Original Article

# Efficacy of high-fidelity simulation in clinical problem solving exercises – feedback from teachers and learners

**Gopalakrishnan P[1], Ponnusamy S[2], Larmie E[3], Soetjipto S[2], Sethuraman K.R[4]**

[1]Department of Anaesthesiology, [2]Department of Medicine, [3]Clinical Skills Centre, AIMST University, Semeling, Bedong, Malaysia. [4]Vice Chancellor, Sri Balaji Vidyapeeth, (Deemed to be University), Pondicherry - 607402.

## ABSTRACT

***Background & Objectives:*** Simulation is one of the methods used to depict the symptoms and signs in clinical problem solving exercises to medical students. The present study examined the efficacy of high-fidelity simulation in problem solving exercises in preclinical medical education based on feedback from the lecturers and students.

***Material and Methods:*** After approval from the research and ethics committee, 29 volunteers from year two in the school of Medicine, in AIMST University, Malaysia were recruited for the study. Two common problems in clinical medicine, chest pain and breathlessness were selected. Pre-test was conducted for all the students on both topics. The teaching and learning of chest pain was conducted as a paper-based problem solving exercise (PSE) while that of breathlessness was conducted as a problem solving exercise using high-fidelity simulation. A post test was conducted after both sessions. The lecturers and the students gave feedback on the efficacy of either method.

***Results:*** Ninety three percent (25) of the students indicated a preference for simulation assisted PSE as compared to paper-based PSE. All the teachers felt that simulation assisted PSE is better in demonstrating signs and symptoms in a PSE for undergraduate medical students. The post-test scores of simulation assisted PSE were significantly higher than the paper-based PSE ($p < 0.0003$).

***Conclusion:*** High-fidelity simulation assisted PSE was found to be more realistic and efficient than a paper-based PSE in portraying the clinical scenario in a problem solving exercise in undergraduate medical education.

***Keywords:***

problem solving exercises, simulation assisted PSE , paper based PSE, teaching and learning

## INTRODUCTION

Problem solving exercises (PSE) involve a case-based learning and an introduction of clinical situations with realistic data. Students are required to take a rational and sequential approach based upon their experiential knowledge. Problem solving exercises are considered to be better alternatives to problem based learning in medical education.[1]

Clinical problems presented to students for solving and management are given in different formats; paper-based, verbal and multimedia presentations.[2] In the sequential solving process, actual blood results, radiographs, electrocardiograms and ultrasound, CT or MRI scans are shown to the students to assist in solving the problem.[3]

High fidelity simulators that simulate real patients have been used in the teaching and learning of clinical procedural skills in a controlled environment. [4, 5, 6] It has enabled interactive learning in a clinical setting, repetition of procedures and hands-on experience in learning motor skills. [7, 8, 9, 10] Simulation has also been used effectively to teach applied physiology to first year medical students and is stated to complement medical education in clinical settings [11,12]

