EFFECTIVENESS OF INTERMEDIATE-FIDELITY SIMULATION TRAINING TECHNOLOGY IN UNDERGRADUATE NURSING EDUCATION

Aim: The aim of this paper is to present the results of a study designed to determine the effect of scenario-based simulation training on nursing students' clinical skills and competence.

Background: Using full scale, realistic, medical simulation for training healthcare professionals is becoming more and more common. Access to this technology is easier than ever before with the opening of several simulation centres throughout the world and the availability on the market of more sophisticated and affordable patient simulators. However, there is little scientific evidence that such technology is better than more traditional techniques in the education of, for example, undergraduate nursing students.

Methods: A pre-test/post-test design was employed with volunteer undergraduate students (n=99) from 2nd year Diploma of Higher Education in Nursing programme in United Kingdom using a 15-station Objective Structured Clinical Examination. Students were randomly allocated to either a control or experimental group. The experimental group, as well as following their normal curriculum, were exposed to simulation training. Subsequently, all students were re-tested and completed a questionnaire. The data were collected between 2001 and 2003.

Results: The control and experimental groups improved their performance on the second Objective Structured Clinical Examination. Mean test scores respectively increased by 7.18 and 14.18 percentage points. The difference between the means was statistically significant ($p<0.001$). However, students'

perceptions of stress and confidence, measured on a 5-point Likert scale, was very similar between groups at 2.9 (1=Not stressful; 5=Very stressful) and 3.5 (1=Very confident; 5=Not confident) for the control group, and 3.0 and 3.4 for the experimental group.

Conclusions: Intermediate-fidelity simulation is a useful training technique. It enables small groups of students to practise in a safe and controlled environment how to react adequately in a critical patient care situation. This type of training is very valuable to equip students with a minimum of technical and non-technical skills before they use them in practice settings.

Keywords: Objective Structured Clinical Examination, OSCE, nurse education, simulation, clinical skills, questionnaire, experimental design.

SUMMARY

What is already known on this topic:

- Simulation technology is increasingly popular for training of healthcare professionals across all disciplines as it is recognised as being a safe training method.
- There is a lack of good evidence of the effectiveness of simulation training, especially in nursing education.

What this study adds:

- Intermediate-fidelity simulation training is beneficial for training undergraduate nursing students.
- There was no correlation between nursing students' confidence and their level of performance whether they received simulation training or not.
- Students who report a lack of confidence also admit being stressed when exposed to working in a technological environment

INTRODUCTION

Increasing use of technology in healthcare and higher expectations on the part of patients have encouraged the development and use of new training tools in healthcare education. Because of advances in simulation training, newly qualified professionals will soon be expected to be expert practitioners from the time they meet their first clients or patients, just as airline pilots confidently fly passenger planes after having only flown flight simulators. Students' experience gained by practice has been diminished for patient safety and ethical reasons (Ziv et al. 2000). Because of the increased demand for clinical placements and limited availability of practice supervisors, students' involvement with patient care and opportunities to deal with practice situations have reduced. Hence, there has been a need to reproduce that experience by some other means.

The use of simulation training enables experiential learning in a safe environment (Cioffi 2001) and has been encouraged in the Institute of Medicine's 1999 report "To Err is Human: Building a Safer Health System" (Kohn et al. 1999, p179) to train novice as well as experienced practitioners in different disciplines (Issenberg et al. 1999). These new tools imply new teaching and training methods (Kneebone 1999) that need to be assessed for effectiveness. If methods are shown to be appropriate and beneficial, they should be instituted in nursing and medical schools, and healthcare organisations for initial and continuing professional development. The general opinion is that such technology is indeed beneficial, and this is shown by the fact that over 190 paediatric and adult patient simulators have been sold in

the United Kingdom alone over the last four years (2000-2004). However, most experts in the field still believe that more research is needed to prove that skills acquired in a simulated environment are transferable to real life patient care and that simulation is a cost-effective teaching method (Ziv et al. 2000, Owen & Plummer 2002, Kneebone 2003). As identified in an assessment of learning needs in nursing education, the resource impact needs to be carefully considered (Mailloux 1998). This is especially important when considering that a patient simulator can cost up to £200,000 (US$360,000 o r €300,000) and also often requires dedicated space and trained staff to operate it.

BACKGROUND

The development of full-scale patient simulators started in the 1960s (Abrahamson & Wallace 1980) in the United States of America. Since then a number of studies have been carried out to determine if the use of such technology as a teaching tool is really beneficial and cost-effective (Hoffman & Abrahamson 1975, Gordon et al. 1980). However, most studies are based on a small number of candidates (Abrahamson et al. 1969, Chopra et al. 1994, Morgan & Cleave-Hogg 2000), or present subjective results relying on participant feedback (Gordon 2000, Gordon et al. 2001, Treadwell & Grobler 2001, Rystedt & Lindström 2001, Cleave-Hogg & Morgan 2002, Murray et al. 2002). Analysis of participants' perceptions of the benefits of using simulation as a training tool is useful, but does not provide a scientific answer as to whether or not it is an effective teaching method. In some cases the study did

not compare traditional teaching methods and simulation training (Chopra et al. 1994).

