Flipped education may help in the education of junior general surgery residents in their trauma rotation; a mixed-method study

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Abstract

Introduction: This study aims to assess the effectiveness of flipped learning in trauma rotation of first-year general surgery residents. This method entails the use of books, podcasts, and movies prior to the discussion of the topics in the classroom/conferences.

Method: All (n=15) junior general surgery residents in Shiraz medical school. In the quantitative phase of the study, 3 test scores were compared. All tests were composed of 20 multiple choice clinical scenarios. A pretest was done on the registration date. After that, the media (videos and podcasts) and books were given to the residents. One month later, the residents had a case-based discussion on the primary trauma survey. An early post-test was done immediately after the case-based discussion, and a late post-test one month following commencement of the program. Also, a semi-structured phone interview was done with residents by an external audit.

Results: The was a significant correlation between pretest (Mean=10.733,SD=2.25) and early post-test scores (Mean=12.8 ,SD=1.82) among residents (P=0.004) . Moreover, residents had a higher delayed post-test score (M=13.267, SD=1.53) in comparison to the pre-test (P=0.002). Surprisingly there was no significant difference between early and late post-test (P=0.404). The resident was also satisfied with the overall usefulness of the program for junior residents (overall score 4/5). We did not find any correlation between gender with the test scores. In the qualitative phase of the study, we noticed that our participants tend to use podcasts more than other materials. They believed that the videos and books help more to foster theoretical knowledge. The case-based discussion makes them more confident in dealing with the patients in their daily encounters

Conclusion: Finding in this study reveals that flipped learning can be a useful, highly beneficial platform and promotive for junior general surgery programs.

Introduction

The education of general surgery residents is complex and complicated. There are many areas to become an expert as a general surgeon. One of these is trauma, which is considered as a primary content area of general surgery residents by the American Board of surgery and other related committees [1]. This issue may be more complicated, considering suboptimal training of the residents because of duty hour restrictions[2]. Trauma is accountable for 20 percent of the global burden of diseases [3]. According to statistics, the trauma victim rate is more than the cumulative numbers of HIV, tuberculosis, and malaria each year. Moreover, trauma accountable for around 20 percent of the global burden of diseases.[4] This requires the immediate attention of surgical curriculum planners, mainly in the developing world, where the fifth-sixth percent of mortalities are based on trauma.[5] Also, in the Emergency Room(ER), the patients' sensitivity and medical presentations necessitate immediate attention, obtaining a proper history and physical examination, precisely ordering first line lab data and start management plan. Clinical management of trauma victims is realm of golden seconds/minutes [6]. In simple words, trauma is a surgical field that seconds matter and not minutes.[7] Evidence showed that following the restriction in duty hours of residents and progression of subspecialty care, trauma training as one of the major core components of the general surgery curriculum has affected miserably[8]. This requires the adoption of unique and novel methodological approaches to enhance learning and compensation of the deficiencies in educational program. Moreover, the traditional concept of surgical education that the training merely occurs in the context of operation room is questionable as me moved forward to enhance efficacy and decrease the risks [8]. Also, education in residency programs differs from other types of training. The pedagogical approach is a traditional and widely known version of education, in which students learn and teachers teach [9]. On the other side, an andragogical approach promotes self-directed, problem-oriented, self-reflected, and learner-centered learning. In this methodology, the mentor/teacher merely facilitates learning. With such an approach, the role is didactic lectures are blurred, and more focus is on other types of learning such as problem-based learning (PBL), small group discussion, game-based learning, simulation-based learning.[10] The surgical education has many complexities as well; many new minimally invasive devices has been introduced in surgey during past few decades. Mastering this techniques and devices ,such as laparascopy, has turned to be an eseential in curriculum design.This provide an unique opportunity to integrate e-learning into the course plans [11]. Integration of any new educational strategy necessitates the proper recognition of cons and pros of the program. One of novel educational method which integrates the traditional “in- classroom” education with e-learning is blended learning [12]. This method is considered as a bridge from the traditional teacher domoinated face to face lectures/discussions to fully web based education[13].

