Technological Innovation in Nursing Education and Practice

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The unprecedented developments in education and information technology in the last decades have led to a metamorphosis in the processes and practices of nursing education. Nursing education has undergone revolutionary shifts in teaching and learning strategies by incorporating simulation and virtual reality to prepare nursing students for clinical practice.

This volume examines the use of simulation and virtual reality in nursing education and practice via reviews, exploratory papers and research studies. It demonstrates how simulation and virtual reality have changed nursing education structurally and, at the same time, enhanced the cognitive development and clinical practice skills of nursing students.

Gill, Baljit Kaur
Tsang Yat Kwan, Alan
Using Human Patient Simulation (HPS) in Nursing Education: A Summative Review

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Abstract

Human patient simulation (HPS) has been widely used in nursing education. An increase in the complexity of care and the rights of patients have resulted in patients’ reluctance to allow nursing student to practise nursing skills. Also, hospital policy has set an unfavourable learning environment for nursing students to practise their clinical skills. HPS provides a realistic clinical environment for the nursing students to practise without endangering patients’ lives. Abundant evidence has been published using HPS in nursing education. A summative review was carried out to evaluate the use of HPS in nursing education and its impact on nursing students and educators. HPS helps to improve nursing students’ skills, knowledge, critical thinking, self-efficacy and communication. It also helps the educators to develop a safe learning environment and a good preparation for nursing students’ clinical placement. However, HPS has limitation for learning enhancement due to there being insufficient instructors, misleading observations, a financial burden and the heavy workload of educators.

Keywords: human patient simulation, nursing education, nursing student, educators
Introduction

In the 20th century, the application of information technology in the medical industry is common. The technological equipment in the health care sectors is so indispensable that technological nursing education has become a general trend in global settings. The increased demand for multifaceted technological equipment in healthcare environments has led to the development of simulation teaching strategies that promote interactive hands-on learning environments (Nehring & Lashley, 2010; Starkweather & Kardong-Edgren, 2008). Consequently, there is no longer only the traditional lecture-based learning, but also simulation training and laboratory sessions in nursing education.

Simulation is defined as a situation in which a particular set of conditions is created artificially in order to study or introduce experience of things that may happen in real life; or it refers to the artificial representation of a real-world process to achieve educational goals via experimental learning (Krishnan, Keloth, & Ubedulla, 2017).

Human patient simulation (HPS) is an active learning approach. Generally, it can be classified into two types, which are low-fidelity and high-fidelity. As Kaur (2017) points out “The low-fidelity human patient simulator is commonly used for teaching fundamental nursing skills with which a nursing student should be equipped. For examples, taking the respiratory rate and breathing sounds through monitoring the rise and fall of the chest on the simulator, assessing pulse and heart rate by placing a stethoscope on the heart location on the simulator …)” (p. 30). The high-fidelity human patient simulator is a more sophisticated, technologically advanced mannequin, which is controlled by the use of computer software. Different health scenarios are first pre-programmed in the HPS programmes. It is capable of mimicking health conditions and healthcare environments as in a hospital setting (Krishnan et al., 2017). Not only can the simulator produce pulse, lung and bowel sounds, but also clinical data such as the blood pressure, respiratory rate, oxygen saturation and heart rate; and the rhythm of the simulators can be shown on the patient’s bedside monitor. It can also speak and interact like an actual patient through the instructor’s control in the simulation control room (Kaur, 2017).

Human patient simulation (HPS) has been implemented for as long as simulation in medical education has been used to provide opportunities for the rehearsal of basic skills (Krishnan et al., 2017). HPS provides critical learning experience in simulated environments, as well as in traditional clinical practice, and can be a place for reflection as an educative method. Low-fidelity and high-fidelity simulation labs provide nursing students with fundamental nursing skills and case scenarios. They are intended to replicate situations commonly found in clinical practice, and simulation labs address aspects of conduct in nursing, such as skill attainment, critical thinking, and professional confidence driven by learner needs (Diener & Hobbs, 2012).

This summative review discusses the pros and cons of HPS in nursing education from the perspectives of nursing students and educators.
Methods
A systematic search was performed using the Boolean search terms “human patient simulation”, “nursing students”, “educators” and “nursing education”, and papers published in the last ten years were retrieved from ProQuest and EBSCO.

Results
The Advantages of Human Patient Simulation: Nursing Students’ View

Effective skill-based practice
Human patient simulation (HPS) experience reflects reality – referred to as “fidelity” in clinical settings (Ober, 2009). According to Bolesta and Chmil’s findings (2014), the introduction of HPS into a School of Nursing provides an opportunity for students to develop inter-professional education and skill-based practice. The skill-based objective aims to develop effective collaboration among student health professionals from similar and divergent fields to optimize patient care. Bray, Schwartz, Odegard, Hammer and Seybert (2011) proposed simulation-based learning as an effective approach for preventing medication errors. According to Bray et al., a class with high-fidelity functions simulating patients in healthcare scenarios raises students’ ability to manage their treatment and practice in a clinic setting in the future. In that study, the majority of the participants agreed or strongly agreed that, in the simulation, they learned things that would be useful in practice and noted that HPS improved their learning of clinical patient care more than standardized traditional lectures. Moreover, in the same study, the nursing staff who attended a simulation class showed a significant reduction in medication error rates in the cardiac intensive care unit from 30.8% to 4%, unlike those who had only completed traditional classroom lecture-based education about medication errors and error rates (Bray et al., 2011). This shows that the simulation class can also provide an opportunity for nursing students to become more familiar with the clinical skills and minimize errors.