A few studies have shown the effectiveness of mannequin-only training for some particular psychomotor skills (Stratton et al. 1991, Roberts et al. 1997), but a full-scale patient simulator is much more than a big part task trainer. A full-scale patient simulator is a full body-size mannequin with realistic anatomical and interactive physiological features as would be expected in a human being (Figure 1). There is a need for a robust and objective study that critically appraises the value of simulation-based training in a broad range of skills. Patient simulators have become very sophisticated over the years and now enable a wide range of invasive and non-invasive procedures to be performed on them, as well as enabling teamwork training. These training models can be very advanced and mimic different parameters of the human physiology in real time using proven mathematical models, including, for example, the effects of drug administration. When set up in a simulated and realistic environment, they are often referred to as High-Fidelity Simulation Platforms. Some are of a slightly lower technological level requiring the operator to pre-programme trends and scenarios or to modify a patient's physiological parameters during the scenario according to the care students are delivering. These are called Intermediate-Fidelity Simulation Platforms. If used appropriately, a similar level of realism can be achieved using either technology.

Figure 1

THE STUDY

Aims

The aim of this study was to critically appraise the value of the use of simulation in nursing education by comparing the performance in a practical examination of two groups of students. One group (Experimental) was exposed to scenario-based simulation training, and one (Control group) was not. The hypothesis being tested was that the experimental group would perform better in the test than the control group.

Design

A pre-test/post-test experiment was designed to enable comparison between a control and an experimental group. The data were collected between 2001 and 2003. Throughout the study students followed their normal curriculum. Students from the experimental group also took part in scenario-based hands-on training sessions in a simulated clinical intensive care setting over two afternoons (Figure 2).

Allocation of students to the groups was performed randomly after an initial assessment session, which was an Objective Structured Clinical Examination (OSCE). Control and experimental group students were re-assessed after 6-months to enable comparison between the two groups and to determine whether or not the simulation experience had had an effect on their level of competence and confidence.

Figure 2

Participants

Participation in this project was open to three consecutive cohorts of students (N=344) in the second year of a Diploma in Higher Education in Adult Nursing. Students were invited to attend the sessions of the research programme in addition to their timetabled classes or as an alternative to some of the specific teaching sessions. Of the 344 students from the three cohorts, 133 volunteered to take part by attending the initial OSCE (38.7% response rate), and 99 completed their participation by attending the second OSCE and the simulation sessions if they were recruited to the experimental group (28.8% participation rate). The average age of the overall population was 29.9 (SD 8.7), against 31.2 (SD 8.2) for the actual sample, and the average age of the students who dropped out was 28.6 (SD 9.4). The proportion of female students was 88.7% within the student population, 83.8% in the participant sample, and 91.2% in the loss to follow-up category. Although a relatively large number of students dropped out of the study, the average age and gender distribution of the sample was still representative of the student population (Table 1).

Power calculation

Using a conservative estimate of a minimum detectable effect size of 0.5, a sample of around 125 was wanted (statistical significance 0.05, power 0.8). In the event, the dropout rate resulted in a final total sample of 99, with a resulting increase in the detectable effect size to approximately 0.66. Given

that the observed effect size was slightly in excess of 1.0, then the initial conservative choice of sample size was adequate to meet the principal research objectives.

Table 1

Data collection

The Objective Structured Clinical Examination was originally developed in the University of Dundee in 1975 to assess the clinical competence of trainee doctors (Harden & Gleeson 1979). Since then, the use of OSCEs has been increasingly recognised as an effective evaluation tool for assessing the practical skills of other healthcare students. In most allied health professions it is recognised as a valid, reliable and practical assessment method (Harden & Gleeson 1979, Sloan et al. 1995). This type of assessment is composed of several short exercises, or stations, through which students rotate individually for a given time. An OSCE is usually composed of 15 to 20 stations that last between 3 and 10 minutes. Each station focuses on a particular clinical aspect, either in a practical way and invigilated by an examiner, or in a theoretical way, in the form of a pen and paper exercise. Students are given a limited time at each station and have to wait for a signal before rotating to the next one (Harden 1990). By the end of the OSCE, all students have passed through all the stations and been marked according to a precise set of criteria. Well-designed marking sheets and appropriate briefing and preparation of examiners ensure that the overall examination is based on objective judgements.

Designing effective OSCE stations is not easy. This type of examination is time-consuming, resource intensive, and requires careful organisation and planning to be successful (Harden 1990). However, this assessment method can be flexible and tailored to the organisers' needs (Alinier 2003). It is also particularly useful for enabling students to evaluate themselves and determine their own weaknesses (Bramble 1994, Sloan et al. 1995).