The blended learning and especially flipped classroom arose from high schools and undergraduates of non-medical fields. However, this method progressed rapidly in many areas, including medicine.[14] In this method, teachers provide content of the curriculum in a balanced, targeted, and a rational salad of methodologies to the students. Some materials are provided in the movie, while others are in podcasts or books. Additionally, the students attend the case based/teacher facilitating discussions after processing that initial resources.[15]. Flipped learning is composed of e-Learning and didactic sessions, in which educational materials (books, podcasts, and videoclips) are provided a priori to the classroom discussion[16].

This method was first used by Jonathan Bergmann and Aaron Sams in 2007 when they decided to provide audio narrated powerpoints for absent students in a chemistry course[17, 18]. They defined this kind of learning as “what which traditionally done in class now is done in the homes, and what which is traditionally done as homework now is done in the class.”[17]

In this approach, as all students are, at least, familiar with the concept of the topic, class time would be more useful to both high-ranked and mediocre ones [19]. Also, as it is learner-based and discussion-based, it would promote higher cognitive function such as analysis and critical thinking.[20]

Flipped learning has emerged in residency programs to address the busy schedule of faculties and residents and help to robust effectiveness considering the restricted duty hours [5]. The application of this method is considered to be highly effective for junior residents. Because they are less experienced, quickly feel overwhelmed, and have high working stress, which may result in early burnout [21]. In designing a flipped curriculum for general surgery residents, teachers, and curriculum planners should design curriculum in a time-effective and flexible manner that does not require to attend all classes in-site [22]. We suppose that the flipped method is the right way for education, especially in first-year surgical residents, in this case, junior general surgery residents. Also, in the COVID-19 era, the practicality of electronic learning (and blended learning) becomes more significant these days[23-25].

There is a wide gap in evidence concerning flipped learning in the medical curriculum, especially the post-graduate curriculum [26]. In the current study, we aimed to investigate the applicability of flipped learning in trauma education among junior general surgery residents in Shiraz medical school. We sought to answers four research questions: (I) can flipped learning foster knowledge acquisition? (II) can flipped learning lead to the encouragement of knowledge retention in trauma rotation? (III) how much is the use of material usage by our residents in flipped learning? (IV) was the overall program satisfactory to participants? To our best knowledge, it is the first reported integration of flipped learning into the trauma rotation curriculum of general surgery residents.

Methods

This study was done with a mixed-method approach. The research sample was all of the junior general surgery residents of Shiraz medical school who were selected by the census method. After explaining the aims and methodology of study for them, all of 15 residents participated in our study. In this step, informed written consents were obtained from the residents. We assured them that their private information would be kept confidential.

In this study, all residents were in the intervention group (educated with flipped learning) with the use of pre-test, early post-test, and a late post-test design after four weeks. We aimed to assess the impact of flipped learning on clinical judgment and problem solving of first-year general surgery residents of Shiraz medical school concerning the primary trauma survey. Then semi-structured phone interviews were conducted with the research samples to determine their quantitive use of material, perceived utility of the material, and overall satisfaction of the program. All the residents fully completed the study, and there was no missing data within the educational intervention.

- **Study design :**

The study was designed in April and May 2019 with a collaboration between “Shiraz trauma hospital” and “office of Continuing education program” of Shiraz University of Medical Sciences. Their educational materials were composed of videos, rapid review podcasts, and books. The paper materials were from two specific references. The first book was Advanced Trauma Life Support (ATLS)10th Edition Student Course Manual 2018, published by ACS American College of Surgeons (or simply ATLS hereafter). The second book was a trauma chapter (7th chapter) of Schwartz's Principles of Surgery 11th edition,2019 McGraw-Hill publication. The novel educational material (video and podcasts) was prepared based on our most extensive discussion of two separate expert panels composing of four trauma surgeons and five medical educationists and mainly according to the titles of the ATLS. The preparation of curriculum and educational materials was done in June and August 2019 in Shiraz trauma hospital. The recorded materials were 17 hours of video and five rapid review podcasts. The video sessions, using real-life scenarios, were about 13 titles (each mainly about 60 minutes and a maximum of 1.5 hours). The titles of the visual media are available in table 1. The podcasts were about 30 minutes and rapidly reviewed the “must-know” points.