Conceptualizing nursing knowledge
Human patient simulation (HPS) also helps to conceptualize the nursing knowledge of the nursing students. Ordinary lectures are important for generating the basic nursing knowledge for students, while high fidelity simulation classes can help them to conceptualize the nursing knowledge. Also, the nursing knowledge should have component-based aspects that are integrated into students’ critical thinking with learned aspects of knowledge components, together with the clinical skill practices with think-on-action and think-in-action that can be reflected by using simulation (Li, 2016). In addition, “Knowledge about the specific patient focus increases after the simulation activity” (Thidemann & Söderhamn, 2013, p. 1599). When the students learn the skills from lectures and practise more on the simulators, they become more familiar with those skills before carrying them out in the real situation. Therefore, HPS can provide the nursing knowledge and skills for the nursing students to conceptualize and practice after learning from the ordinary lectures.
**Enhancing critical thinking and resilience**

Human patient simulation (HPS) also improves resilience in the clinical setting. Nurse should be capable of problem-solving, utilizing the resources and acting as a team (HKNC, 2012). HPS is beneficial for managing emergencies and enhances students’ resilience which is one of the most important characteristics with which a nurse should be equipped. Every simulation scenario is different and focuses on various targets, which aim to demonstrate the diversity of cases in clinical practice as long as it covers the practical skills (Nuraini et. al, 2015). If the students can practise more via HPS, their resilience and critical thinking can be increased. Jeffries (2007) suggested that the dynamic environment in HPS learning promotes learning through the kinesthetic, tactile, visual, and auditory senses of nursing students, which can be useful for increasing students’ critical thinking. Alfaro-LeFevre (2004) has “strongly advocated for the use of case studies or scenarios to teach nurses how to critically think, contending that as nurses analyze the situation of a case study they will learn the type of deductive reasoning skills that they will need to become a better practitioner” (p. 18). The HPS scenario can develop the essential critical thinking and reasoning skills of nursing students as they can learn the most effective ways of solving patients’ problems. Kinesthetic learning strengthens students’ technical skills, decision-making and critical thinking (Jeffries, 2005, 2007). These elements are important for nursing students as they may face different situations in the future, such as cardiac arrest of a patient who needs resuscitation. They can learn how to manage the situation through HPS and enhance their critical thinking and resilience.

**Strengthening self-efficacy**

Human patient simulation (HPS) can improve the self-efficacy of nursing students. Nurses should have good self-efficacy and confidence in managing every procedure. It is undeniable that self-efficacy affects nurses’ performance somehow, despite the rich knowledge and clinical skills they have. In Brewer’s study (2011), all the students reported that their confidence in managing the care of an acute patient emergency was strengthened in HPS. HPS always includes reflective sessions, which allow educators to evaluate the performance of students (Jeffries, 2007). Students get opinions, suggestions and appraisals that boost their confidence within the process of evaluation, which also helps them to consolidate what they have learned.

**Effective communication**

Nurse should also be capable of clear and effective communication (HKNC, 2012). Human patient simulation (HPS) provides a group environment and offers an opportunity for students to work as a team. It can also act in similar and divergent fields to develop effective collaboration among student health professionals to optimize patient care (i.e. the collaboration among nursing students and medical students) (Bolesta & Chmil, 2014). HPS is more than a skill-based practice as it introduces a similar situation for nursing students to work with different professionals to give treatment for
cases as in reality. Students also learn how to communicate with patients and family members with or without medical jargon via the roles they play in the simulation (Jeffries, 2007). Moreover, Brewer (2011) stated that the simulation laboratory is a controlled environment free from distraction and interruptions. Students may interact as a group, promoting teamwork as they would in the workplace. The HPS setting provides a working situation for student nurses which they can adapt to their workplace in the clinical setting.

**The Limitations of Human Patient Simulation: Nursing Students’ View**

**Ineffective learning due to insufficient instruction**

Insufficient instruction can affect nursing students’ learning. Human patient simulation (HPS) emphasizes instruction and immediate feedback given by the instructors. In simulating real clinical cases, adequate instruction should be given on every move of the nursing students as the simulator will not give responses spontaneously. In the guidelines for HPS in foreign nursing schools, an instructor to learner ratio of 1 to 3–4 is considered to be ideal, but this is not feasible in the current medical curriculum (Krishnan et al., 2017). Immediate feedback following simulation experiences is crucial for students’ learning (Diener & Hobbs, 2012). A lack of instructors has become a barrier to HPS learning as students have commented that they always feel a sense of loss in HPS sessions. Therefore, insufficient instruction may cause ineffective learning by students.

**Misleading observation skills as a result of the limitation of simulators**

Observing patients’ signs and symptoms is a key part of learning clinical skills. HPS overlooks the patients’ physical signs due to a limitation in the design of the model. The model’s design should be emphasized as how many of the features a model covers is the key to clinical learning in HPS (Li, 2016). The learning of HPS is overly reliant on the simulator, and if the design of the simulated model is old or poor, this has a direct impact on learning, causing false learning. In such cases, the simulator design may miss certain types of physical signs, such as skin colour. Consequently, students claimed that it was easy for them to overlook patients’ signs and symptom in the real situation (Ober, 2009). Therefore, the limitations of simulators may mislead students in their development of observation and inquiry skills in the HPS learning process.

