The use of simulation as a novel experiential learning module in undergraduate science pathophysiology education

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Abstract

Teaching of pathophysiology concepts is a core feature in health professional programs, but it can be challenging in undergraduate medical/biomedical science education, which is often highly theoretical when delivered by lectures, and pen and paper tutorials. Authentic case studies allow students to apply their theoretical knowledge, but still require good imagination on the part of the students. Lecture content can be reinforced through practical learning experiences in clinical environments. In this paper, we report a new approach using clinical simulation within a human pathophysiology course to enable the undergraduate science students to see 'pathophysiology in action' in a clinical setting. Students role-played health professionals and in these roles they were able to interact with each other and the manikin 'patient', take a medical history; and perform a physical examination and consider relevant treatments. Evaluation of students' experiences suggests that using clinical simulation to deliver case studies is more effective than the traditional paper-based case studies by encouraging active learning and improving the understanding of physiological concepts.

Key words: simulation, pathophysiology, practical class, medical science, undergraduate

Introduction

The teaching of pathophysiology, i.e. the abnormal physiology of disease states, is a core feature in health professional programs. While content can be efficiently taught by lectures, it is generally accepted that a deep approach to learning necessitates embedding content knowledge into case studies (1). Such case studies are built around an authentic scenario, ideally prepared in consultation with practicing clinicians and educators to ensure contemporary practices are embedded into the case material. However, when taught in the classroom, the success of these case studies with regard to promoting a deeper approach to learning is in part reliant upon the student's capacity to successfully engage with the material and create a mental image of the clinical situation. This is very challenging for undergraduate science students who may have limited clinical experience with, or observation of, actual patients.

In the training of health professionals the opportunity to see 'pathophysiology in action' is provided by clinical practicum. The burgeoning demand for clinical placements (11) and considerations of patient and student safety have been drivers to supplement authentic clinical experience with simulations of varying fidelity (6). High fidelity manikins have undergone significant advances in recent years. These highly technical manikins can be programmed to reflect physiological signs, such as heart sounds, breath sounds, pulses, blood pressure, oxygen saturation; and to respond to procedures performed by the students (4, 8, 10). Immediate feedback, in the form of verbal responses via the manikins to student interventions and offering learning experiences within representative clinical settings are additional, unique features of simulations. Thus, there is a strong argument for the use of simulations in teaching pathophysiology to undergraduate science students.

While use of simulation in medical and nurse education has been reported previously (3, 6, 10, 13), there have been no reports of its use to train medical/biomedical scientists. In this paper we report on the development and incorporation of two simulation scenarios into a second year medical science subject (Human Pathophysiology) at a large metropolitan university in an attempt to promote a greater understanding of the underlying pathophysiology as well as provide a means to support the development of desired graduate attributes, including communication skills, team work, leadership, and decision making.

Method

The present study was carried out in the Spring semester (August to early November) of three consecutive years from 2011 to 2013, at the Faculty of Science, University of Technology Sydney. Subjects comprised in total 433 students (100 students in 2011, 158 students in 2012 and 175 students in 2013) in their second year of the Bachelor of Medical, or Biomedical, Science programs participating in laboratory sessions in the 'Human Pathophysiology' course. The particular session described in this paper took place in the clinical simulation laboratories in the Faculty of Health, University of Technology Sydney.

Course structure

The course consists of three one-hour lectures and a two-hour practical class each week. Different patient scenarios were used in each practical class to facilitate transfer of the theory learned during the face-to-face lecture into practice. In addition students were exposed to requisite skill training on laboratory diagnostic methods.

The simulation practical classes used both a flipped learning (pre-class self-study) and a problem based learning (PBL) approach. Students were provided with case notes and questions, which required them to find the answers prior to the laboratory class. The questions consisted of the following aspects,

1) What aspects of this case do you wish to focus upon?
2) Which examinations will you carry out on the patient immediately?
3) Given the patient's history, what other conditions could account for his presentation?
4) Discuss the measures which need to be taken to limit the extent of the condition?
5) List the measures which you would advise the patient to take in order to reduce the progression of the current disease.

