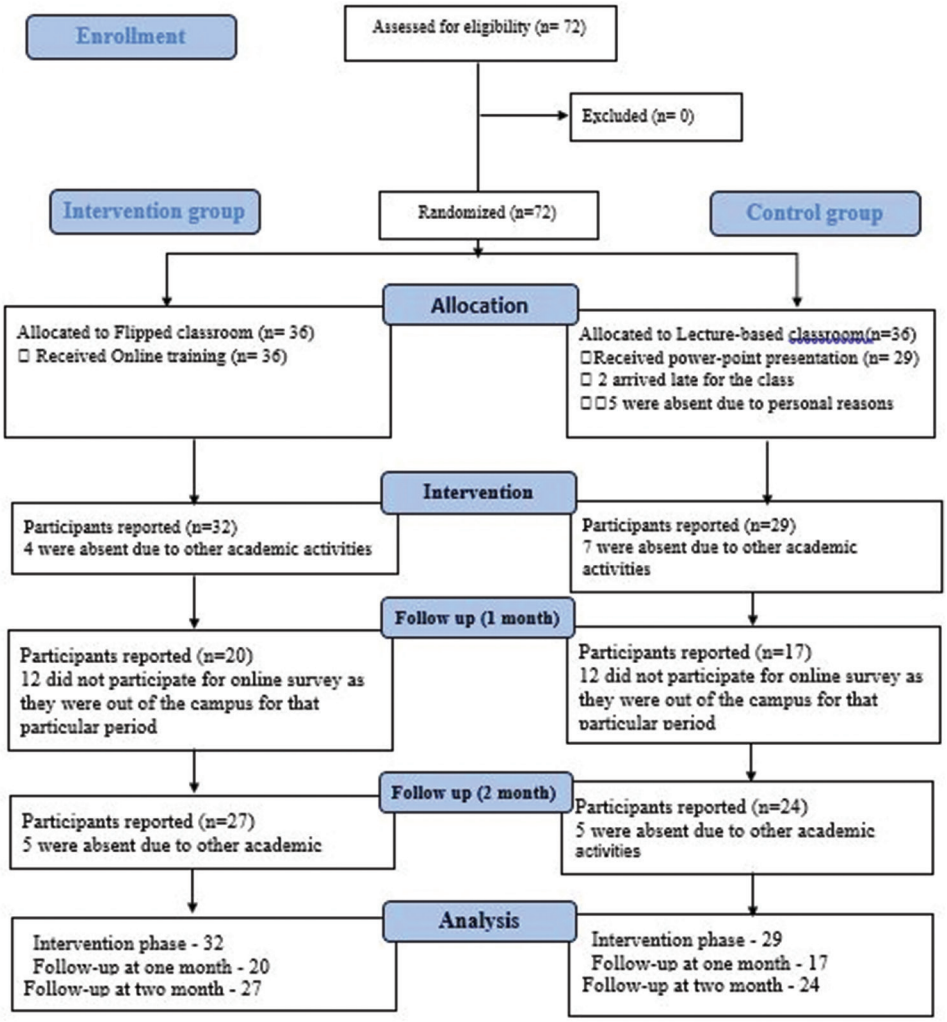

Figure 1: CONSORT flowchart of study participants

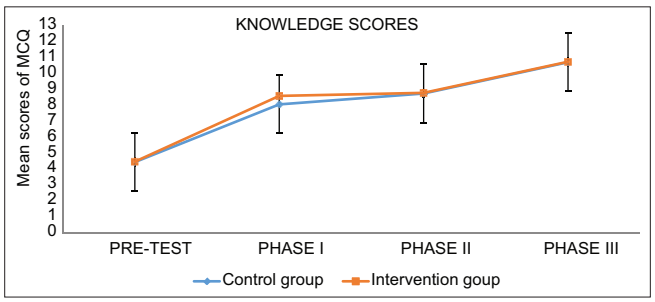

Figure 2: Error line plot of knowledge score among different phases of both groups. Mean scores of control group: pretest – 4.41 (±1.82), Phase I – 8.03 (±1.59), Phase II – 8.71 (±2.80), Phase III – 10.67 (±1.88). Mean scores of intervention group: pretest – 4.44 (±1.81), Phase I – 8.56 (±2.16), Phase II – 8.75 (±2.69), Phase III – 10.70 (±2.09)

did not have any effect in improving the knowledge and skill acquisition compared with the traditional setting of teaching.