**Misleading transpersonal caring as a result of task-oriented simulation**

Nursing students lack affordances for affective and transpersonal aspects of patient care (Delmar, 2012; Diener & Hobbs, 2012). Sessions of HPS always tend to aim at demonstrating task-oriented procedures and practical skills in general schools of nursing; and these sessions always have a standard to justify the performance of students by the assessment of their clinical skills. In this mode of clinical practice, students have said that they intend to adopt the standardized treatment in real situations as long as their nursing work involves doing only what is absolutely necessary – which is sometimes called a “technical” approach (Delmar, 2012). According to the relevant studies, the risk
of ignoring or not paying attention to the human dimensions of suffering, anxiety, grief or hope increases in HPS education (Delmar, 2012, Locsin, 2005). For example, students require ethical thinking in their engagement with the real situation in a clinical settings, as those who lack this can cause patient fatalities. In order to provide comprehensive care for patients, transpersonal caring has been proposed, in which caring should be distinctive and dynamic, with professional knowledge provided by nurses (Dunnington, 2015). Likewise, routine procedures and treatments can turn into pure technique which becomes the student nurses’ sole focus of attention, in spite of considering the whole picture of nursing care (Delmar, 2012). Simulation-based learning may also encourage shortcuts, such as omitting patient consent and safety procedures (Krishnan et al., 2017). Students have commented that studying with the use of simulators can mislead their ethical thinking as it is difficult to treat the simulator as a real person, thus reducing their alertness to protecting the privacy of patients or the sense of crisis in protecting them (Ober, 2009).

The Advantages of Human Patient Simulation: Educators’ View

Developing a safe, positive attitude and a comfortable learning environment

Unlike the traditional lecture-based curricula which involve a teacher-centred teaching strategy, HPS is an active learning style based on student-centredness, in which educators plays the role of facilitators and observers (Jeffries, 2005). Through HPS, educators can help nurses to develop a positive attitude and build up self-confidence. The simulated environment is designed to allow learning and re-learning as often as required to correct mistakes (Lateef, 2010). In such a controlled and predictable environment, with monitoring from instructors and educators, students can practise steps and skills over and over again as well as having the chance to apply knowledge and make decisions without any fear of causing harm to a patient (Jeffries, 2005). HPS creates an active learning atmosphere, as learning without risk can reduce students’ feelings of anxiety and the educators’ burden and stress. It therefore allows teachers and students to focus their attention on the aspects of the interaction which are most relevant for the training needs at that time. Teachers can provide immediate feedback and discussion on students’ performance with the use of HPS, which can boost their confidence, allow them to make mistakes safely, and learn the implications of failure (Guise, Chambers, & Valimaki, 2012). There would be greater efficiency in students’ problem-solving if teacher could answer questions immediately in lectures (Jeffries, 2005). Therefore, through the implementation of HPS, students have better problem-solving skills than in traditional lectures because of better teacher-student interaction.

Pre-set scenarios

With the introduction of HPS in nursing education, pre-set scenarios and training workshops are available in the market, which enables teachers to develop scenario-based format teaching materials to be delivered via simulation. Since HPS can simulate physiological responses such as electrocardiogram patterns, pupil condition,
chest movement, heart sounds, lung sounds, bowel sounds and verbal cues, it helps teachers to teach fundamental concepts and basic principles, as well as demonstrate things that seem abstract and hard to describe in words and drawings. HPS enables the practice of various nursing skills. For example, a simulator with the structure of the upper gastrointestinal tract can be used for demonstrating and practising nasogastric tube insertion and nasogastric tube feeding. HPS can also be programmed to present a large variety of interactive clinical scenarios such as an acute asthmatic attack and hypovolemic shock. Since the simulators are able to provide responses and feedback, students can role-play patients, nurses and observers in the case studies. It is valuable in developing students’ competency in communication skills while performing interviews, health assessments and counselling (Decker, Sportsman, Puetz, & Billings, 2008). With the implementation of HPS, the skill performance of students can be assessed by individual skill performance tests and group-based skill performance during simulation examinations. Teachers can evaluate students’ synthesis of knowledge, practical skills, teamwork and communication skills to obtain a comprehensive assessment of their ability.

*Preparation for clinical placement*

Most nursing schools and universities practise combining HPS and clinical placement to promote learning. In clinical experience, educators act as mentors in a real clinical setting to guide and support students in practising nursing skills; deal with unexpected situations; create therapeutic relationships; and socialize professionally. Before that, human patient simulation takes place as preparation for clinical placement, offering teachers valuable opportunities to work with students in a lifelike environment and acquire the necessary skills. HPS is indispensable for teachers to facilitate a shared learning platform for students in learning to respond to real-life cases, which maximize students’ competency so that they perform better in (Larue, Pepin, & Allard, 2015). On other hand, HPS is not only for teaching technical skills to nursing students, but also for developing new clinical skills in existing nursing staff. Bremner, Aduddell, Bennett and VanGeest (2006) show that practice using HPS can reduce potentially life-threatening medical errors in clinical performance by novice nursing staff. Also, educators can identify the weakness of staff and provide some immediate recommendations and improvement methods for them. It therefore enhances the clinical performance of nurses and provides quality and safe nursing care for the public.

**The Limitations of Human Patient Simulation: Educators’ View**

*Financial burden*

The financial burden is the major challenge in implementing HPS in nursing education, whether in universities, nursing schools or hospitals. The setting up and maintenance of simulation centre laboratories can be extremely expensive (Bremner et al., 2006). As we all know, for the material resources to simulate a realistic ward environment, there is a need for laboratory space and the provision of enough simulators and medical
equipment for students to practise. The cost includes equipment such as simulators and their computer system, videorecording equipment, and audio-visual equipment; venue-related work, such as design and fitting-out; medical equipment, such as hospital beds, gas and vacuum pumping, electrocardiographic machines, infusion pumps, medicine trolleys and wheelchairs; and medical supplies, such as sterile supplies, catheters, medicines, intravenous fluids, lotions and bandages (Lee, Lee, Wong, Tsang, & Li, 2010). For human resources, educators need to have satisfactory trainings on the manipulation of simulation and teaching strategies. Also, the implementation of simulation sometimes requires additional faculty or staff to assist with teaching or provide technical backup, so the number of staff could be more than for traditional lectures. The staffing cost therefore includes the training cost such as simulation workshops for faculty members and purchasing teaching materials; and salaries for faculties and technicians.