Each of the two simulation practical classes focused on two different organ systems - cardiovascular (CVS) or gastrointestinal (GIS). The first simulation scenario was based on an elderly patient who experienced a myocardial infarction, while the second scenario was that of a younger patient with a sudden haemorrhage due to a duodenal ulcer. To enhance authenticity and context, the patient cases were deliberately based on real hospital cases. Activities included taking a medical history, performing a physical examination, and performing medical treatments (e.g. sub-lingual administration of a drug and delivery of oxygen via a face mask). Prior to each simulation experience the students were taught, during a face-to-face lecture, the principles underlying the diseases, including etiology, causes, symptoms, diagnosis, and treatments.

In each two-hour practical class there were a maximum 40 students. We divided the students into four sub-groups (1-4) with a maximum 10 students in each. The two-hour class was divided into two one-hour simulation sessions and each student only attended one session. The simulation session comprised two parts (see Table 1) – half the student group (n=10) rehearsing physical assessment skills on each other and on lower fidelity manikins, and the other half (n=10) engaging in a facilitated simulation scenario with a high-fidelity manikin. Due to their non-health professional major, there were always a couple of students in each group who only wanted to observe the other students performing examinations on the manikin, but who could still benefit from vicarious learning in seeing the disease state or process 'come alive' through the simulation scenario. Scheduling smaller group experiences was a deliberate strategy to increase the engagement and interaction of students within the simulation experience. Due to the large overall student numbers, sessions were repeated 11 times over the day (see Table 1).

At the commencement of the simulation scenario, the demonstrator (science laboratory tutor) read out the patient history, clinical symptoms and vital signs as given in the practical manual. Students were then given the opportunity to interact with the manikin in order to elicit a more detailed patient history. In order to have real-time conversations with the students and increase the fidelity of the experience the voice of the manikin was provided by an academic staff member or a specially-trained nursing student. This element of the learning experience facilitated two-way conversations between the 'patient' and students to encourage the engagement of every student. Next a physical examination (including blood pressure, heart and lung sounds, and radial pulse) of the manikin was performed. Subsequently the students worked together to come up with suggestions regarding additional tests which could be undertaken, a provisional diagnosis and treatment strategies. The students then implemented some simple treatments. The session ended with the students being asked by the demonstrator additional questions related to a differential diagnosis during a preliminary debriefing. A more comprehensive debrief session was carried out in the following week when, following a period of reflection, students could discuss questions or concerns arising from the simulation experience with the demonstrators and review the preparatory patient case questions.

In talking with the manikin, taking a medical history, performing a physical examination and patient treatments, students were role-playing health professionals and in these roles they were taught how to read the patient monitors and interpret vital signs. Guidance was provided throughout the simulation scenario by the demonstrators and through responses via the manikin.

Study Design and Materials

At the end of the second simulation class, students were asked to participate in an anonymous questionnaire about their experiences with this renewed approach to learning. Student feedback was collected from 2011-2013. A bespoke survey was created, reviewed and trialled by the authors to evaluate this innovation as there was a lack of suitable tools in the published literature specific to this context. The questionnaire consisted of 12 statements and students were asked to rank each statement on a five-point Likert scale from *Strongly Disagree* to *Strongly Agree*. The statements addressed whether students felt the simulation experience had benefitted their learning. Some qualitative data were also collected. Specifically, open-ended questions were included that allowed students to comment on how they felt the simulation experience had contributed to their learning in comparison to a paper based study. Additional measures of the impact of the simulation on learning were sourced from students' aggregated subject grades (marks). The student survey was anonymous and voluntary, hence the evaluation was judged to be of negligible risk to the survey participants. This study is an approved activity within a peer-reviewed Teaching and Learning (T&L) grant sponsored by the university's Deputy Vice Chancellor T&L and Associate Dean of T&L, Faculty of Science. Utilizing students' aggregated grades (marks) was considered as *nil-risk* by the Human Research Ethics Committee (HREC) of the University of Technology Sydney.