For the purposes of this study, a 15-station OSCE was developed. This meant that only 15 students could be examined in each session. Students had five minutes per station, with a one-minute gap to rotate to the next one, which made the total examination last 90 minutes. Each OSCE session ran over two hours as students needed to sign in, be given an anonymity number, and be reminded about the organisation of the OSCE. The OSCE included four theoretical stations with questions on safety and nursing practice (Alinier et al. 2004). Each of the other 11 stations was supervised by an examiner and required students to use their clinical knowledge, technical ability, and communication skills. Those stations were marked at the time of the examination, whereas the theoretical stations were marked later. A concise set of instructions and marking scales was prepared for the 15 stations in order to make the marking as objective as possible. All OSCE examiners were trained by the principal investigator to ensure consistency in the marking.

First OSCE

The initial OSCE was run under summative assessment conditions and represented the first exposure to an examination of this kind for the students. This made it a fairly stressful experience because they were being observed and assessed in different skills. However, it was seen as a useful and valuable experience, according to the feedback given by students (Alinier 2003) and as found previously by Bramble (1994). It was taken by all of the volunteer students to determine the baseline of their current skills.

Simulation session

The aim of the simulation sessions was to give students in the experimental group realistic clinical experience in a safe environment while avoiding any specific preparation for the OSCE examination. Students were separated into subgroups of 4 and attended two simulation sessions, each of three hours, focusing on patient care and clinical skills. Two subgroups were invited to each session, with one group acting as observers while the other group took part in the scenarios (Table 2).

Table 2

The first part of the session comprised an introduction and discussion about teamwork and communication in the context of the clinical environment (Table 3). This was run in an informal way to gain students' confidence and to help them relax before the scenarios. Students were then introduced to the concept of "*simulation*" and familiarised with the patient simulator. Before

beginning the scenarios students were clearly briefed about the remainder of the session. It was explained what was expected from them and what help they could request from the facilitators if needed.

During the scenarios students worked in pairs and had the opportunity to be in charge of two distinct simulated situations and to care for the patient simulator as they would do in a real ward setting. Working in small groups gave them the opportunity to have as much hands-on experience as possible. The remainder of the group observed the scene in a different room. Both aspects were seen to be important as part of the overall experience. The simulated clinical environment was arranged so that students involved in the scenario were not disturbed by those observing them. This was achieved using an audio/video link which simultaneously recorded and displayed the scene on a monitor in an adjacent room. The points observed were communication, teamwork, situation awareness, decision-making, and clinical skills. Students who observed the session participated in the debriefing by commenting on what they had seen and according to the notes they had taken. They benefited from analysing the actions taken during the scenarios by their peers, from taking part in the debriefing, and from hearing any advice given.

Table 3

Four different scenarios involving pre- and post-operative patients were programmed for use in the simulation sessions. Students were also given a

set of patient notes and background information to take into consideration when treating the patient.

Students reacted well to the use of simulation. After a few minutes they usually started considering the mannequin as a real patient, and communicated with “him”. When appropriate, one of the facilitators running the session took the role of resuscitation officer or doctor. After each scenario the students’ performance was discussed, with the participation of the observers. This debriefing was conducted in a non-threatening way and participants were given recommendations on issues that they might have overlooked during the scenarios. It was expected that students would benefit from seeing their peers dealing with clinical scenarios and from taking part in the debriefings. Observing and taking part in the scenarios was considered to be an important part of the overall experience.

It is important to note that in this simulated intensive care setting, students may have needed to use some of the equipment that was also present in the OSCE, but this was very distinctive from the way they were used during the examination meaning not clear – what are 'they'?. They were given advice and could ask questions related to the scenarios; however, they were not briefed or reminded about how to use the equipment as they should already have known how to use it to some extent.

Second OSCE

All students were invited to attend a second OSCE to determine their skills and competence level at that time. According to Niehaus et al. (1996), the same OSCE can be repeated up to four times a year with different groups of students without affecting the results. A six months separation between the two OSCEs, together with the number of stations and the random order in which they were taken, ensured that students were not simply learning how to do the test. For those in the experimental group, the second OSCE was conducted at least five weeks after their simulation sessions, further avoiding any tendency for those sessions to 'prepare' them for the OSCE. The OSCE stations and marking schemes remained identical throughout the project to enable comparison of the results. In addition, for the second OSCE, students were given feedback after the assessment period for each practical station. This type of Objective Structured Clinical Examination is called "mixed mode" (Alinier 2003), because it lies between traditional formative and summative OSCEs by enabling both data collection and feedback to students at each station. Many students preferred the second OSCE to the first one as they could receive immediate feedback on their performance and were less stressed because they had already experienced the first OSCE session.

After participation in the study students were given a certificate of attendance. The research co-ordinator adopted an open-door policy to give them the opportunity to discuss their performance and see how they had progressed between the two OSCEs. Students added their certificate of attendance to their nursing practice portfolio (record of their clinical practice and

achievements). At this stage many students from both study groups gave further positive feedback which emphasised the fact that they valued the different sessions of the programme.

Questionnaire

Before the start of the second OSCE all students completed a questionnaire about the use of technology in nursing practice and their level of confidence and stress when working in a technological environment. The questionnaire was also used to obtain demographic information and details about students' previous healthcare experience and current placement area. This information enabled us to determine whether or not the two randomly selected study groups were comparable.