**Heavy workload of educators**

As mentioned previously, current nursing education involves the combination of theoretical lectures, HPS and clinical placements to promote learning. Educators in nursing schools, universities and hospitals not only have to prepare lecture notes, teach in lectures and tutorials, and guide and examine students in clinical placement, but also need to do administrative work. The implementation of HPS increases educators’ workload to some extent, because they have to spend time on getting satisfactory training on learning and revising the manipulation of different models of simulators and simulation designs, and preparing materials for scenario-based teaching (Bremner et al., 2006). In addition, simulation involves practising small-class teaching due to limited space and simulation materials. Only a small number of students can participate in one session of simulation at one time. Therefore, educators have to spend time in designing a specific timetable for the simulation sessions to satisfy a large number of students. Double the time is needed for preparing the simulation materials and repeating the same topic for all groups, compared with traditional mass lectures. Educators want to do the best they can for their students, but they have a heavy workload which may affect the quality of their teaching.

**Conclusion**

To conclude, the use of human patient simulation (HPS) is already becoming an essential element in nursing education which directly affects the clinical performance of nursing students, educators and novice staff. Through HPS, nursing students and novice staff gain new clinical skills, enhance their critical thinking and resilience, and strengthen their self-efficacy and communication skills; and educators develop a safe, positive attitude and a comfortable learning environment, and implement scenarios. This improves the quality of clinical performance. Although HPS has many advantages for nursing education, it has some disadvantages that should not be ignored, such as the increasing workload of staff and misleading observation skills due to the limitations of simulators, which may obstruct further development in nursing education. Therefore –
reflecting on the real situation – for further improvement, the transferability and increase in the applications of either low-fidelity or high-fidelity patient simulators for different aspects of nursing are necessary.

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References


The High-Fidelity Human-Patient Simulation: A Concept Analysis

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Abstract

The advancement in computer technology has led to the development of sophisticated human-patient simulators which has resulted in a widespread acceptance and use of high-fidelity human-patient simulators in simulation laboratories in nursing education programmes (Norman, 2012). There is a wide range of publications on the application of, and research on, high-fidelity human-patient simulation (HFPS), but there is no concrete definition of HFPS. Different texts and research studies have used different terms and levels of fidelity in interpreting HFPS. This article has adopted Walker and Avant’s (2011) concept analysis strategies to discuss what HFPS is. In this paper, HFPS is defined as “the use of computerized human look-alike mannequins to provide a high level of realism and interactivity between the mannequins and users.” It helps nursing students to apply the acquired knowledge to manage a patient and/or a clinical situation with confidence in a realistic controlled environment.

Keywords: high-fidelity human-patient simulation
Introduction

In the past decades, the use of simulation has been an integral part of nursing education (Gates, Parr, & Hughen, 2012). High-fidelity human-patient simulation (HFPS) provides standardized types of patients and presents the progression of the disease process in them during their hospitalization, which offers nursing students an anatomically correct human substitute and allows them to observe the sequelae of care (ibid.).

There is no consensus on the definition of the concept of HSPS, a term involving complex ideas. The literature includes debate on the conceptual understanding of high-fidelity patient simulation. The terminology in this area – including HFPS, simulation-based learning and high-fidelity simulation – is used interchangeably or as a personal preference because of the lack of a clear definition (Cant & Cooper, 2010; Kowitlawakul, Chow, Salam, & Ignacio, 2015; Richardson & Claman, 2014).

In pursuing HFPS for nursing students, difficulties have been recognized and experienced by the instructors and students in nursing schools and university (Shearer, 2013). For example, although there are tools to evaluate the characteristics of simulation design, the concept of fidelity is not well-defined. The construct validity cannot be established to test the validity of the current instruments. It is difficult to compare and choose the HFPS as a teaching tool (Paige & Morin, 2013). It is therefore essential to clarify the impact of HFPS in developing nursing students’ confidence, decision-making and patient care skills (Shearer, 2013). This concept analysis aims to clarify the definition of HFPS to help in developing future study tools and enhance the quality of simulation training for nursing students.

Method

In this paper, the Walker and Avant Framework of Concept Analysis is adopted, which has seven steps. In the first step, the definitions of HFPS is explored; in the second step, the literature is reviewed to analyse and integrate the characteristics of HFPS; and in the third step, model, borderline, related, contrary and illegitimate cases are illustrated with the use of the characteristics analysed. In the fourth and fifth steps, the antecedents and consequences related to this concept are discussed. In the sixth step, the empirical references are explored and, in the final step, the implications for nursing research are identified.

Results

Step 1: Definitions of HFPS

Dictionary definition of HFPS

HFPS does not appear in dictionaries as a single term. A dictionary search was carried out separately for ‘human’, ‘patient’ and ‘simulation’. The Oxford Dictionaries (2018) defines ‘human’ as “relating to or characteristic of people or human beings; ‘patient’ as “a person receiving or registered to receive medical treatment”; and ‘simulation’ as “the production of a computer model of something, especially for the purpose of
study”. ‘High-fidelity’ and ‘human-patient simulation’ can also be found separately. According to the Oxford Dictionaries, high-fidelity is “the reproduction of sound with little distortion, giving a result very similar to the original” (ibid.) The Cobuild Advanced English Dictionary defines high-fidelity as “the use of electronic equipment to reproduce a sound or image with very little distortion or loss of quality” (Collins Dictionary, 2018). The Cambridge International Dictionary of English with Chinese translation defines ‘high-fidelity’ as “the production by electrical equipment of very good quality sound that is as similar as possible to the original sound” (Cambridge Dictionary, 2018). All these dictionary definitions of high-fidelity are related to using electrical equipment to produce good quality sound and/or images. On the other hand, ‘human-patient simulation’ can be found in only one dictionary. According to The Free Dictionary Medical Dictionary, ‘human-patient simulation’, which is an interchangeable term for ‘human-patient simulator’, is “a mannequin equipped with technologies that make it resemble and respond like a living person, used in health care education for role playing, skill building, and hands-on, active education” (The Free Dictionary, 2018).

