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# Simulation Learning: Effectiveness and Stressfulness in Medical Student Teaching

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## Abstract

**Introduction:** The aims of this study were to assess the effectiveness of different modalities of simulation learning in medical students and the resulting stress response.

**Methods:** Students were randomised into two groups for simulation learning, on the assessment and management of acutely ill patients. Group 1 performed assessments in a static individual format, whilst group 2 performing assessments in a dynamic group format. The stress response was measured by heart rate monitors worn by students, and performance was graded by a final simulator assessment.

**Results:** The stress response did not significantly vary between groups, but there was a significant increase in heart rate in all students during the simulation learning; with a mean increase of 34 beats per minute in group 1 and 38 beats per minute in group 2. Performance in the final simulator assessment was significantly better in group 2, with a mean score of 21.5 points, compared to 16.2 points in group 1.

**Conclusion:** A dynamic group simulation learning strategy is more effective in teaching medical students than simulations performed individually. Simulation learning, however; results in a significant stress response in all students, which must be carefully managed when delivering this type of learning.

**Keywords:** Simulation learning; Medical student teaching; Stress response; Effective learning

## Introduction

Simulation learning has become a key component of the medical curriculum (McCoy *et al*., 2011; Stegmann *et al*., 2012; Adamson *et al*., 2013; Burton and Hope, 2018), with proponents claiming that it promotes translation of knowledge into reasoned action, and improves student confidence in decision making and performing clinical skills

(Gordon *et al*., 2006; Ganley and Linnard-Palmer, 2012; Shin *et al*., 2015; Kim *et al*., 2016; Mok *et al.,* 2016; Walters *et al.,* 2017). With increasing focus on patient safety, it has also been suggested that simulation learning can help to reduce medical error, and enable training of clinicians without directly placing patients at risk (Gordon *et al*., 2006; Jarzemsky and McGrath, 2008; Hope *et al.,* 2011; Handley and Dodge 2013; Cantrell and Mariani, 2016; Cantrell *et al*., 2017; Unsworth *et al*., 2016).

Simulator training is, however expensive, and the superiority of simulator training in comparison to more traditional didactic teaching has been questioned (Gordon *et al.* 2006; Jarzemsky and McGrath, 2008; Lavoie *et al*., 2018). It has been recommended that the effectiveness of simulator training can be improved by regular feedback, integration into the curriculum and variation in simulator scenarios, with increasing levels of difficulty (Forrest *et al*., 2013; Forneris, 2017). Another important component of effective simulation learning is simulator fidelity, which can increase the validity of the teaching modality (Paskins and Peile, 2010). Higher fidelity simulators allow the teaching of more complex skills, and robot type mannequins are now regularly used to teach medical students the assessment and management of acutely unwell patients (Burton and Hope, 2018; Presado *et al*., 2018).

One potential concern with the increasing realism of simulators is that this may in turn increase the stressfulness of the teaching experience, with consequent negative implications on learning (Girzadas *et al.,* 2009; Muller *et al*., 2009; Zendejas *et al.,* 2010; O'Reagan *et al.,* 2016). There is also concern that feedback in relation to simulation learning may significantly impact on student self-confidence, which may particularly affect more anxious or more junior students (Tooth *et al*., 1989; Forneris, 2017).
The aims of this study were to assess the effectiveness of different types of simulator learning strategies in medical students, and the stress response which this evoked.

## Methods

Second year medical students, who were new to simulation learning, were asked to participate in the study. Institutional approval was obtained and all participants provided verbal and written consent. The conceptual framework for the study was based on Bandura's social learning theory (1971), which demonstrates how observation of others can positively impact on learning.

Students were randomised into two groups for simulator learning, which involved standardised clinical scenarios for the management of the acutely unwell patient. These were performed over a two-week period, using a robotic mannequin (SimMan, Laerdal, Norway). In group 1, students performed scenarios in a static format with one individual performing the clinical scenario, and the other members of the group passively observing. In group 2, students performed scenarios in a more dynamic format, with one individual commencing the scenario, and other members of the group being substituted into the scenario to perform different components of the patient assessment and management; thereby involving the whole group in the scenario.