Pilot study

Prior to the full study reported on here, all the sessions were piloted during their development with a mixed group of nursing and paramedical students. The results of the pilot OSCEs and feedback given by both students and examiners were used to improve the validity and objectivity of the OSCE. The most difficult aspect to assess objectively was how confident students were in using a particular piece of equipment or carrying out a particular skill. The only solution found was to monitor the time taken to perform a task and mark it against a pre-determined scale (Owen & Plummer 2002).

For the pilot of the study, only 4 students were invited for each simulation session, with a team of two educators. It was felt that the simulation

experience needed to be maximised as it was a key element of the study. As a result of the pilot study, the duration of exposure to the simulated environment was increased by allowing an additional group of 4 students to observe the session before being actively involved in the simulation training. Having gained sufficient experience in running the simulation sessions and the layout of the simulation centre being appropriate, the number of facilitators was reduced to one as this was considered to be sufficient.

Validity and reliability

OSCEs are recognised as a highly reliable and valid assessment method (Sloan et al. 1995). In our study, very detailed attention was paid to the design of the OSCE instructions and to the marking and answer sheets. Checklists were used to make sure that assessment was objective. A panel of educators was involved in the validation of the 15 stations for content and accuracy. The design and content of the marking sheets was such that even someone with very little knowledge of the skill being tested could reliably mark the performance of students. Harden and Gleeson (1979), pioneers of OSCE, determined that there could be three variables: the students, the examiner, and the patient. In our case, the variability of the patient, often a standardised patient in the case of an OSCE (Collins & Harden 1998), was removed by only assessing students' interaction with equipment and/or mannequins. All OSCE assessors were trained to examine particular stations and remained allocated to that station as much as possible.

Ethical considerations

Approval was granted for this study by the Faculty of Health and Human Sciences Ethics Committee. Access to the students was gained through cohort tutors. All students of the cohorts involved were informed of the purpose, requirements, duration, and anticipated benefits of the study, and were given the option not to participate. Volunteers were allocated an anonymity number and signed a consent form just before attending the first OSCE session. They were also informed that they could withdraw from the study at any time without giving any justification. Students who had been allocated to the control group were invited to attend the simulation training sessions after attending their second OSCE session so that they were not disadvantaged. Students were informed that they would be awarded a certificate of attendance to add to their professional portfolio when completing the study.

Data analysis

Data analysis was performed using SPSS version 11.0. Experimental and control group OSCE performances and questionnaire results were investigated. Statistical significance of the difference in OSCE results was evaluated using t-tests. A Mann-Whitney U test was used to analyse the difference between students' perceptions of stress and confidence.

RESULTS

The results presented are based on the 99 students who completed the study by attending all the required sessions. Fifty were in the control group and 49 in the experimental group. Table 1 presents the demographic profiles of the two study groups and shows that they are comparable.

The average performance for the first OSCE was 48.18% (95% C.I. 46.31-50.06) (Table 4). Analysis of the first OSCE performance of students lost to follow-up indicated that their average performance was 47.38% (95% C.I. 44.10-50.67) for the first OSCE (Table 4). Although this is slightly lower than that of the completing students, it remains comparable and hence indicates that their withdrawal from the study should not bias the results. After having randomly allocated the students between the two groups for the rest of the study, and omitting OSCE results of those who dropped out at that stage, the average OSCE score was 48.82% (95% C.I. 45.90-51.73) for the control group and 47.54% (95% C.I. 45.11-49.97) for the experimental group (Figure 3, Table 5). The results of the first OSCE are shown as box plots in Figure 3 and illustrate the broad comparability of the two distributions, perhaps with the slight exception of a single, although modest, outlier in the control group.

Table 4

Figure 3

A comparison of the results of the two groups for the second OSCE indicates that students in the experimental group generally obtained higher marks than those in the control group (Table 5). The box plots (Figure 4) suggest only very minor skew, while there is clear evidence that most experimental group students were scoring higher than the control group students. On average, the control group obtained 56.00% (95% C.I. 53.32-58.69) at the second OSCE, whereas the experimental group scored 61.71% (95% C.I. 59.56-63.88).

Figure 4

The main result was the difference in performance between the two OSCEs for the two groups. The improvement in performance was 7.18 percentage points (95% C.I. 5.33–9.05) for the control group and 14.18 percentage points (95% C.I. 12.52–15.85) for the experimental group (Table 5, Figure 5). The difference of 7.0 percentage points between the means (95% C.I. 4.5–9.5) was highly statistically significant (Independent sample t-test df=97, $p<0.001$; test for equality of variance $F=0.623$, $p=0.432$).

Table 5

Figure 5

Questionnaire results showed that the two groups differed only slightly with respect to perceptions of stress and confidence when measured using a 5-

point Likert scale: 2.9 (1=Not stressful; 5=Very stressful) and 3.5 (1=Very confident; 5=Not confident) for the control group, and 3.0 and 3.4 for the experimental group (Table 6). The main findings were that the two groups were unsure about whether it was stressful for them to work in a highly technological environment, and they were not really confident about working in such an environment. The differences did not approach statistical significance (Mann-Whitney U test: perception of stress p=0.562; confidence p=0.819), which shows that the simulation-based training did not have a statistically significant effect on perceptions of stress or confidence about working in a highly technological environment in the experimental group. Similar findings were reported by Morgan and Cleave-Hogg (2002) when exposing medical students to anaesthesia simulation scenarios, and also by Graham and Scollon (2002, p296), who concluded that “improvements in the training of specific advanced life support techniques does (sic) not lead to improved overall confidence in using these skills”. In addition, our results show that, irrespective of their group, students who are not confident also admit to being stressed when exposed to working in a technological environment (p=0.002, Chi-Square, df=2, n=99).