The evaluation form consisted of the following questions:

1. I understand what the simulations were supposed to represent
2. Simulation helped the understanding of the diseases
3. Using simulation is a better way to improve learning compared with a paper-based case study
4. The simulations were easy to perform
5. The level and clinical aspect are proper for a science student and the tasks are within their capabilities
6. The manikin simulation is a good experience
7. I would recommend the simulation class to the peers
8. I would feel overwhelmed if the manikin deteriorated and died due to wrong diagnosis or intervention
9. The simulations were a waste of time
10. Having more than one simulation class during the semester would be good for the learning experience
11. The simulation gave me some idea of a hospital setting
12. Although I may not become a health professional in the future, the simulation is a good experience

The question clusters and related aspects of the student experience tested in this evaluation are listed in Table 2.

Case Scenarios

Two simulation scenarios were developed based on expected physiological changes during each scenario - an elderly patient who experienced a myocardial infarction (CVS) and a young patient with upper gastric bleeding due to a duodenal ulcer (GIS).

1. Details about the patient who experienced a myocardial infarction included:

'Mr M.H. is a 60 year old man, who presents to the Emergency Department (ED) with his wife. He has a two-hour history of chest pain, nausea and vomiting. He took two tablets of Panadol (name of a popular brand of paracetamol) at home, which did not help. His past medical history includes type 2 diabetes (treated with Rosiglitazone), reflux esophagitis (treated with antacids) and rheumatoid arthritis (treated with piroxicam, a drug which possesses anti-inflammatory properties similar to aspirin). Social history includes moderate alcohol consumption (40-60 g/day) and cigarette smoking (20 per day for the past 35 years). M.H. works as a journalist for a daily newspaper. On examination, the patient is 70kg with 170cm in height. He is in considerable distress, clutching his chest with a clenched fist. He is sweating profusely and breathing rapidly. High flow oxygen is immediately delivered by face mask.'

Within this scenario students engaged in using an electrocardiograph to diagnose a myocardial infarction and assessed and interviewed the 'patient' to determine relevant signs and symptoms. In addition to the physical parameters students engaged in dialogue with the 'patient' to determine the severity of the pain and reactions to immediate treatment strategies (anginine, oxygen and morphine). Appreciation of the timeliness in relieving chest pain to minimise damage to the heart was a key learning outcome for students that was intended to be made more overt through the simulation experience.

2. Details about the patient with upper gastric haemorrhage included:

'Your patient Sam is a hard working science PhD student at University of Technology Sydney. This afternoon, Sam had a late lunch in the tea room as usual. He was half way through his second sushi roll when he suddenly had severe upper abdominal pain, and vomited his food up. He immediately felt dizzy and had cold sweats. He lost balance when he tried to stand up. His supervisor was informed immediately and arranged a taxi to take him to the hospital. Sam told the triage nurse that he felt uncomfortable in the stomach (mild blunt pain) before lunch. He thought that it was only because he was hungry. He has been having this problem for a while, which was always relieved by food. He only had some water since he arrived at the Emergency Department and vomited a couple of times since admission. He had no significant health problems in the past. The triage nurse did a quick abdominal examination on him, suggesting no abdominal muscle guarding, but pain in the middle upper abdominal area. The nurse passed the information to you when you took over caring for Sam. You observed that Sam is a tall and thin young guy, who is in a supine position in bed. He is very pale and looks anxious due to the abdominal pain. He could answer some questions, but does not look focused. You could see the vomitus in the container next to his bed.'

A bowl on the bedside table contained moulaged coffee ground vomit which accurately depicted the vomit visually and by odour. This enabled students to chemically test for the presence of traces of blood. To make Sam's case more engaging, we programmed physiological changes in the manikin that represented a significant amount of active blood loss due to increased internal bleeding, where blood pressure drops and heart and respiratory rates increased accordingly. The students were required to recognize this sudden life-threating deterioration and provide emergency treatment strategies that could save the patient's life. Once treatments were implemented the students were able to visualize improvements in Sam's vital signs (blood pressure, heart and respiratory rates).