**For Correspondence**

*Dr. Prabhakar Gopalakrishnan*

*Email: gpkar11@gmail.com*

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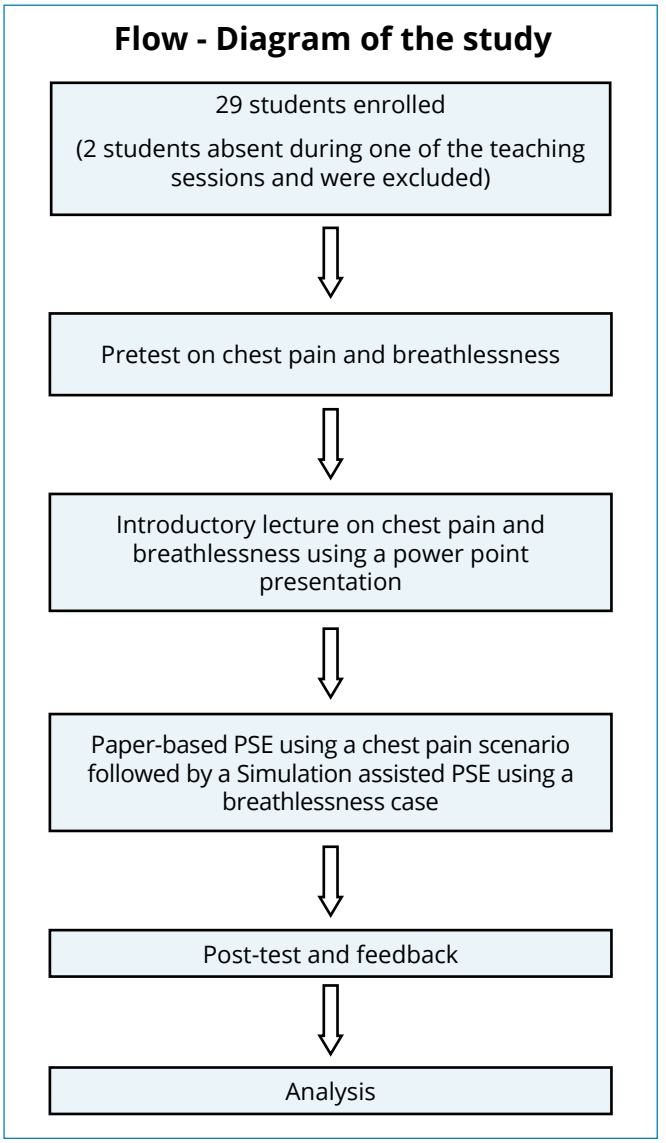
In AIMST University, Malaysia, a systems-based integrated curriculum has been adopted for undergraduate medical students. High-fidelity simulation is used to teach scenarios such as hypotension, hypoxia and hypercarbia along with the physiological responses in these clinical situations to second year medical students. We contemplated on making use of these high-fidelity simulators in demonstrating clinical signs and symptoms in problem solving exercises in undergraduate medical education. The aim of the present study is to find out the efficacy of high-fidelity simulation in teaching and learning of clinical situations through problem solving exercises in second year medical students based on the comparison of post-test scores and the feedback given by teachers and learners of these sessions.

## MATERIAL AND METHODS

The study was approved by University's research and ethics committees. Students in the second year of medical school pursuing the MBBS course were informed about this study and those willing to participate were invited. They were assured that their performance in this study will not be considered for their academic assessment. Twenty-nine students were recruited. Written consent was obtained from all the 29 students.

As cardiovascular and respiratory problems are commonly encountered in clinical practice, two common clinical cases from either system, chest pain and breathlessness were chosen as topics for the study. A summary flow chart of the study is shown in Figure 1.

**Figure 1:** Flow diagram of the study




*Pre-test*:

A pre-test was completed prior to the teaching sessions. This involved 15 single response multiple choice questions in each topic. Of the 15 questions, 10 were regarding pathophysiology and clinical features and 5 based on clinical scenarios.

*Introductory lecture*:

The pre-test was followed by an introductory power-point presentation on the cases in the study, chest pain and breathlessness.

*Teaching and Learning sessions*:

Students were then divided into 3 groups, with either nine or ten students in each group. A paper-based PSE was completed using the chest pain scenario by all the students. Two days later, a simulation assisted PSE was completed using the breathlessness case with all the students.

*Chest pain paper-based PSE*:

A paper-based case scenario of a patient with chest pain was given to the students. They were encouraged to ask questions regarding the patient's history and clinical findings with the facilitator providing the necessary details. Blood reports and a12- lead ECG were then shown to the students to assist in their problem solving. A brief discussion of the pathophysiology of the clinical problem, differential diagnosis and management of the problem followed, led by the facilitator. (Annexure 1)

*Simulation assisted Breathlessness PSE:*

This session was conducted using a METI-I Stan high-fidelity simulator at the Clinical Skills Centre of the University (Figure 2). It features heart sounds, breath sounds, chest movement, peripheral pulses, cyanosis and eye-lid movement. The interface-monitor displayed electrocardiogram tracing, blood pressure, oxygen saturation and temperature.

A brief clinical scenario was given verbally to the students who were asked to elicit a detailed history from the simulator. The voice of the patient was played through a speaker located in the simulator by the facilitator. After the history-taking, the students summarised and presented their findings. General and systemic examinations were then performed on the simulator, where clinical features such as tachypnoea, cyanosis, crepitations and wheeze could be elicited. The examination findings were presented to the facilitator. Positive findings were demonstrated on the mannequin and the clinical monitor by the facilitator. A discussion relating to the diagnosis, differential diagnosis, pathophysiology and management of the simulated problem followed. (Annexure 2)

One facilitator conducted the paper-based PSE while another facilitator conducted the simulation assisted PSE for all groups. Both facilitators had similar educational and linguistic background, academic qualifications and teaching experience.