Table 6

DISCUSSION

The OSCEs were a very important component of this study and special attention had to be paid to their design and content. Although participating in such a series of short examinations is known to be stressful, OSCEs are

generally well appreciated by students, who see them as a valuable learning tool (Bramble 1994, Alinier 2003). However, they are known to be difficult to organise due to the number of people required to assess students' performance or to provide feedback if required, and to ensure that students learn what is expected (Salas & Burke 2002). The main limitation of the present study was the fact that the two OSCEs and the simulation experience were not part of the Diploma in Nursing curriculum. Students often participated in the study in their own time, and many were mature students who had family commitments. This had an impact on the number of volunteers recruited, as well as on the number of OSCE sessions that had to be organised to suit students' availability. This made the study more difficult to manage and more resource-intensive.

Students and facilitators both need to be adequately prepared for the use of patient simulators as a teaching tool. No assumptions about students' understanding of simulation should be made. Student briefing should be well-structured in order not to omit any details about the session, environment, equipment, or patient simulator. It is important to remind students that they should engage in the scenario as themselves and not to engage in role-playing (Streufert et al. 2001). As highlighted by Salas and Burke (2002), a tool can only be effective if it is appropriately used. The use of simulation technology also has great potential in continuing professional education and lifelong learning (Issenberg et al. 1999).

Students from both our groups may have gained some experience from the practice placement part of their normal study programme. This variable was particularly difficult to isolate, as it depended very much on the supervision students received and the place where they were practising (e.g. Accident and Emergency, Community, Coronary Care Unit). The questionnaire used at the start of the second OSCE asked about students' past experience as well as the place where they were currently placed. However one difficulty in monitoring this was that during the study students rotated on a regular basis through different specialist units, whereas our questionnaire only asked them to state their current or latest placement specialty. However, overall it can be assumed that the different types of placement, group size and randomisation balanced the effect of clinical experience between the control and experimental groups.

It is very difficult to conduct a valid study evaluating the impact on clinical practice of rapidly changing technology such as simulators (Kneebone 2003). Despite the constraints of our study and the somewhat small sample of students, the results support those of other studies (Abrahamson et al. 1969, Gordon et al. 1980, Chopra et al. 1994) and provide quantitative evidence of a positive impact of simulation training. Thanks to these positive results, we expect that some components of realistic scenario-based simulation training will be integrated into future nursing curricula, as has been the case at the University of Dundee (Issenberg et al. 2003).

The feedback from participants was also very much in favour of the use of such training methods, and this is consistent with findings in other surveys (Gordon 2000, Gordon et al. 2001, Treadwell & Grobler 2001, Cleave-Hogg & Morgan 2002). One of our participants reported that the “general feeling amongst the group was that this session, combined with observation and practice, is vital for preparing students for emergency situations on the ward or in recovery”. Another student reported having been praised by her clinical tutor for the role she played during a cardiac arrest in her ward. She said that she had been able to put into practice what she learnt during the simulation session. This highlights the potential for such training to be counted as part of students’ clinical practice hours. It allows trainees to be exposed to a wide range of cases in a relatively short period of time. Informal feedback revealed that students also valued the fact of being observers while their peers were in the ‘hot seat’. When taking part in scenarios, most students initially thought that they would not be comfortable because of the camera and knowing that they were being observed, but all very rapidly forgot about these when a scenario started.

We also hope that the results of this study will encourage recognition of the time spent by students taking part in simulation training exercises as counting toward practice or placement hours, as this could partly compensate for any shortage of placements. Many medical simulation centres are now regularly organising training sessions for healthcare professionals from different disciplines. Simulation is also a very useful and safe method for introducing

practice in new procedures and becoming acquainted with the effects of new drugs.

CONCLUSION

Our results support the use of simulation in nursing education. It is, however, important to recognise that it can only be beneficial to students if it is used appropriately and in a way that improves the quality of teaching and learning. There are many aspects to the appropriate use of simulation as an educational tool that must be taken into consideration and applied for it to become an effective teaching method.

New training tools require new ways of teaching, and this is particularly true with the newer patient simulators as they offer greater realistic interactivity between facilitators and trainees. This means that facilitators can, and probably should, have less interaction with students during scenarios. Students themselves should play the major role during the sessions, as they should be the ones “in control” of the situation. They should decide on the appropriate treatment and actions to care for the “patient”. This allows them to learn from mistakes and act on their own judgement. Both basic skills training and following on from a scenario-based training session are forms of practice, and ‘practice makes perfect’. Furthermore, students should regularly receive feedback to make sure that they take away from the experience what was expected. This is one of the reasons why providing feedback to students is so important and is often highly valued by them.