**Literature definitions of HFPS**

Unlike in the dictionaries, both of the terms ‘HFPS’ and ‘high-fidelity patient simulators’ appear in the literature. Instead of giving an explicit definition of HFPS, McGarry, Cashin and Fowler (2014) indicated that high-fidelity represents a greater realism of the simulation while human-patient simulation represents electronically controlled mannequins with physiological responses. Cant and Cooper (2014) defined HFPS in terms as simple as the use of computerized mannequins to simulate real-life scenarios. Also, Dowie and Phillips (2011) described HFPS as a life-size and realistic-looking mannequin which is equipped with computer programmes so that it can respond to stimuli automatically and then mimic real-life scenarios. In the view of Smithburger, Kane-Gill, Kloet, Lohr and Seybert (2013), HFPS is a more than life-sized and computerized human mannequins which responds to real-life situations and can process human anatomical features such as breathing, blinking and talking. HFPS can interact and respond to users’ actions in a safe and controlled environment. Bradshaw and Hultquist (2017) stated that HFPS refers to the use of computerized simulators, virtual reality or standardized mannequins which are sophisticatedly realistic and able to provide a high level of interactivity and realism for the learners. Given these definitions, HFPS related to clinical practice could be defined as “any use of computerized simulators that are sophisticatedly realistic and able to provide a high level of interactivity and realism for the users”. The term ‘HFPS’ is used by physicians, nurses, and other healthcare professionals. Each profession defines HFPS as focusing on the level of sophisticated realism and interactivity of computerized simulators and the impact on its discipline.

**HFPS in nursing**

Recently, HFPS has been broadly used and become an essential strategy for learning clinical nursing in many nursing schools (Lewis, Strachan, & Smith, 2012; Yuan,
Williams, Fang, & Ye, 2012). With the use of sophisticated computerized mannequins, not only can cardiovascular features – such as heart sounds, palpable pulses and blood pressure – be generated, but also respiratory features – such as ventilation and breath sounds, and the vital signs such as SpO2 and electrocardiographic waveforms – can be displayed on a computer screen (Dahlstrom, 2011; Mitchell, 2012). Some spontaneous features, such as blinking and reactive pupils, augment the realism for students. In order to enhance the interactivity between the learners and mannequins, some modifiable physiological responses – such as the change of heart sounds, breath sounds and respiratory rates – can be controlled by instructors or be stimulated by users’ actions (Nehring, Ellis, & Lashley, 2013). A well-planned high-fidelity simulation can mimic high risk, complex and lifelike clinical situations, while providing a safe and controlled environment for students to practice their clinical skills, develop their clinical judgement and promote their confidence in a realistic situation without exposing patients to unnecessary risks (Parsh, 2010; Spooner, Hurst, & Khadra, 2012; Wright, Taekman, & Endsley, 2013). The work mentioned above suggests that the definition of HFPS within the nursing discipline should be along the following lines: “The use of computerized and life-sized mannequins with a complex electronic multisystem model that is able to provide a high level of realism by generating observable responses from the simulators and allowing users to interact with the mannequins as they would experience the actual situations in the clinical settings”.

### Step 2: Characteristics of HFPS

The literature review helped us to identify the characteristics of HFPS, which can be summarized into two key defining characteristics: the use of computerized mannequins and virtual simulation (interactivity and realism).

#### Use of computerized mannequins

Bailey defined the use of computerized mannequins as the computer software used to teach the anatomy and physiology of the human body, as well as to teach pathophysiology, pharmacology and clinical decision-making (as cited in Bradshaw & Hultquist, 2017). Similarly, Smithburger et al. (2013) defined the use of computerized mannequins as the computer programme that produces human physiologic functions – such as the changes in the respiratory rate, heart rate, blood pressure, bowel, heart and lung sounds, and even sweating and bleeding – in response to the students’ actions and medical treatment plan, in order to teach their physical examination and drug administration skills.

#### Virtual simulation (interactivity and realism)

According to the study by Meakim et al., HFPS was described as “the full scale computerized simulators, virtual reality or standardized patients that are extremely realistic and provide a high level of interactivity and realism for the learners” (as cited in Bradshaw & Hultquist, 2017, p. 245). Bailey also stated that the virtual simulation provides real-life scenarios for enhancing students’ ability to develop their knowledge,
communication and decision-making skills, and improving their learning (as cited in Bradshaw & Hultquist, 2017). We further describe the virtual simulation in terms of interactivity and realism.

Parsh (2010) described interactivity as the inner-relationship between the instructors and students. With the HFPS, students can raise more technical questions with the virtual simulation, while the instructors are able to give a holistic explanation and discuss pathophysiology thoroughly at the same time. As a result, students can formulate clinical decisions under the instructors’ guidance and supervision, enhance their confidence in clinical situations and boost their critical thinking skills. Furthermore, Smithburger et al. (2013) described the interactivity of HFPS as the inter-professional teamwork which is essential for offering holistic care to a patient with complex medical and social problems. Under the safe and controlled environment of the HFPS, students can practice discussing the patient care issues with other professionals, such as medical practitioners, physiotherapists and medical social workers. Through the interactivity of members of the interdisciplinary team, students are able to enhance the efficiency of their patient care with a full picture of the roles and responsibilities of different professions and better communication skills (ibid.)