*Post-test and feedback*:

After the sessions on the two topics using the two different methods, a post-test, which was similar to the pre-test, was conducted.

Feedback-rating forms were given to the students and they were asked to give a rating on the various components regarding their understanding of the clinical scenarios presented. (Annexure 3)

Nine members of the faculty of medicine, of whom four were professors and five were associate professors, observed both the sessions. They provided their feedback on the efficacy of either method on feedback forms and commented on the advantages and disadvantages of both methods.

**Figure 2:** High-fidelity simulator in the clinical skills centre

**Table 1:** Comparison of feedback scoring from the students

| Feedback scoring | | | | |
|---|---|---|---|---|
| Serial Nos. | Paper based PSE (P) (out of a total score of 70) | Simulation assisted PSE (S) (out of a total score of 70) | Preference | difference |
| 1 | 43 | 52 | S | 9 |
| 2 | 50 | 64 | S | 14 |
| 3 | 57 | 61 | S | 4 |
| 4 | 51 | 56 | S | 5 |
| 5 | 57 | 57 | S | 0 |
| 6 | 64 | 64 | S | 0 |
| 7 | 50 | 53 | S | 3 |
| 8 | 45 | 67 | S | 22 |
| 9 | 40 | 61 | S | 21 |
| 10 | 42 | 70 | S | 28 |
| 11 | 56 | 62 | S | 6 |
| 12 | 63 | 67 | S | 4 |
| 13 | 57 | 56 | S | -1 |
| 14 | 52 | 61 | S | 9 |
| 15 | 61 | 64 | S | 3 |
| 16 | 62 | 63 | S | 1 |
| 17 | 67 | 63 | P | -4 |
| 18 | 55 | 65 | S | 10 |
| 19 | 60 | 64 | P | 4 |
| 20 | 57 | 61 | S | 4 |
| 21 | 57 | 66 | S | 9 |
| 22 | 61 | 67 | S | 6 |
| 23 | 50 | 50 | S | 0 |
| 24 | 62 | 63 | S | 1 |
| 25 | 54 | 58 | S | 4 |
| 26 | 54 | 59 | S | 5 |
| 27 | 51 | 62 | S | 11 |
| Mean | 54.74 | 61.33 | S 92.6% | 6.59 |
| SD | 6.9 | 4.89 | P 7.4% | 7.42 |
| p value | < 0.0001 | | | |

*Statistical analysis*:

Means, standard deviations and change in the mean scores were computed from the pre-test and post-test scores for both topics and comparisons were carried out using SPSS software.

The students' feedback ratings were converted to a score (out of a maximum score of 70) using the number they circled in a five-point ascending rating scale and was compared between the two different teaching methods.

A paired two-tailed t-test was used to compare the two samples and a p value ≤ 0.05 was taken as significant. The normality of distribution was tested using the Shapiro-Wilk's test.

## RESULTS

Twenty nine students were enrolled in the study. Two students were absent during one of the teaching sessions and were excluded from the assessment.

The feedback rating results, obtained from the students, indicated that 93% [25] preferred the simulation assisted PSE to the paper-based PSE. (Table 1)

The mean feedback score of simulation assisted PSE (61.33) was higher than the mean feedback score of paper based PSE (54.74) and was statistically significant. ($p < 0.0001$)

The facilitators involved in conducting the PSE sessions and observers from the faculty of medicine opined that high-fidelity simulation can be effectively used to demonstrate the symptoms and signs to preclinical medical students in PSE sessions.

The mean post-test score was higher than the mean pre-test score for chest pain (paper based PSE) and was statistically significant. The mean score increased from 45.68% to 60.25% ($p<0.0001$). Similarly, the mean post-test score was higher than the pre-test score for breathlessness (simulation assisted PSE) and was statistically significant. The mean score increased from 48.89 to 71.6%. ($p<0.0001$) (Table 2)

The difference between the mean pre-test scores of chest pain (paper based PSE, mean score = 45.68%) and breathlessness (simulation assisted PSE, mean