Table.1 the subjects of videos (13 topics)

Initial assessment and management	**Airway and ventilatory management**	Shock
Thoracic trauma	Abdominal and pelvic trauma	Head trauma
Spine and spinal cord trauma	Musculoskeletal trauma	Thermal injuries
Pediatric trauma	Geriatric trauma	Trauma in pregnancy and intimate partner violence
Transfer to definite care		

- **Implementation phase :**

The implementation of the education program and evaluation phase lasted from September to November 2019. In September 2019, a pre-test examination was held to assess the baseline knowledge of the residents regarding the primary trauma survey. After that, all junior general surgery residents received educational movies, podcasts, and books for primary trauma surveys. One month later, a case-based discussion was held for residents in a 2.5 hours class discussion. In that class, the attendings reviewed the concepts of the educational materials by case-based teaching and interactive lecture. For assessing the early efficacy of the program in clinical problem solving, and early post-test was done after the case-based discussion. One month later (early November), all residents participated in a delayed post-test examination to assess the impact of the whole program in knowledge retention of the contents. In order to assess the higher level of cognition, pretest, early post-test, and late post-test, all were composed of 20 comparable clinical scenarios to evaluate clinical judgment and problem-solving capabilities[27]. In mid-November 2019, a semi-structured phone interview, using a five score Likert scale, was conducted by an external expert. Each interview lasted around 20 minutes. The interviews were then transcribed and analyzed using qualitative content analysis.

- **Data collection tools :**

In the quantitative phase of the study, we used three comparable multiple choice question (MCQ) examinations as a pretest, early post-test, and late-post test. All composed of 20 clinical scenarios on the primary trauma survey. Each correct answer awards one positive score for the responder and a total score of 20. The content and face validity of the exams were confirmed by four content experts of the “Educational Developmental Center” of Shiraz University of Medical Sciences. The reliability of tests was approved with a correlation coefficient of 0.8, 0.75, and 0.78 using test-retest reliability techniques.

The tool used in the qualitative phase of the study was a semi-structured interview. The content validity of the structured interview form was validated by four content experts of the “Educational Developmental Center” of Shiraz University of Medical Sciences. The forms had five main sections with related subsections. The residents were asked to rate the whole program, how much they used each material, the benefits of each in knowledge acquisition/retention, and promoting confidence in decision making. The final question was an open question to evaluate the benefits/drawbacks of this model. Based on the permission of the residents, their phone interviews were transcribed verbatim and studied by the first and corresponding authors and analyzed with qualitative content analysis. The appropriate text fragments were chosen. Following that, the fragments were labeled and sorted. At the final step, utilizing these fragments, central themes were extracted. Where these authors were not in full agreement, the final decision was made by the second author. Finally, eight main themes were extracted, which are available in table 3.

- **Evaluation phase :**

Data Analysis was mediated by SPSS statistical software (version 18, Chicago, IL, USA). The Mann-Whitney test, Spearman's rho, and paired T-test used where applicable. The study was confirmed by the Ethics committee of Shiraz University of Medical Sciences.

Results

One aim of the present study was to investigate the attitude of junior general surgery residents toward flipped learning. Another aim of the study is the impact of the flipped learning on the gaining and keeping of residents’ problem-solving ability in the area of primary trauma survey. Of the 15 participants, 9 (60%) were male, and 6 (40%) were male. The mean age of the residents was 29 ± 3 years. In order to investigate the problem-solving ability, 20 multiple choice clinical scenarios were used to assess the competency of residents' problem-solving in the pre-test, early post-test, and late post-test (Table 2).