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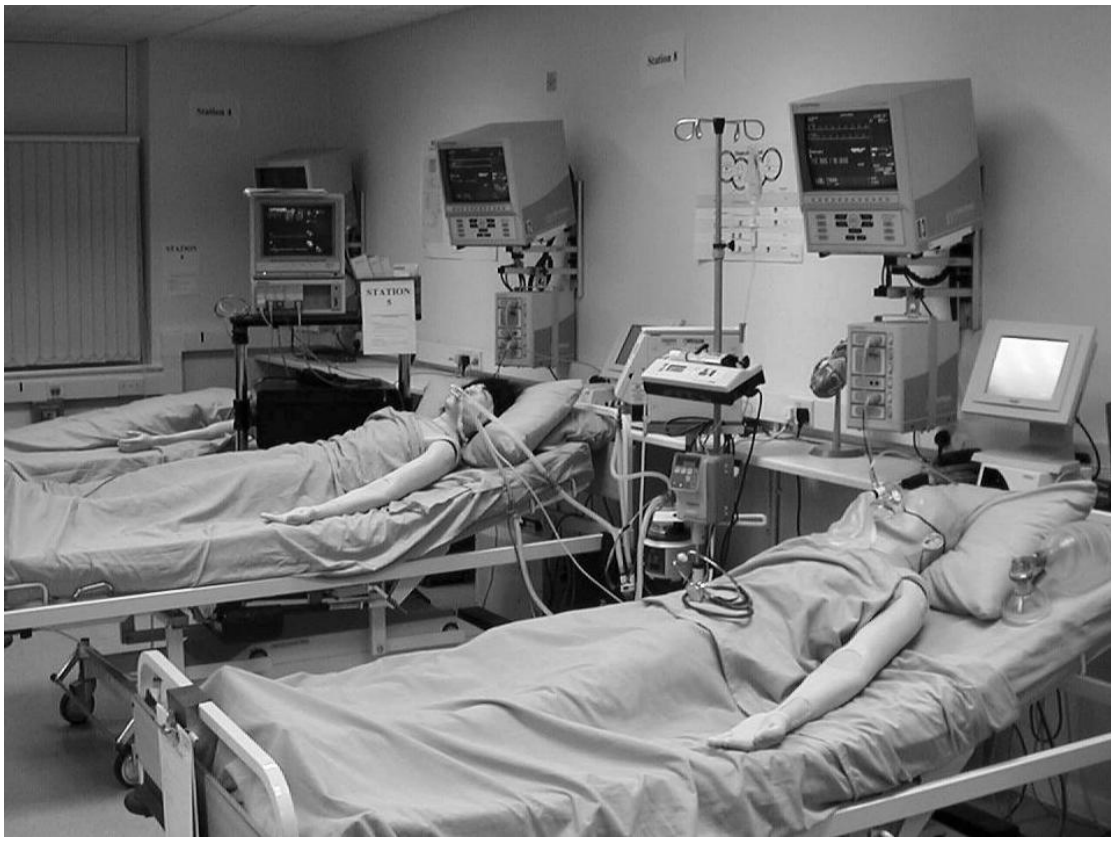