**Table 2:** Variance between the scores and statistical analysis

| S.No. | Paper based PSE Pretest Vs Paper based PSE Post-test | Simulation assisted PSE Pretest Vs Simulation assisted PSE Post-test | Paper based PSE Pretest Vs Simulation assisted PSE Pretest | Paper based PSE Post-test Vs Simulation assisted PSE Post-test |
|---|---|---|---|---|
| 1 | 6.67 | 40.00 | 6.67 | 40.00 |
| 2 | 33.33 | 20.00 | 26.67 | 13.33 |
| 3 | 0.00 | 6.67 | 20.00 | 26.67 |
| 4 | 0.00 | 20.00 | 0.00 | 20.00 |
| 5 | 0.00 | 20.00 | -6.67 | 13.33 |
| 6 | -6.67 | 26.67 | -13.33 | 20.00 |
| 7 | 13.33 | 40.00 | -13.33 | 13.33 |
| 8 | 26.67 | 33.33 | -6.67 | 0.00 |
| 9 | 20.00 | 13.33 | 6.67 | 0.00 |
| 10 | 40.00 | -6.67 | 33.33 | -13.33 |
| 11 | 20.00 | 0.00 | 13.33 | -6.67 |
| 12 | 20.00 | 13.33 | 20.00 | 13.33 |
| 13 | 0.00 | 33.33 | -26.67 | 6.67 |
| 14 | 20.00 | 13.33 | -6.67 | -13.33 |
| 15 | 0.00 | 6.67 | 0.00 | 6.67 |
| 16 | 13.33 | 26.67 | -6.67 | 6.67 |
| 17 | 6.67 | 20.00 | 13.33 | 26.67 |
| 18 | 13.33 | 46.67 | 0.00 | 33.33 |
| 19 | 40.00 | 20.00 | 13.33 | -6.67 |
| 20 | -6.67 | 13.33 | 0.00 | 20.00 |
| 21 | 20.00 | 40.00 | 0.00 | 20.00 |
| 22 | 26.67 | 20.00 | 6.67 | 0.00 |
| 23 | 26.67 | 20.00 | -6.67 | -13.33 |
| 24 | 20.00 | 26.67 | 26.67 | 33.33 |
| 25 | 20.00 | 40.00 | -6.67 | 13.33 |
| 26 | 0.00 | 33.33 | -13.33 | 20.00 |
| 27 | 20.00 | 26.67 | 6.67 | 13.33 |
| Mean | 14.57 | 22.72 | 3.21 | 11.36 |
| Std Dev | 13.34 | 13.11 | 14.25 | 14.65 |
| p value | <0.0001 | <0.0001 | 0.25 | <0.0003 |

**Figure 3:** Mean pre-test scores of chest pain (paper-based PSE) and breathlessness (simulation assisted PSE. (p>0.24 NS)

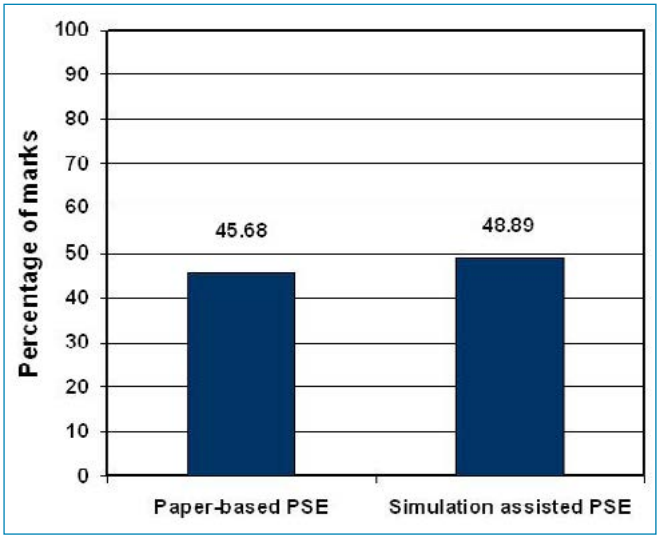
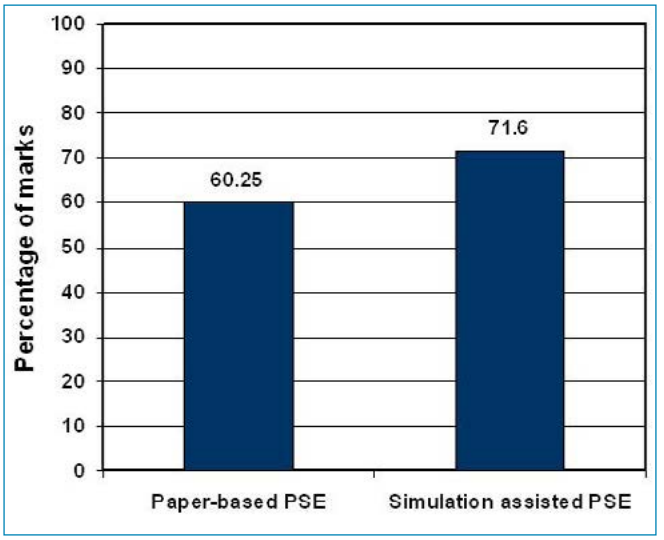