Staff Training

Before each practical class, members of the research team ran workshops for all the demonstrators. During the workshops the demonstrators were briefed on simulation learning objectives, and were given the opportunity to pre-run the scenarios. The learning objectives included: (a) to understand the physiological regulation of heart rate, blood pressure and breathing rate, (b) to identify the cause, developmental process and consequences of the presenting disease, (c) to recognize the classical symptoms of the emergency situation within the case context, (d) to perform the essential examinations to diagnose the specific disease, (e) to gain knowledge of the principles underlying the medical treatment for this emergency, and (f) to master the skills to perform blood pressure, pulse, and ECG measurements on each other.

From 2012, second and third year undergraduate nursing students who had prerequisite level of medical knowledge and clinical experience were employed to be the voice of the 'patients'. Mentored by a team member, nursing students communicated with the science students via the manikins from a control room (with one-way glass). These 'patients' engaged the science students in conversations and through their advanced nursing and medical knowledge, were able to relate to the case and quickly prompt the participants as required. Questions from the 'patients' were pre-determined but personalized according to the personality of the individual role-player. Impromptu dialogue was possible dependent on the interactions with the 'patient' by the science students.

Data analysis

Each questionnaire response was tallied to determine the extent to which the science students agreed or disagreed with each statement in each year group. This number was converted into a percentage of the total number of students in the year group to allow for comparison between year groups. The consensus of each statement was compared between the three cohorts from each year to determine consistencies and trends over time. Free text comments were analyzed using a qualitative, thematic approach.

Results

1. Student feedback on learning experience

The results of the evaluation are represented in Table 3. The response rates for each year were 53.2% in 2011, 89.8% in 2012, and 76.1% in 2013. Among the different student cohorts there was overwhelming support for the simulations as a means of achieving a better understanding of the pathophysiology taught in the lectures. Students felt that the simulations were easy to undertake and they welcomed a greater use of technology in the course. They also strongly expressed that the simulation provided them with an experience akin to working as a health professional. One unexpected result was that across the years of the study the cohorts were fairly evenly divided regarding their concern for the 'patient' (*cf* the responses over the three years for question 8).

Free text responses from students were mostly positive and constructive. Of the students who provided comments, which was less than 40%, responses ranged from a few words to complete sentences (24 in 2011, 48 in 2012, and 51 in 2013). The nature of these comments differed between years, however words and phrases including 'helpful', 'enjoyable', 'helped them to understand the concepts' and good 'experience' were common. Another common theme among student comments related to a sense that the simulations enhanced their learning by embedding the teaching in an authentic setting,

- *It makes the process of learning more interesting and engaging, really does capture a "real-life experience" as in a hospital setting.*
- *It demonstrated how theoretical knowledge is applied in a hospital setting.*
- *I think they help by putting you in a real situation with patients. It's very interesting since you usually don't get the opportunity to work with manikins, and it is very exciting. I'd rather more simulation classes than theoretical classes.*
- *I find it easier to learn/retain information from practical sessions. Definitely makes it more fun.*

Provision of lectures and pre-laboratory questions followed by the simulation session was judged to represent a flipped learning approach which was recognised by students.

- *It was really good to be able to apply knowledge instead of just remembering as assortment of facts. I can remember things like normal heart rate, blood pressure, etc, off by heart now.*
- *Was really beneficial to apply the knowledge I had gained in lectures to physical/practical experience.*

In addition to application of discipline knowledge, it was thought that the simulations would also contribute to development of communication skills both between students as well as with the 'patient'. Notable comments from the students in relation to this aspect included:

- *We learnt how to interact with a patient and how to obtain patient history by asking the patient questions.*
- *What texts are important when a patient is brought into a hospital? [The simulation offers] an idea of what questions to ask a patient. And the symptoms that are vital for a diagnosis*

Students also commented on the positive support provided by the demonstrators:

- *The passion from my demonstrators really encouraged me to participate and take an active role in my classes.*
- *I liked using the nursing* manikins *in this subject and that learning environment of the demonstrator shooting questions at students. It made me prepare and learn material before the demonstration, which makes me a better student.*
- *Demonstrators really helpful, answered questions and allowed plenty of time to learn.*

2. Demonstrator feedback on student learning

Feedback in the form of emails from the demonstrators suggested an increased level of student's engagement as well.