Figure 1: Patient simulators

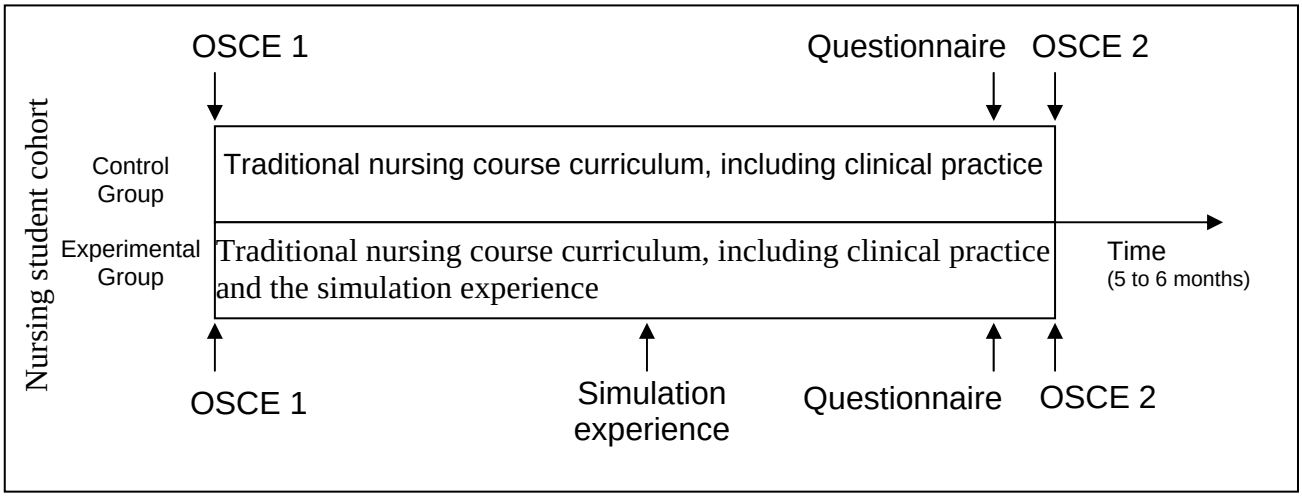

Figure 2: Study design

Student demographics

	Experimental Group	Control Group	Student Population
Number of students (n)	49 (49.5%)	50 (50.5%)	344
Gender: Male	7 (14.3%)	9 (18.0%)	39 (11.3%)
Female	42 (85.7%)	41 (82.0%)	305 (88.7%)
Average age (Years)	29.3 (SD 7.5) Range [20-46]	33.0 (SD 8.4) Range [21-55]	29.9 (SD 8.7) Range [19-66]
Candidates with previous experience	20 (40.8%)	16 (32.0%)	-
Average experience in years of experienced students	2.2 (SD 2.1) Range [0.3-8]	3.4 (SD 2.6) Range [0.3-11]	-

Table 1: Student demographics

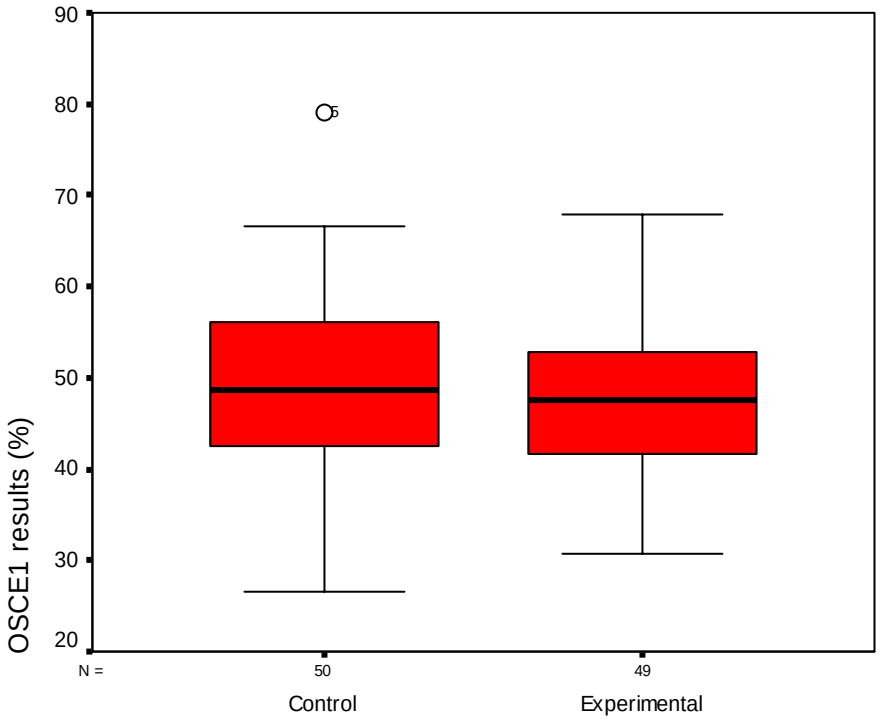

Figure 3: Boxplot of students' results for the first OSCE.

Simulation Sessions / Role of Students	Session 1	Session 2	Session 3	Session 4	…	Session X
Observing	Group A	Group B	Group C	Group D	…	Group X
Participating in scenario	Group X	Group A	Group B	Group C	…	Group X-1

Table 2: Role of students during the simulation sessions.

Note A, B, C… X indicate different groups of 4 students.

Programme	Duration
Registration and Introduction	10 min
Teamwork & communication discussion	20 min
Introduction to SimMan and familiarisation/demonstration	20 min
Break	5 min
Scenario with 1st pair of students and feedback with observers' comments	25 min
Scenario with 2nd pair of students and feedback with observers' comments	25 min
Debriefing	10 min
Break	5 min
Scenario with 1st pair of students and feedback with observers' comments	25 min
Scenario with 2nd pair of students and feedback with observers' comments	25 min
Debriefing and Conclusion	10 min

Table 3: Programme of the simulation sessions.