**Figure 4:** Mean post-test scores of chest pain (paper-based PSE) and breathlessness (simulation assisted PSE) (p<0.0003)




score = 48.89%) was not statistically_significant (p > 0.24), indicating equivalence of the topics chosen (Figure3). The mean post test score of breathlessness (71.6) (simulation assisted PSE) was higher than the mean post test score of chest pain (60.25) (paper based PSE) and was statistically significant (p < 0.0003) (Figure 4).

## DISCUSSION

Problem solving exercises assist with the integration of basic concepts into clinical situations and promote team work.[13] Furthermore, undergraduate medical students have benefited from the exposure to clinical reasoning through simulation prior to their clinical

clerkship.[14] This beneficial outcome has also been demonstrated when standardised patients were used to simulate clinical scenarios to pre-clinical medical students.[15, 16]

Our study has shown that high fidelity simulation provides a realistic environment for a PSE session, where students can interact with the simulated mannequin, look for clinical signs and observe the physiological parameters on the patient-monitor before discussing the clinical problem. This improved their understanding of the clinical situation portrayed. It also promoted a sustained interest with the students making learning more interesting and enjoyable.

High-fidelity simulation has been used as a tool to teach basic medical sciences and has commonly been used to enhance the psychomotor skills in clinical education.[17, 18, 19, 20, 21] In addition, it has also been found to be useful in teaching higher level cognition and critical thinking.[22]

In our study, we used high-fidelity simulation to enable the students to recognise and appreciate signs and symptoms in clinical problem solving exercises. Most of the students found that the simulation assisted PSE provided more insight into the problem depicted, enhancing their understanding of the clinical features, thus enabling them to systematically and logically come to a conclusion. This might account for the significant increase in the post-test scores of simulation-assisted PSE as compared to the paper-based PSE.

The feedback from the students and teachers and the comparison of the post-test scores indicated that the kinaesthetic aspect of learning was important in medical education and it supplements other aspects of learning such as visual, auditory and reading/ writing.

Some of the students had commented about specific areas of the teaching modules used. Based upon their comments, we could gather that 12% of the students found that the simulation assisted PSE was systematic and productive in teaching and learning. 18% of the students opined that simulation assisted PSE was more active and rewarding than paper-based PSE. However, they felt that modifications such as improved clinical demonstration and continuous facilitator guidance would make it more effective. On the other hand, 4% of the students felt that the paper based PSE was equally good. Probably these students are good in perceiving clinical scenarios described in words as well as a visual depiction. Two of the professors had also commented that the high-fidelity simulator which was used for the present study would not be effective for neurological, endocrine, renal and metabolic diseases and simulation assisted PSE would also not be effective for larger groups of students.

Didactic lectures given at the beginning were essential to give background knowledge to the students who came for the PSE, as they had to apply their knowledge in approaching and solving the clinical problems in these sessions. However, it is possible that this might have influenced the post-test scores.

In this study design, we did not divide the students into two groups to compare the two teaching methods, but invited all the students to undergo the teaching and learning of two different topics by two different teaching methods. Though the mean pre-test scores were not statistically significant, the comparison of the post-test scores may not be sensitive as the topics used for the two sessions were different. A further limitation of this study is that the students were not chosen randomly. Those who volunteered for the study were enrolled.

## CONCLUSION

Using high fidelity simulation, made problem-solving exercises more realistic, effective and enjoyable. As medical students can be considered to be under stress during their learning period[23, 24] this method of teaching and learning could help to reduce this pressure during the preclinical stages. Further studies using different designs are required to confirm the superiority of high-fidelity simulation assisted PSE over paper-based PSE and to quantify its benefits.