For realism, Smithburger et al. (2013) described HFPS as the use of a life-sized simulator with the features of human anatomy to provide a real-life patient and situation for learning. Students can practice their nursing skills in the real-life scenarios created by instructors which they might encounter in future clinical practice, such as patient-family social issues and communication barriers. Similarly, Dowie and Phillips (2011) stated that the students can experience the realistic clinical situation under the supervision of their instructors with the use of HFPS, as the mannequins look realistic and life-sized. Also, Yuan et al. (2012) noted that HFPS provides an opportunity for students to learn and practice in a very realistic environment, as the simulators allow them to experience a situation as close to reality as possible in both psychological and engineering technology.

Step 3: Model case, borderline case, related case, contrary case and illegitimate case

Model case

Bradshaw and Hultquist (2017) illustrated a model case about respiratory assessment and nursing care using high-fidelity simulation that demonstrated all the defining characteristics of the concept. This case is described below.

A nursing student, Peter, participated in a simulation training session. He had to demonstrate nursing management on a SimMan (computerized mannequin) with respiratory disease. On arrival at the simulation laboratory, Peter was provided with the patient’s history and progress notes. In the simulation laboratory training, a life-sized SimMan was connected to a computer and operated by the instructor. The SimMan was programmed to show signs of moderate hypoxia which included rapid shallow
breathe, 92% oxyhaemoglobin saturation and rales on chest auscultation (realism). Peter assessed the patient’s condition and vital signs such as respiratory effort and lung auscultation, and provided appropriate nursing care which was oxygen therapy. After the implementation of oxygen therapy, the SimMan responded to Peter’s action. The breathing pattern returned to normal, with a respiratory rate of 16 per minute, and oxyhaemoglobin increased to 97%. After that, the instructor changed the computer programme to a condition where respiratory deterioration of the SimMan occurred. The SimMan exhibited signs of pneumonia, a decrease in lung compliance, and an increase in shunt fraction. The body temperature was increased with reduced tidal volume as well as changes in the heart rate and arterial blood gases (realism). Peter was asked to assemble the required equipment by making a clinical decision based on the data presented. He gathered the items, such as oro-pharyngeal airways and suction equipment. However, he lacked confidence in his decision and raised questions in the virtual situation. The instructor explained to him that the patient’s manifestation of ineffective airway clearance was due to increased sputum production and, therefore, the patient’s condition deteriorated even though oxygen therapy was provided (interactivity). The instructor also discussed the pathophysiology of pneumonia thoroughly at the same time. After that, Peter was able to formulate clinical decisions and implement suction under the instructor’s supervision. At the end of the session, Peter said that he had learned how to comprehensively assess a patient’s condition in a setting that resembled a ward. He felt more confident about his critical thinking and clinical skills.

In this case, the simulated patient demonstrated the characteristics of HFPS, which included a computerized mannequin, interactivity and realism. In the scenario, the life-sized SimMan showed human anatomical and physiological features which resembled a real-life patient (realism) – connected and controlled by the instructor through a computer programme (computerized mannequin) – and responded to nursing actions (computerized mannequin). During the learning process, Peter raised questions and the instructor provided a thorough explanation and discussed the pathophysiology (interactivity) of pneumonia. Finally, Peter successfully acquired knowledge about managing a patient with pneumonia with confidence in a realistic environment.

Borderline case

A borderline case demonstrates most critical attributes but not all of the defining attributes (Walker & Avant, 2011). An example of this case is described below.

As the model case, a SimMan was connected to a computer and operated by the instructor. In this setting, the SimMan showed signs of moderate hypoxia. A nursing student, Tom, participated in a simulation training session after learning the related knowledge in the classroom. He was required to demonstrate the use of the five stages of the nursing process on the SimMan with respiratory disease. Case notes with the patient’s history were provided to him. Tom assessed the patient’s condition, identified his medical and nursing problems and provided him with suitable nursing care. The
nursing action was oxygen therapy. After he implemented the oxygen therapy, the SimMan’s breathing pattern and oxyhaemoglobin saturation remained abnormal. The SimMan did not respond to Tom’s action. After that, the instructor adjusted the SimMan to a deterioration condition. The SimMan exhibited signs of pneumonia, decreased lung compliance, and increased shunt fraction and body temperature with reduced tidal volume as well as changes in the heart rate and arterial blood gases (realism). Tom assembled the required equipment to deal with the identified problems of the patient by his decision-making skill. Although Tom was uncertain whether his decision was correct, he was too embarrassed to ask the instructor. He continued his nursing actions on the patient, but a change in the physiologic variables and the effects of various therapeutic options could not be observed, despite his actions. The patient’s condition deteriorated finally because Tom chose the wrong nursing actions for him. As he was too embarrassed to ask questions, he just gained limited experience or knowledge after the simulation because there was no interactivity.

This case has many similarities to the model case, but the simulated patient did not demonstrate interactivity to be an HFPS. In this scenario, the life-sized SimMan demonstrated human anatomical and physiological features which resembled a real-life patient (realism), and was connected and could be manipulated by the instructor (computerized mannequin) but it did not respond to nursing actions by Tom. During the learning process, Tom felt too embarrassed to raise questions and did not ask the instructor for the best method to treat the patient. Therefore, Tom could only train some skills and acquired limited knowledge on managing a patient with pneumonia in a very realistic environment.