- *The sessions were guided well by the students who were most comfortable with engaging.*
- *Part of my focus throughout the day was prompting responses from those who were less inclined to be involved.*
- *I found that my role in them changed a lot between the first and second sessions – I was able to stand back and observe the students rather than feeling like I was there to guide the session.*

3. Learning outcomes

We have reviewed the mark distribution in 2010 (prior to implementing the simulation practical class) and for the study period 2011-2013 (Figure 1). The results indicate a significant shift from a *pass* grade (50-64) towards higher grades and mark ranges (75-84, and >85), comparing 2010 to the 2011-2013 time period. In 2010, nearly 50% students were in the *pass* range (50-64), while only two students achieved an overall score >85. This may reflect the difficulties for the Science students to understand the concept of pathophysiology through the teaching and learning strategies in place at that time. In 2011-2013, the marks moved towards a bell curve distribution with double the rate of students attaining a *distinction* grade (75-84) and a higher number of students in the *high distinction* category (>85). On the lower end of the distribution, the *fail* rate was also halved in

2011-2013 period compared with 2010 results. The distribution of marks and grades was relatively consistent across the 2011-2013 period.

Discussion

This paper reports on the experiences and success of using simulation in motivating and encouraging science students to learn about human diseases. This has not been previously reported in the literature.

Simulation as a training strategy has been used within health, aviation and military contexts for decades. Adoption of more simulation activities within healthcare has been influenced by advances in the technological capabilities of manikins and driven by patient safety agendas (4, 9, 12, 13). When planned and delivered appropriately, participant engagement, learning and reflection on practice is heightened more so than traditional learning formats. At a minimum, the contextual nature of a scenario experienced within life-like settings allows participants to act out what they know and learn from errors without consequences to the 'patient', in essence enabling experiential learning within a community of practice (9). Benefits for future practice include: learning how to work in teams, awareness of effective communication strategies and appreciating the holism of practice (9, 11).

The successful use and incorporation of a range of simulation strategies within the training of health professions encouraged us to examine how the patient cases used to teach pathophysiology to Science students could 'come alive' in the simulation labs. Students prepared for the session through lecture and online content, and then in groups stepped through the patient cases guided by the science-trained demonstrators and by interacting with the 'patient'. These sessions were delivered within the Faculty of Health simulation laboratories which are modelled on hospital wards and so students could appreciate the hospital environment and patient experience within the scenario. In communicating with the 'patient', students were able to respond verbally and through touch, additionally appreciating the 'patient's' experience of being ill in hospital. Before this approach, students were traditionally trained to identify pathological conditions by reading through printed text in a manual, thus relying heavily on their imagination, which is difficult for someone who has never dealt with a patient in the context of a health professional. It was felt that the latter approach favoured a surface approach to learning by students simply memorising the information without adequate context.

Simulations are problem-based tools thought to encourage students to learn through responding to immediate situations, providing a practical alternative to paper-based case studies. This PBL approach is believed to increase students' knowledge efficiently and to assist in developing problem-solving skills (2, 5, 14). The increasing sophistication of the manikins enables students to perform all manner of clinical procedures. Through practicing physiological assessment (taking pulses, blood pressure) on each other or the manikins, students assumed health professional roles. Bedside monitors, oxygen masks, intravenous fluids and additional moulage e.g. 'coffee ground vomit' contributed to the authenticity of the patient scenarios. During the simulation scenario, representing the stomach bleed with the 'patient' feeling *dizzy and sick*, appropriate vocalisations and sounds were emitted from the manikin and students responded by frantically offering a vomit bag.