Table 2: **The result of problem-solving scores in the intervention group during Pre-test, early post-test, and late post-test.**

Test	Values	Method	Level of significance	Correlation
Pre-test Early- post-test	M= (10.733,SD=2.25) M=(12.8 ,SD=1.82)	Paired T-test	(p=0.004)	Significant
Pre-test Late post-test	M= (10.733,SD=2.25) (M=13.267 ,SD=1.53)	Paired T-test	(p=0.002)	Significant
Early post-test Late-post test	M=(12.8 ,SD=1.82) (M=13.267 ,SD=1.53)	Paired T-test	(p=0.404)	Non-significant

- *Level of significance considered as below p = 0.05. Values are expressed with the mean and standard deviation*

As can be observed in the table above, the results showed that in the **quantitative phase, there was a significant difference between pretest (M=10.733,SD=2.25) and early post-test (M=12.8 ,SD=1.82)** (p=0.004)**, also between pre-test(M=10.733,SD=2.25) and late post-test(M=13.267 ,SD=1.53)** (p=0.002). **Interestingly, there was no significant difference between early post-tests and late post-tests** (p=0.404)**.**

Also, we correlated the test scores with the residents’ gender. **There was no correlation between test scores and gender (table 3).**

Table 3. Comparison of the result in test scores between both sexes

Group Statistics							
	sex	N	Mean	Std. Deviation	Test	P_value	Correlation
Pretest	female	6	11.333	2.3381	Mann_whitney	0.474	Non-significant
	male	9	10.333	2.2361			
Early post-test	female	6	13.500	.8367	Mann_whitney	0.211	Non-significant
	male	9	12.333	2.1794			
Late post-test	female	6	13.500	1.2247	Mann_whitney	0.798	Non-significant
	male	9	13.111	1.7638			

Level of significance considered as below p = 0.05 . Values are expressed with the mean and standard deviation

The results of the test scores are available in the above tables. In each test, the mean and standard deviation of scores are provided. Utilizing the mann_whitney test, we found no correlation between the results and genders.

In the qualitative phase, residents were called by an external audit and answered the related question in the semi-structured form. The questions were mainly about the quantitative use of the materials, the overall gain of each material in the term of promoting theoretical knowledge, and bedside decision making. Moreover, they were asked to rate the program with a score of 1 to 5. The data are summarized in table 4.

Looking to the table number 4, in the evaluation of the qualitative phase of the study using the semi-structured interview form, the residents were satisfied with the overall usefulness of the program (overall score 4/5). The use and perceived benefits of the materials are available in table 1. In the case of the videos, the average rate of the use of video was 1.93/5. But those who used video believed that the usefulness of the videos on the promoting of theoretical knowledge and increasing the confidence in bedside decision making was 3.33/5 and 3.67/5, respectively. Regarding the podcasts, the mean employment of the podcasts among residents was 5/5. The perceived gain of the podcasts on the knowledge and confidence in the management of the patients in real life was shown to be 4.33/5 and 3.6/5. In terms of the paper materials (books), the quantitative use of the books was 2.2/5, and our study showed that the rate of the respondents to the books o increase theoretical knowledge was 4.13/5, while the impact of the books on the clinical judgment was 3.38/5. Concerning the case-based discussion session, all the residents attended that particular session (5/5). They believed that the efficacy of that case-based discussion on their knowledge and bedside judgment was 3.93 and 4.4 out of 5, respectively. Lower use of the videos may be attributed to lengthy duration of them.

Table 4. The average of the quantitative use of the educational materials, and the overall benefit of each materials and the program as a whole

The overall score of the whole program (out of 5)	Efficacy of the case-based discussion in increasing the confidence in bedside decision making (out of 5)	Efficacy of the case-based discussion in promoting theoretical knowledge (out of 5)	Attendance in the case-based discussion	Efficacy of the books in promoting increasing the confidence in bedside decision making (out of 5) (out of 5)	Efficacy of the books in promoting theoretical knowledge (out of 5) (out of 5)	Quantitative use of the books (out of 5) (out of 5)	Efficacy of the podcasts in increasing the confidence in bedside decision making (out of 5) (out of 5)	Efficacy of the podcasts in promoting theoretical knowledge (out of 5)	Quantitative Use of the podcasts (out of 5) (out of 5)	Efficacy of the videos in increasing the confidence in bedside decision making (out of 5) (out of 5)
4	4.4	3.93	All attended	-3.38	-4.13	2.2	3.6	4.33	5	3.67