Related case

A related case shows the concept being analysed but does not contain all the defining attributes (Walker & Avant, 2011). An example of this case is given below.

Jane attended web-based simulation training to manage a patient suffering from pneumonia. She had to make clinical decisions and take nursing actions based on the background and medical history of the patient and the presenting signs and symptoms as shown on the screen. An instructor was present to control the simulation programme and manipulated the physiological responses of the patient according to the nursing actions of Jane and gave a real-time debriefing on her clinical decisions.

Jane’s case is related to computerized simulation training with physiologic responses (realism) and continuous interaction between Jane and the instructor. However, the computerized mannequin, one of the defining attributes, was absent.

Contrary case

A contrary case refers to a lack of all the defining attributes (Walker & Avant, 2011). An example of this case is described below.
A student, Brian, had to manage SimMan with moderate hypoxia. Case notes with the patient’s history were provided to him. The SimMan was not connected to a computer, resulting in the signs of moderate hypoxia not matching the real signs and the responses of the SimMan were unrealistic. Brian could not determine what he should do based on the available information. He did not interact with the SimMan as he was confused about the situation, and he gave up continuing with the hand-on practice of the simulation.

In this case, the human-patient simulator could not demonstrate the computerized interactivity and realism to be an HFPS to train a student’s decision-making skills. As the SimMan was not connected to a computer, the instructor could not adjust the respiratory rate and pulse oximetry of the SimMan through the computer. The SimMan did not show the signs of moderate hypoxia, thus making Brian feel confused in determining the assessment and intervention. Also, as Brian was not actively involved in the simulation training, interactivity with the SimMan was blocked and therefore Brian did not acquire experience and learn the skills for managing a patient with hypoxia.

**Illegitimate case**

This is related to using the concept term improperly or out of context (Walker & Avant, 2011). Again, an example of this case is described below.

Jimmy, a nursing student, purchased a simulated video game of car racing. To have the real experience of driving, Jimmy installed a simulated racing car seat and a set of driving gear that consisted of a steering wheel and paddle shifters. He could use the hardware to control the speed and steer the racing car according to the race course situations shown on the screen.

This example of illegitimate case shows that there is no computerized mannequin, and the realism and interactivity of HFPS are out of context.

**Step 4: Antecedents**

Antecedents are incidents or events that must happen before the existence of the concepts (Walker & Avant, 2011). Identification of the antecedents and consequences of HFPS are required for understanding the value of high-fidelity simulation and how it is beneficial for advancing modern nursing education and practices. There are several criteria which indicate the rationales behind aspects of the antecedents of HFPS.

**A need for additional clinical experiences**

According to Cant and Cooper (2010), high-fidelity simulation, as a process of educating, is the essence of student immersion in the unfamiliar scenarios of clinical situations and clinical practices in a safe environment. Using high-fidelity simulation with mannequins as an aid in teaching the students is an effective way of providing additional or complementary experiences before tackling the real clinical conditions/situations.
Setting scenarios to meet standardization

The standards of a simulated scenario must be well developed and match the reality of clinical practices for nursing students to have publicly accepted professional competency for delivering care. Several well-known international institutions, including The International Nursing Association for Clinical Simulation and Learning and Ako Aotearoa’s National Project Fund have established high-fidelity simulation standards for participants. They recommend that academic institutions comply with these standards which emphasize that a realistic simulation should offer the most authentic learning to prepare the students to perform high-quality nursing practice for actual patients.

Cohen and Boni (2016) stated that the use of simulation only allows nurses and nursing students to have the opportunity to practice for unexpected situations in clinical reality, familiarize themselves with the clinical environment and refine their skills. The foundational knowledge of basic nursing care should be a prerequisite for using a high-fidelity simulator to apply holistic care. This foundational knowledge could be classified as the basis of professional knowledge that mutually equips people who work in the healthcare industry as nursing professionals, including nursing students. At a minimum standard, it involves a basic understanding of nursing care, medical terminology and abbreviations, and physiological processes. In addition, Cohen and Boni (2016) pointed out that the foundational knowledge and awareness of self, others, and the environment offer the nursing students a fundamental understanding of the caring and healing dynamics which are required in high-fidelity nursing simulation. Cordeau (2010) concluded that the preparation of nursing students for clinical simulation is crucial and determines the success of the simulation experience.

Measurable objectives and evaluation tools

Measurable and achievable objectives of simulation training must be laid down and communicated to all the participants (Lioce et al., 2013), and evaluation tools must be validated (Boese et al., 2013). Linking the simulation experience to the learning outcomes and establishing a concrete association with the learning objectives are necessary to enable the students to consolidate their knowledge base and wisdom, and provide a more focused and in-depth learning experience for enhancing critical judgement, decision-making and clinical reasoning (Ricketts, 2011). Cordeau (2010) concluded that a link to learning objectives and ensuring that the students are fully aware of what is expected of them during the simulation assist in the transference of knowledge to clinical skills.

Debriefing facilitation

The literature has emphasized that quality learning with simulation is jeopardized without a debriefing (Parker & Myrick, 2010). The instructor who arranges the debriefing for a training session on simulation must be adequately trained to provide a quality debriefing session. Debriefing requires the exploration of actions utilized during
the simulation; identification of the gaps in the participants’ knowledge; the practical skills performed in the training; and reflection on the simulated experience (Cohen & Boni, 2016).