In students having more than one simulation session, there was more opportunity to reinforce the importance of so called 'soft skills' such as: leadership, teamwork, professional skills, problem solving and decision making, and caring for people in vulnerable situations. In the first simulation class, the demonstrators played a critical role in the briefing process and orientation to the environment, and facilitating a change in approach to learning. Rather than students passively being questioned by the demonstrators, the shift in expectation was to active inquiry and physical examinations on the patients to obtain useful information relevant to the situation at hand. As such, at the commencement of the second simulation class, demonstrators only gave a brief introduction of the 'patient' and reasons for coming to hospital. One student in each group took over the leadership role to perform further verbal enquiry and led discussions with the other team members. Active discussion undertaken in response to a clinical problem between the students facilitated by the demonstrators encouraged critical thinking for problem solving (7). This contrasted with the predominant didactic delivery of conventional lectures which only allows limited interaction between the teacher and students, while any opportunity for group discussions is equally difficult (2). Thus a PBL approach within simulation practical classes focuses learning through hands on application, connecting students' theoretical knowledge with opportunities to develop contextually relevant problem solving skills (2, 14).

Such learning experiences can also promote a better understanding of the knowledge behind the case study, which is reflected by the significant shift in students' mark distributions from a predominance of *pass* grades towards *distinction* and *high distinction* grades. There is likely some influence on these changes due to implementing the simulation strategies, that is using an authentic setting where students were able to apply existing knowledge in 'real life' situations. Note that participants were all undergraduate Science students who in general were less likely to be motivated to learn medical knowledge compared with medical students. Therefore, we believe that simulation is an effective approach in motivating Science students to learn the different concepts of human diseases.

This novel approach also induced a significant role change for the demonstrators to one facilitating learning as students took on more active roles, with the demonstrators only giving advice or direction as required. Coaching and modelling were techniques used by the simulation team to assist demonstrators to deliver enquiry-based and experiential learning modes within the simulations rather than didactic approaches. Refreshers on these techniques have been provided each year to ensure an equitable student experience across classes.

Problem-based learning (PBL) is typified as a time-efficient and, thus, more effective educational model (7). However, the introduction of a PBL-style simulation with a 'patient' is not without its difficulties. For example teaching PBL to large groups of students (more than 100) is constrained by timetables and availability of laboratory spaces (14). Also PBL is resource-intensive in terms of staff and time spent teaching (2). In the case of the current approach there is the additional demand for access to high fidelity manikins to make the experience as authentic as possible. Training sessions provided to the demonstrators, as well as to academic staff/nursing students who played the manikin voice, prior to the class were also essential. In the face of these challenges we have successfully engaged over 200 students in simulation sessions in one day. This suggests simulation is scalable and able to be implemented in the study of the physiology of disease despite challenges in rigid timetabling, and resources to maximise student interaction. However, it is still worth noting that a gap exists between the reality and the simulation laboratory experience regardless of how authentic it is. This is reflected by Question 8 'what if the 'patient' deteriorates due to wrong medical decision', where only half of the students had a sense of responsibility to keep their patient 'alive'.

Limitations

The use of questionnaires in this study provided a practical methodological tool for collecting a large sample of data. The principal limitation is that they represent a snap-shot of the student experience and rely heavily upon the quality of responses and researchers' interpretations. Inclusion of Likert-style questions does however provide some level of objectivity. Another limitation is that these survey questions were self-reported evaluations of student learning which offer insights but are open to bias compared with more objective measures that is, students' grades. Although an improvement in grades were seen following the introduction of this intervention, specific causations could not be attributed to the simulation approach as other aspects of learning contribute to overall results. These potential limitations of measuring 'impact' are the focus of healthcare simulation groups globally; further, some elements of learning and practice are difficult to quantify and need to be illuminated through qualitative or mixed methods approaches.

Future directions

This initiative, to offer an authentic learning environment to improve the understanding of pathophysiological concepts by applying it in real-life scenarios, is now incorporated into ongoing curricula in Human Pathophysiology education. An authentic assessment to examine 'soft skill' sets, such as group collaboration, communication and decision making will be ideal to provide further evidence on such learning outcomes.

In conclusion, we found that using interactive learning approaches (e.g., role playing, flipped learning, enquiry based learning) led to an enhanced student experience of learning pathophysiology when compared to that of a paper-based teaching strategy. With the resources available and strategic planning and management, we were able to deliver this teaching approach consistently to a large size class over several years.

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Figure captions

Figure 1: Students' aggregated mark distribution and mark range before (2010) and during the simulation pilot phase (2011-2013).