As summarized in table 5, the final question in our phone interview was an open question. We asked the residents to mention any other required points to improve the programs. After writing down all 15 interviews, these subjects were categorized into eight cardinal themes. Seven residents believed that the course was highly beneficial, and they suggested that this course should be held every 2-3 months in a progressive mode. Six residents believed that the interactive nature of the case-based discussion was excellent assistance for them to overcome their stress in real-life situations. While one resident believed that 2.5-hour discussion was not enough to have a good overview of the topics, he/she believed that the session should be around 2.5 hours to cover all topics. Five residents pointed out that they suppose the first month of the residency program should be devoted to their preparation and making them knowledgeable and capable enough to deal with patients, while two residents disagreed with this. That two residents claimed that education happens in dealing with the patients, and they prefer to have ongoing educations while they are serving the patients on the clinical wards. In our qualitative study, five residents were confident that podcasts are a great asset for learning that they were a rapid review of essentials in a brief and informative way. They believed that they could listen to these audios while waiting for patients or going from one ward to another ward or in their leisure time, conveniently. One resident suggested that the case-based discussion settings can be with the presence of the senior residents, which helps the junior residents to use their experiences. The presence of the seniors can also facilitate the establishment of a peer near mentorship between juniors residents and senior ones (table 5).

Table 5. The attitude and suggestion of the residents toward the program

Statement	Resident number
Regarding the timing, I suppose that the first month of our training program should be a pure observership with no clinical posting. In that time, we should learn/review all “must-know” points and then attend the wards. This will make us more confident when dealing with the patients	3,4,7,11,14
I suppose that we should not have a pure observership month filled with classes, because we will notice the importance of the knowledge if we see their practicality in the field	12,13
The case-based discussion was done in interactive mode and was helpful to decrease our stress of patient contact	2,4,5,9,11,13,15
This method should be held every 2-3 months. The course should be in a progressive mode, starting with a primary trauma survey and go forward to more advanced care.	1,2,6,8,10,11,15
Podcasts were highly concise and too beneficial as we can review them when/where ever needed.	3,10,11,12,14
Videos were comprehensive and excellent for learning, but the duration of them should be more limited	4
Presence of senior residents as teacher assistants in CBD sessions may help us to have their experience as well and foster their mentoring role	8
The 2.5-hour class was not enough to review all essentials	3

Discussion

The result of the study showed that the students' problem solving and retention was significantly improved after the intervention. This finding is in parallel with other findings, which showed the effectiveness of flipped learning in terms of knowledge acquisition in medical education[18, 23, 28-32]. The results reveal that flipped learning is useful in the encouragement of deep and active learning[33, 34] and school achievement [35]. The flipped learning or classroom is increasingly getting a reputation as a fascinating and successful instructional methodology. Evidence is still scarce in the utilization of flipped learning in medical education and especially surgical education and the field of trauma. This is the first paper which investigates the applicability of the flipped learning in the trauma for general surgery residents.

Moreover, in our survey, the retention of the knowledge was confirmed by a lack of difference between the early and late post-test. We believe that this occurred possibly because the provided materials were prepared according to daily encountered scenarios of our local trauma care. This may enforce contextual learning resulting in a comparable late post-test in comparison to the early post-test. As in our study, several surveys have proposed this method causes more satisfaction of participants, program directors, and may increase test scores in comparison to traditional methods [22, 36]. Similar to other studies, this research also shows a high level of satisfaction among participants In a study by Tan et al., 96% of respondents were satisfied with the belief that their flipped curriculum in emergency medicine was over the traditional curricula. The participants believe that having the resources, in advance, encourages learning and is considered as a motivator [18]. Moreover, in a cohort study, it was shown that besides experiencing a higher level of satisfaction, medical clerks with flipped surgical curriculum were more interested in pursuing surgery as the prospective field of the study and profession.[35] Another study by Liebert et.al in surgery clerkship showed that about 90% of students rated their flipped learning curriculum excellent or outstanding. Moreover, 84% of the clerks believed that other clerkships should adopt a flipped based curriculum [37].