In total 28 medical students participated in the study, with 14 students randomly assigned to each group. Within each group, students were subdivided into cohorts of seven, as this provided a more practical group size for simulation teaching. Students in both groups underwent briefing prior to each simulator scenario, and structured feedback was provided afterwards.

The stress response was determined by student heart rates, as this is considered an objective physiological marker of stress (Gizardas *et al*., 2009; Bong *et al*., 2010). Students wore chest strap monitors (CooSpo H6 monitor, China), which measured heart rates continuously throughout the scenario. After the scenario, students were also asked to complete a standardised questionnaire, in which they were asked to quantitively grade how stressful they found the simulation teaching, and how useful they found the learning experience; as well as to qualitatively describe what particular aspects of the simulation learning they found most useful.

The effectiveness of the simulation teaching was assessed by a final clinical scenario (assessment and management of acute myocardial infarction), which all students performed individually. This was graded by one investigator (CK), who was blinded to the original group of the students and followed a standardised grading sheet. This comprised history taking, patient assessment, appropriate investigation and management; with a maximum score of 42 points (Figure 1).

**Figure 1:** Mark scheme for simulation assessment

**Myocardial Infarction Mark Scheme**

Points only to be awarded if candidate gives the answer themselves (but hints from the "nurse" allowed). If two points available second to be awarded during re-assessment.

History
-asks about 2 or more risk factors for cardiovascular disease ☐
-SOCRATES ☐
-previous episode ☐
-past medical history ☐

Assessment

Airway:
- Talks to patient, recognises can move on to assessing B ☐ ☐

Breathing
- Respiratory rate ☐ ☐
- Sats ☐ ☐
- Auscultation ☐ ☐
- Percussion ☐ ☐
- Puts on 15l oxygen via non-rebreathable mask before moving on if Sats less than 94% ☐

Circulation
- Heart rate ☐ ☐
- Blood pressure ☐ ☐
- Capillary refill ☐ ☐
- JVP ☐ ☐
- Auscultation ☐ ☐
- Starts iv fluids ☐

Disability
- AVPU ☐

Exposure
-Temperature ☐
-Glucose ☐

Investigations
- ECG ☐
    - Recognises diagnosis ☐
- CXR ☐
- Bloods including troponin ☐
- ABG ☐

Management
- GTN ☐
- Aspirin ☐
- Clopidogrel ☐
- LMWH ☐
- Morphine ☐

Recognises need to escalate ☐

Starts chest compressions when output lost ☐

Marks .......

Statistical analysis was performed using Excel (2019, Microsoft, USA) and SPSS (v26, IBM, USA) with paired and unpaired T-tests for dependent and independent continuous variables and Fisher exact test for categorical variables. The significance level was $p<0.05$.

## Results/Analysis

There was no statistically significant difference in heart rates between the two groups. In group 1, where students performed scenarios in a static individual format, the overall mean heart rate was 87 beats per minute (bpm) (range 62 – 116), with a mean maximum heart rate of 110 bpm (range 74 – 152) and a mean minimum heart rate of 73 bpm (range 50 – 95). In group 2, where students performed the scenarios in a dynamic group format, the overall mean heart rate was 88 bpm (range 70 - 116), with a mean maximum heart rate of 109 bpm (range 90 - 139) and a mean minimum heart rate of 76 bpm (range 55 – 105). There was, however; a significant increase in heart rate in both groups during the simulation scenario, with a mean increase of 34 bpm in group 1 (range 16 – 53) and 38 bpm in group 2 (range 19 – 72) ($p<0.001$) (Table 1).