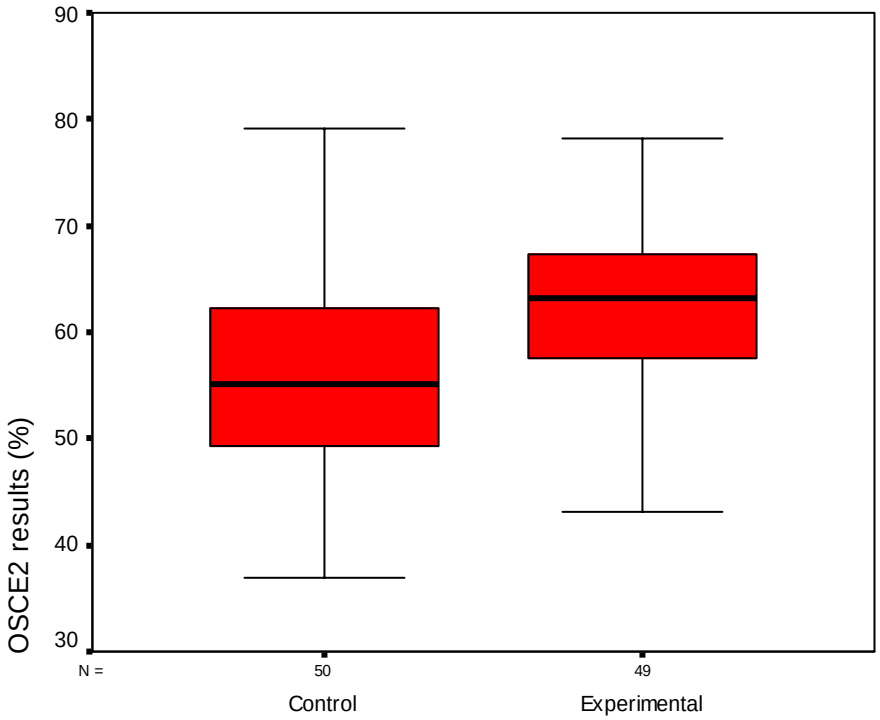

Figure 4: Boxplot of students' results for the second OSCE.

OSCE 1 results (%)

		Participants (n=99)	Sample (n=133)	Loss to follow-up (n=34)
Mean		48.18	47.98	47.38
95% Confidence Interval for Mean	Lower Bound	46.31	46.37	44.10
	Upper Bound	50.06	49.59	50.67
Std. Deviation		9.38	9.36	9.41
Minimum		26.67	23.11	23.11
Maximum		79.11	79.11	68.44

Table 4: Overall results of the first OSCE.

			OSCE 1 results (%)	OSCE 2 results (%)	% improvement (OSCE2 - OSCE1)
Control Group (n=50)		Mean	48.82	56.00	7.18
	95% Confidence Interval for Mean	Lower Bound	45.90	53.32	5.33
		Upper Bound	51.73	58.69	9.05
		Std. Deviation	10.26	9.46	6.54
		Minimum	26.67	36.89	-5.33
		Maximum	79.11	79.11	23.56
Experimental Group (n=49)		Mean	47.54	61.71	14.18
	95% Confidence Interval for Mean	Lower Bound	45.11	59.56	12.52
		Upper Bound	49.97	63.88	15.85
		Std. Deviation	8.46	7.53	5.80
		Minimum	30.67	43.11	2.67
		Maximum	68.00	78.22	26.44

Table 5: Results of the two OSCEs and improvement in performance

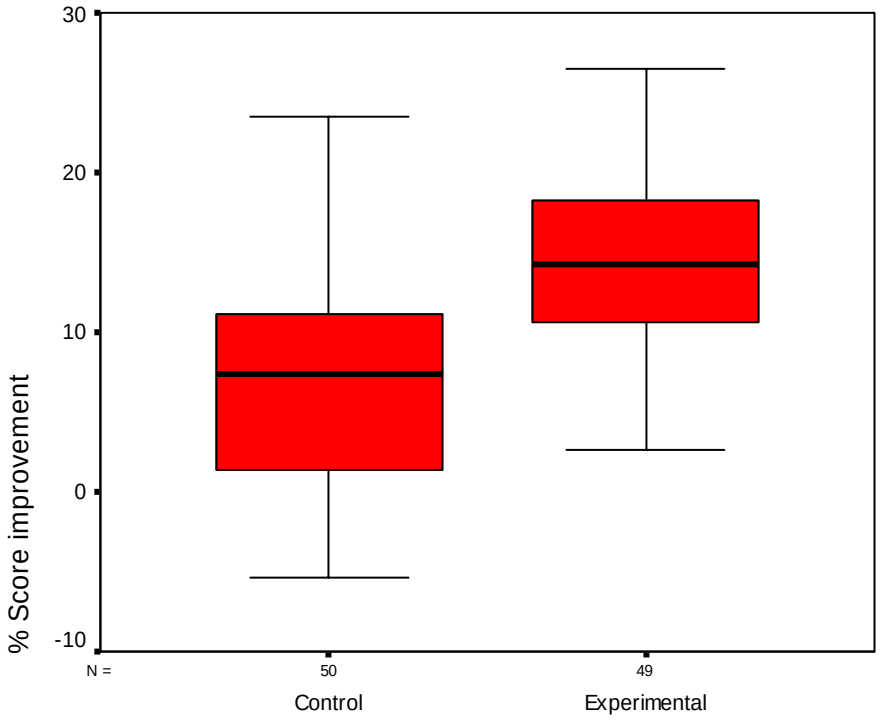

Figure 5: Boxplot of students' overall improvement in OSCE performance.

	Experimental Group	Control Group
Confidence in working in a technological environment (1=very confident, 5=not confident at all)	3.4 (SD 0.8)	3.5 (SD 1.0)
Stressfulness of working in a technological environment (1=not stressful at all, 5=very stressful)	3.0 (SD 0.8)	2.9 (SD 1.1)

Table 6: Students' perceptions of stress and confidence in working in a technological environment