## CONFLICTS OF INTEREST

None.

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## ANNEXURE 1

### Outline of Paper-based PSE on chest pain

***Session 1: Introduction of paper-based case scenario***

Case scenario

- A 45-yr-old man, presented to the emergency room with chest pain which radiated to the jaw and left upper limb, associated with sweating, nausea and belching. He also felt shortness of breath. The pain which was aggravated by exertion was not relieved on taking rest. He was a known diabetic on tablet metformin 500mg tds and takes pain killers for his chronic low back pain. He was a chronic smoker of 20 pack years and a social drinker. O/E Patient was in pain, pale, clammy, pulse 58 bpm, BP 90/60, CVS, RS, GIT were all normal. The following features were discussed by the students with brief inputs from the facilitator.
- Classification of chest pain according to cardiac and non-cardiac causes
- Clinical features of the different causes of chest pain
- Clinical anatomy of thorax and coronary blood supply
- Definition of acute coronary syndromes

The differential diagnosis for the chest pain scenario and the basic investigations which need to be done to arrive at a diagnosis were discussed by the students with brief inputs from the facilitator

The ECG of the patient with features of acute Inferior wall myocardial infarction was shown.

The following features were discussed

- Investigations that should be done in a patient with possible acute coronary syndrome and the results expected
- Basic ECG interpretation –wave forms, leads, ST-T wave changes and their diagnostic importance in acute coronary syndromes
- Immediate management of acute coronary syndromes
- Indications and contraindications for thrombolysis
- Complications of acute coronary syndromes.

## ANNEXURE 2

### Outline of Simulation assisted PSE on breathlessness

A case scenario was introduced in the I-Stan high-fidelity simulator

A 55 year old man, a smoker for 30 years, comes to the out-patient department complaining of breathlessness for 6 yrs

- The students were invited to elicit a detailed history from the simulated mannequin. The voice of the simulated patient was played through a speaker on the simulator by the facilitator.
- The students were asked to present the positive aspects (breathlessness on exertion, long term smoking, cough with productive, mucoid sputum) derived from the history. A summary of the symptoms was discussed.

The following issues were discussed by the students with brief inputs from the facilitator

- Definition of breathlessness
- Classification of breathlessness according to RS, CVS, Abdominal, CNS causes
- Classification of breathlessness as acute and chronic
- Applied anatomy and physiology of breathlessness

The students were asked to independently do a general and systemic examination on the simulated mannequin and present their clinical findings.

- Cyanosis, tachypnoea, wheeze and crepitations were enabled on the mannequin.
- ECG, non invasive blood pressure and spO2 were observed in the patient monitor.
- During debriefing, the sequential examination was emphasized and the students re-examined the simulated mannequin to appreciate the clinical signs.

- The provisional diagnosis, differential diagnosis and investigations were stated
- Management of chronic bronchitis and bronchial asthma was reviewed.
- Types I and II respiratory failure were discussed.
- Other complications of chronic obstructive pulmonary disease were discussed.

## ANNEXURE 3

### Feedback form comparing the efficacy of paper-based PSE and high-fidelity simulation assisted PSE

Kindly fill in this feedback form. Circle the appropriate number (1 to 5) depending on how you would rate the following parameters. **1-strongly disagree 2- disagree 3-neutral 4-agree 5-strongly agree**

| | Paper-based PSE on chest pain | | | | | Simulator assisted PSE on breathlessness | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I was able to understand the given problem | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I got to know additional information (more information about the presented problem) | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I was able to discuss the pathophysiology and clinical features based on the history derived from the patient | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I was able to understand the clinical findings/signs of the patient | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I was able to gain knowledge by interacting with the facilitator/ tutor during the discussion | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I was able to learn from other members of the group during the discussion | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I learnt the various aspects of monitoring and investigating the patient | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I learnt the various treatment modalities | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I was able to come to a conclusion after knowing about the patient's symptoms | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I was able to classify and discuss various causes of the presenting symptoms | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I was able to systematically and logically arrive at a diagnosis | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I was able to understand and discuss the differentiating features of other similar diseases | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I was able to correct my mistakes and wrong perceptions | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| I was able to redo or repeat the exercise | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |

Given an option between the two methods of teaching, which one will you prefer?
(Kindly make a tick mark next to the teaching method)
Paper based PSE [ ]
Simulation assisted PSE [ ]