Tables

Table 1: Student activities and student numbers in each time slot within a typical two-hour practical session.

Class time	Manikin consultation (simulation)	Rehearsal of physical assessment skills
9-9:30	Group 1	Group 2
9:30-10:00	Group 2	Group 1
10:00-10:30	Group 3	Group 4
10:30-11:00	Group 4	Group 3

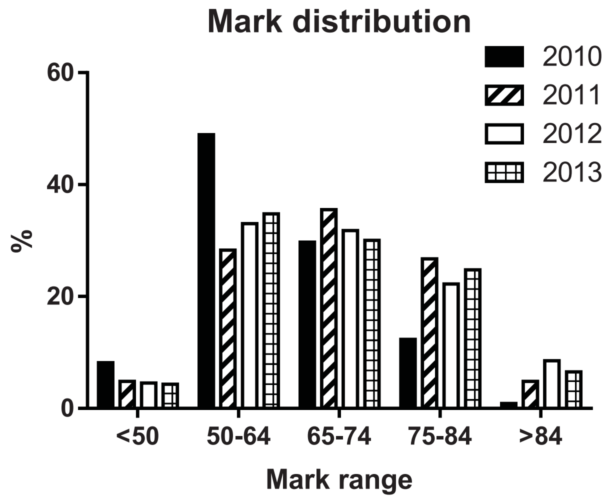
Table 2: Question clusters and related areas of analysis.

Question number	Aspects of the student experience tested
1, 2, 3	Understanding of theory
4, 5,7, 8, 9	Comfort level with simulation
11	Idea of hospital setting
6, 9, 12	Enjoyment and approval of the simulations
7, 10, 12	Approval level of how the simulations are incorporated into the course
3, 10	Offers some idea of the impact of this new initiative for ongoing use and integration into the curricula

Table 3: Summary of simulation evaluation items between 2011-2013.

		Number (Proportion)		
Item	**Students' opinion**	**2011 (N=100)**	**2012 (N=158)**	**2013 (N=175)**
1. I understand what the simulations were supposed to represent	Agree/Strongly Agree	89 (89%)	150 (95%)	156 (89%)
2. Simulation helped the understanding of the diseases	Agree/Strongly Agree	96 (96%)	155 (98%)	158 (90%)
3. Using simulation is a better way to improve learning compared with a paper based case study	Agree/Strongly Agree	97 (97%)	155 (98%)	166 (95%)
4. The simulations were easy to perform	Agree/Strongly Agree	85 (85%)	150 (95%)	147 (84%)
5. The level and clinical aspect are proper for a science student and the tasks are within their capabilities	Agree/Strongly Agree	87 (87%)	150 (95%)	158 (90%)
6. The manikin simulation is a good experience	Agree/Strongly Agree	100 (100%)	149 (94%)	154 (88%)
7. I would recommend the simulation class to the peers	Agree/Strongly Agree	95 (95%)	134 (89%)	158 (90%)
8. I would feel overwhelmed if the manikin deteriorated and died due to wrong diagnosis or intervention	Disagree/Strongly Disagree	49 (49%)	88 (56%)	75 (43%)
9. Simulations were a waste of time	Disagree/Strongly Disagree	95 (95%)	149 (94%)	161 (92%)
10. Having more than one simulation class during the semester would be good for the learning experience	Agree/Strongly Agree	85 (85%)	131 (83%)	159 (91%)
11. The simulation gave me some idea of a hospital setting	Agree/Strongly Agree	95 (95%)	152 (96%)	158 (90%)
12. Although I may not become a health professional in the future, the simulation is a good experience	Agree/Strongly Agree	100 (100%)	156 (99%)	154 (88%)

Figure 1



	2010 (n)	**2011 (n)**	**2012 (n)**	**2013 (n)**
Total enrolment	219	187	176	230
85-100 (high distinction)	2	9	15	15
75-84 (distinction)	27	50	39	57
65-74 (credit)	65	66	56	68
50-64 (pass)	107	53	58	80
<50 (fail)	18	9	8	10