**Table 1: Heart rate during simulation learning (beats per minute)**

| | Overall mean heart rate | Mean maximum heart rate | Mean minimum heart rate | Mean increase in heart rate |
|---|---|---|---|---|
| Group 1 | 87 (range 62 – 116) | 110 (range 74 – 152) | 73 (range 50 – 95) | 34* (range 16 – 53) |
| Group 2 | 88 (range 70 - 116) | 109 (range 90 - 139) | 76 (range 55 – 105) | 38* (range 19 – 72) |

*p<0.001

Student performance as assessed by the final graded simulation scenario was significantly better in group 2, with an overall mean assessment score of 21.5 points (range 16 – 26), compared to 16.2 points in group 1 (range 12 – 20) ($p<0.001$). In particular, patient assessment scores were significantly higher in group 2, with a mean score of 12.4 points (range 8 - 16), compared to 6 points in group 1 (range 2 – 11) ($p<0.001$) (Table 2). There was no correlation between assessment scores and student heart rate.

**Table 2: Final simulation assessment scores**

| | History (maximum score 4) | Assessment (maximum score 26) | Investigations (maximum score 5) | Management (maximum score 5) | Overall (maximum score 42) |
|---|---|---|---|---|---|
| Group 1 | 2.4 (range 1-4) | 6 (range 2-11) | 2.9 (range 2 – 4) | 3.1 (range 2-4) | 16.2 (range 12 - 20) |
| Group 2 | 1.6 (range 1-3) | 12.4* (range 8 – 16) | 2.9 (range 2-4) | 2.7 (range 2 -3) | 21.5* (range 16 – 26) |

*p<0.001

There was no significant difference in how stressful students in either group graded the simulation scenarios in the questionnaire, with overall three students (11%) finding the experience very stressful, 14 students (50%) finding it moderately stressful and 11 students (39%) finding it slightly stressful (Table 3).

**Table 3: Student questionnaire stressfulness rating (How stressful did you find the simulation learning?)**

| | Not at all stressful | Slightly stressful | Moderately stressful | Very stressful |
|---|---|---|---|---|
| Group 1 | 0 | 5 (36%) | 8 (57%) | 1 (7%) |
| Group 2 | 0 | 6 (43%) | 6 (43%) | 2 (14%) |
| Overall | 0 | 11 (39%) | 14 (50%) | 3 (11%) |

Slightly more students in group 2 graded the simulation learning experience better than group 1, but again this was not statistically significant, with four students (57%) rating the learning experience as very good in group 2 compared to two students (29%) in group 1 (Table 4).

**Table 4: Student questionnaire effectiveness of teaching rating (How effective did you find the simulation learning in meeting your needs?)earning in meeting your needs?)**

| | Poor | Fairly Good | Good | Very Good |
|---|---|---|---|---|
| Group 1 | 0 | 0 | 10 (71%) | 4 (29%) |
| Group 2 | 0 | 0 | 6 (43%) | 8 (57%) |
| Overall | 0 | 0 | 16 (57%) | 12 (43%) |

In the qualitative component of the student questionnaire, common themes that occurred in the feedback were that simulation learning improved student's self-confidence, forced them to think on the spot and also simulated being a real doctor. None of the themes were specifically associated with a particular group type, however.

## Discussion

Simulation learning has become an integral component of medical training at both undergraduate and postgraduate level. With increasing numbers of medical students undergoing simulation as part of their training, however; it is important to maximise the effectiveness of this type of learning, especially when it is performed in larger groups (Harder *et al*., 2013).

Previous studies have demonstrated that students working in pairs or dyads, is more efficient and similarly effective to individual simulation exercises in teaching clinical skills (Shanks *et al*., 2013; Toslgaard *et al*., 2015). The result of this study suggest that an interactive group simulation structure can be significantly more effective in teaching medical students the skills of assessment and management of acutely ill patients, compared to students performing simulation scenarios individually and the rest of the group passively observing. This is possibly because by engaging the entire group in each simulated scenario, each student will better focus on the scenario objectives; thereby enabling them to progress through the individual components of Bandura's (1971) observational learning construct (O'Reagan *et al.,* 2016).