Postintervention, the knowledge levels improved similarly in both the groups. The traditional classroom approach may have helped participants from both the groups learn CPR. During Phase II, the scores remained the same but, at Phase III, we found that knowledge on CPR improved, suggesting that these students may have retrained themselves or got accustomed to the set questions. Similarly, the skill score levels at Phase I was alike in both the groups. At Phase III, the skill scores declined over time in both the groups implying a deterioration of skills. This contrasts with a study performed by Pangandaman[8] which resulted in a slight improvement in skills and knowledge after using the FCL strategy. However, there was no significant difference in the skill score between the two groups in our study. This could be due to a lack of hands-on experience for all the participants, thus emphasizing the need for skill training and exploring the need for dedicated time on skill retraining.

Our study noted that in Phase I, checking for response activating EMS and providing correct compression and ventilation ratio domains was consistently well performed by the participants. The domain with the least number of the correct answer was the use of AED. During Phase III, it was noted that the participants could consistently check the victim's response during the assessment period. The performance across other domains

Table 4: Mean scores of knowledge and skill component

Study phase	Mean±SD			
	Knowledge scores		Skill scores	
	Control group	Intervention group	Control group	Intervention group
Pretest	4.41±1.82	4.44±1.81		
Phase I	8.03±1.59	8.56±2.16	11.69±1.69	10.81±2.82
Phase II	8.71±2.80	8.75±2.69		
Phase III	10.67±1.88	10.70±2.09	9.42±1.88	9.37±2.35
Comparison of scores between groups at different time points (*P* values)				
Study phase	**Knowledge**		**Skills**	
Phase I	0.36		0.24	
Phase II	0.93			
Phase III	0.81		0.74	
Comparison of scores within the group at different time points (*P* values)				
Study phase	**Control group**		**Intervention group**	
	Knowledge	**Skill**	**Knowledge**	**Skill**
Pretest to Phase 1	0.000		0.00	
Pretest to Phase III	0.000		0.00	
Phase I to Phase II	0.192		1.00	
Phase I to Phase III	0.000	0.004	0.00	0.034

SD: Standard deviation

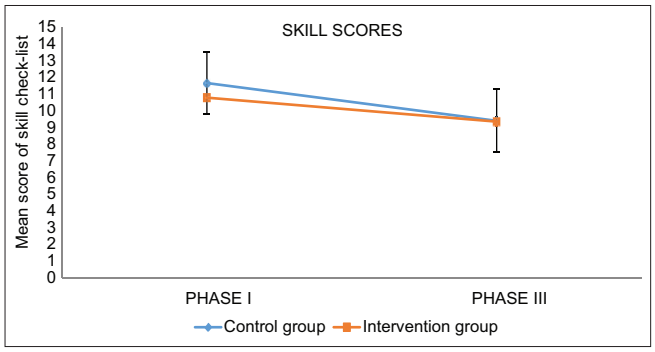

Figure 3: Error line plot of skill score among different phases of both groups. Mean scores of control group: phase I – 11.69 (±1.69), Phase III – 9.42 (±1.88). Mean scores of intervention group: phase I – 10.81 (±2.82), Phase III – 9.37 (±2.35)

was variable. The poorly performed skill was providing rescue breath and high quality CPR high-quality CPR.

Subsequent analysis of the feedback forms revealed the attributes of the HCP toward CPR. The participants agreed to the need for CPR in society, though few of them were unsure about the benefit of this program to the general public. This can be attributed to the participants' age and lack of medical knowledge as they are new to the healthcare professional program. However, they all agreed to share the knowledge learned with their friends and family members. Furthermore, all participants were comfortable and satisfied with the traditional approach of learning over FCL. A similar feedback finding was observed by Tang *et al*.,[13] which revealed that participants preferred traditional classroom learning over flipped learning.

The main limitation of our study was that the participants' learning pace could not be tracked using an online classroom. Additionally, the traditional classroom participants' access to the training resources could not be monitored. Furthermore, we could not identify the reasons for the improved MCQ scores at 2 months or the maintenance of the scores at 1 month. We could not establish a relationship between the online training tools provided and the scores obtained at 1st and 2nd months.

Conclusion

We did not find an additional advantage of FCL in obtaining a better result postintervention and follow-up at 1 and 2 months in MCQ and skill scores. Therefore, in our context, FCL may not be effective in improving the knowledge level or CPR concepts in students before their lecture class learning. However, once familiarized with the technique of flipped learning strategy, it may help improve knowledge.

Acknowledgment

We acknowledge the Professors from the Department of Anaesthesiology, KMC, Manipal, India, for providing support in the development of the video and training the students and National Health Care Provider Solutions for granting permission to use the questionnaire.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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