Advocating self-directed, active, and efficient learning are chief objectives for educational interventions for fostering adult learning (andragogy) [18, 38, 39]. Other studies have shown the effects of flipped learning in metacognitive skills [40]. One main reason is that in this method, the residents have the authority to manage resources, pace, place, and time which makes them capable of self-regulation and performance [18, 34, 41]. In our study, we found that the residents were highly satisfied with their curriculum and uniquely interactive case-based discussion. They found it was constructive in decreasing their stress in real patient encounters. Another study confirms these findings as the participants believed that flipped learning and especially case-based discussion sessions could lead to a higher level of cognitive functions such as analysis and synthesis of knowledge[42, 43]. Multiple papers concerning flipped learning support the effectiveness of case-based learning in these settings [19, 44, 45]. Cases based learning will foster higher-order educational objectives in bloom taxonomy and cognitive ladder. The cases can serve as a well-established infrastructure and scaffold in which reinforces and categorizes the concepts and knowledge. Others believe that this method is helpful as it encourages constructivism in medicine. They suggest that flipped learning helps learners to build their knowledge based on the pre-class materials, the case-based discussion, and their clinical experiences. [17, 46]

One of our residents believed that the duration of the videos was lengthy; however, it was comprehensive. Our videos were 17 hours on 13 subjects (with an average of 1 hour for each topic and max 1.5 hours). We believed, as an improvement, all future video sessions should be limited to 1 hour. This finding is consistent with another study in which the authors finally decided to change the preparation time of the videos to 60 minutes following the commencement of their study [45, 47]. Some experts believe that long videos can easily fill people's working memory, which has minimal capacity. However, shorter videos make the individual process the information actively and follow the change[48].

In this regard, we noticed that our participants tend to use podcasts more than other materials. It is possibly because of the nature of the podcast, which is remarkably shorter than the videos and more flexible to use based on time and place. Our findings are similar to another study in which synopsized materials

such as podcasts were more favorable to be used by the participants [18].

Moreover, our residents believed that videos and books help more to foster knowledge. The case-based discussion (CBD)makes them more confident in dealing with the patients (table 2,3). It may be implied that the high rate of the CBD is potentially due to the preclass mind preparation of the participants, which encourages learning [16] and another proof of concept for flipped learning. We noticed that none of the materials result in better results, per se. But in accumulation, they led to a significant difference, which is proof of the concept for this method (Table 2). We believe the ideal framework should entail all of the formats of the materials and multiple strategies to cover numerous learning styles and meet the educational objectives of the program [49].

The high acceptability of the flipped learning in this study revealed the efficacy and utility of this method in the surgical field and especially trauma. In surgical residency programs, different schedules of residents, limited educational times, and immediate need for care of trauma victims threaten proper, uniform, and synchronized education of residents. Flipping the education will help the residents to have an invaluable source of learning, which is always available to them. This method also saves the time of instructors to repeat basic and repetitive facts. The latter help the surgical team to focus on more advances point of care details which is often neglected due to time constraint[18].

Limitation :

Although our general surgery programs is one of the most significant general surgery programs in Iran, this study was in a single school with limited sample size. The high rate of the participants may mitigate the biases, but further investigations are required

Conclusion

We concluded flipped learning is invaluable where the pace of attaining certain competencies matters like trauma. In our study, participants had a high rate of satisfaction. The early and late post-tests were significantly higher in comparison to the pre-test, which was in favor of the efficacy of flipped learning in knowledge acquisition and retention. All educational tools have their related cons and pros, and we suggest that they should be provided in a salad. Further studies, with larger samples, are required to investigate the applicability of flipped learning in trauma.

Declarations

Competing interests: The authors declare no competing interests.

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