Other studies have also supported the benefits of an active role in simulation over passive observation. Harder *et al*.,(2013) assessed student nurse experiences of high-fidelity simulation and found that active structured engagement positively impacted on student learning, compared to observer roles, which increased frustration with this type of learning. Conversely Stegmann *et al.,* (2012) assessed simulation learning in communication skills training of medical undergraduates, and found by providing observers with a structured feedback protocol, the benefit from the learning was as high as with active involvement in the simulation scenario itself (Stegmann *et al.,* 2012). It has also been suggested that if learning experiences are too 'hands on', this may in itself limit the learning benefits, by making the experience too stressful, and preventing learners from seeing the wider context of the learning event (Hober and Bonnell, 2014).

Most evidence on simulation learning suggests that this type of teaching encourages students to 'think on their feet', and in turn can assist in translating prior knowledge into clinical judgement and action (McCaughey and Traynor, 2010; Lee and Oh, 2015). It is therefore likely that by actively engaging all students in each simulation scenario, but not individually overwhelming them with the burden of the entire scenario; this encourages this translation of knowledge into reasoned action, thereby improving their ability to learn the skills of assessment and management of acutely ill patients (Oldenburg *et al.,* 2013; O'Reagan *et al.,* 2016).

Although there wasn't a significant difference in the stress response between groups in our study, the simulation scenarios did invoke a significant stress response in each individual student, with a mean increase in heart rate of 34 bpm and 38 bpm in groups 1 and 2 respectively.

Some authors have suggested that simulation learning is more stressful than didactic learning. Bong *et al.,* (2010) assessed heart rate and salivary cortisol in physicians undergoing simulation and tutorial teaching, and found the evoked stress response was significantly higher in the simulation group; with heart rate increasing by a median 18 bpm. In contrast, Gizardas *et al.,* (2009) performed a study assessing the changes in heart rate in medical residents performing a critical airway scenario and found the mean change in heart rate from pre-scenario to critical intervention was only 4 bpm. Interestingly, both of these studies had much lower changes in heart rate during simulation learning than our study. This difference may have been because our study involved junior medical students, new to simulation learning, who may have found the clinical scenarios much more difficult and therefore stressful.

Of particular note in our study, was that the stress response between individual medical students varied markedly in both groups, with some individuals only increasing their heart rate by 19 bpm, during the scenario, and others increasing their heart rate by 72 bpm. The results of the student questionnaire also indicated that whilst the majority of students rated the scenarios as slightly or moderately stressful, there was a small proportion of students who rated the experience as very stressful.

It is well recognised that individual responses to stressful stimuli are highly variable (Bong *et al*., 2010; Zendejas *et al*., 2010). The exact role of stress and learning is also yet to be fully understood, but it has been suggested that students who are more anxious, may find more complex simulation scenarios less beneficial to their learning (Hassan *et al.*, 2006). Conversely, students who are less anxious may actual benefit more from complex and challenging scenarios (Buchanan and Lovallo, 2001). It is therefore important to appreciate that individuals will respond very differently to simulation scenarios, and it is important to ensure that students who are more prone to anxiety are not overwhelmed by the stressfulness of the experience, especially early on in their clinical training.

Limitations of this study include that it was performed on relatively small group sizes, and only focused on junior medical students, who were all new to simulation learning. It may be that the stress response would be different if it was assessed on more senior undergraduates or at the postgraduate level. In addition, the student questionnaires were performed in an anonymous fashion, therefore it wasn't possible to correlate these results with the heart rate data, which would have provided a useful comparison.

## Conclusion

This study demonstrates that interactive group simulation scenarios are more effective at teaching the assessment and management of acutely unwell patients, compared to individually performed scenarios. This study also demonstrates that all students experience a significant stress response during simulation training, irrespective of the way in which this is performed. In particular, there is marked variation between individuals in the extent of this stress response, which supervisors need to carefully manage, when delivering this type of teaching.

## Take Home Messages

1. Simulation learning is more effective when performed in an interactive group format than in individual simulations
2. Simulation learning is a stressful experience for all students and the stress response varies markedly amongst individuals

## Notes On Contributors

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Figure 1: Source - the authors.

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## Appendices

None.

## Declarations

*The author has declared that there are no conflicts of interest.*



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The study was approved by the University of Bristol on 05/07/17, reference number: 53102. Informed consent was sought from all participants prior to the study and signed consent forms were obtained.

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