**Step 5: Consequences**

Consequences are events that result from the existence of the concept (Walker & Avant, 2011). The consequences of HFPS and quality nursing education can be viewed as congruent, which helps students to develop their clinical competence, critical thinking and clinical decision-making (Cohen & Boni, 2016). Five consequences can be found, as discussed below:

**Synthesis of knowledge in nursing care**

A high-fidelity experience benefits students from acquiring and synthesizing planned and coordinated knowledge, and viewing the ‘patient’ in the stimulated experience as a whole being. Viewing the patient holistically can help the students to achieve the desired patient outcomes (Lioce et al., 2013).

**Growth in knowledge, skills, attitudes and personal growth**

A high-fidelity simulation enhances students’ knowledge, skills, attitudes, and their personal growth. Cohen and Boni (2016) found that simulation was effective for nursing students’ learning since it promotes four essential learning elements associated with nursing care, viz. the enhancement of technical skills; the fulfilment of academic needs; the provision of a situated learning context; and the incorporation of a psychological element in learning.

**Development of critical thinking and clinical decision-making**

A high-fidelity simulation helps students to integrate a way of thinking, practicing, and reflecting on patient care (Dossey & Keegan, 2009). It helps to build up their ability in more refined critical thinking, clinical reasoning, and clinical judgement. Also, the outcomes of well-designed simulation training enhance the nursing skill performance and clinical knowledge of the students.

**Competence and confidence**

A high-fidelity simulation boosts students’ confidence and competence in prioritizing and undertaking holistic nursing care when they are exposed to simulation (Decker et al., 2013). Reilly and Spratt (2007) pointed out that high-fidelity simulation is an innovative strategy which enables nursing students to develop competence in clinical skills and confidence for practice.

**Improved clinical outcomes**

It is more likely that future patients will receive holistic nursing care in different situations after students have been exposed to high-fidelity and holistic nursing
simulation experiences (Cohen & Boni, 2016). Ultimately, it can improve patient outcomes in physical, mental, social and spiritual aspects.

**Step 6: Empirical references**

The sixth step in concept analysis is to identify empirical references for defining the attributes which are instances that, by their existence, demonstrate the occurrence of the concept (Walker & Avant, 2011). The defining attributes of an HFPS are complex as there are several essential components that must be combined in a fully defined HFPS. To standardize the concept of HFPS, Bland, Topping and Wood (2011) and Cohen and Boni (2016) have suggested the following measurable indicators of HFPS.

1. Students participating in simulated experiences should be familiar with measurable objectives that address the application of nursing care in fulfilling the physiological, psychosocial, cultural, and spiritual needs of a patient.

2. During simulation scenarios, students must apply clinical decision-making and critical thinking to prioritize the needs of a patient and use the theoretical framework of nursing procedures learned in the school and the clinical wisdom learned from previous clinical experiences.

3. To ensure that the students can learn successfully from an HFPS, evaluation tools for measuring learning objectives on all dimensions of nursing care in simulation should be validated by interrater reliability among those trained in simulation education.

4. Experienced instructors play a crucial role in guiding the students who have limited knowledge and experience of the simulation scenario which is similar to a real-world patient’s situation by adherence to scripts and training.

5. The learning process continues after the simulation scenario is completed. A debriefing session should be included for students to reflect on accomplishing the learning objectives and express their personal feelings on their performance.

To achieve the above five indicators, the attributes of HFPS should be included. As already mentioned, The International Nursing Association for Clinical Simulation and Learning and Ako Aotearoa’s National Project Fund have established the standards for high-fidelity simulation for academic institutions to take into consideration as references to utilize best practices in using simulation as a teaching method (Edgecombe et al., 2013). There are four recommendations and strategies that can be implemented in HFPS, including the instruction, objectives, realism and a debriefing session (Cohen & Boni, 2016).

**Instruction**

All students participating in simulation-based exercises or scenarios should be introduced to the simulator manikin with clear instruction (Edgecombe et al., 2013). This can be done by:
(1) introducing the concept of the simulator manikin;
(2) explaining the purposes of the session;
(3) explaining and demonstrating the utility of the simulator manikin; and
(4) reinforcing the expected professional manner in the scenario.

**Objectives**

The simulation experience should provide clear learning objectives and outcomes for the students (ibid.). The objectives should:

(1) include the course framework/session objectives and expected outcomes of the session;

(2) demonstrate a clear connection to the current course;

(3) address the behaviours, skills and attitudes expected in performance;

(4) give an adequate time limit to achieve the objectives; and

(5) integrate with evidence-based practice.

**Realism**

To achieve realism, the simulation for teaching and learning should reflect real clinical practice (ibid.). This can be achieved by:

(1) ensuring that equipment and the environment are similar to the real practice environment – such as an in-patient ward setting or simulated living room for community-based nursing;

(2) enhancing a sense of realism to the manikin e.g. hospital clothing, and simulated wounds;

(3) providing medical items and supplies which the students would encounter in the clinical setting, e.g. intravenous lines, a dressings set, and patient identification bracelets;

(4) ensuring that all the written documents are similar to the clinical setting;

(5) utilizing evidence-based practice to give realism, and expect students to perform nursing care in a research-based way; and

(6) adopting the technology, such as virtual reality, to demonstrate the reality of the clinical setting to help students immerse themselves in the setting.

**Debriefing session**

In the debriefing session, reflective thinking as a premise for learning should be included to maximize the learning experience in the HFPS (ibid.). The debriefing session should:
be facilitated by an instructor who is involved in the simulation scenario and familiar with the techniques of debriefing;

be based on a structured framework and standardized procedure;

be based on evaluating the objectives, the performance and the outcomes of the simulated experience; and

create an atmosphere of confidentiality, trust, and open communication to facilitate self-analysis and reflective thinking

Step 7: Implication for nursing research

HFPS is likely to raise students’ ability in clinical judgement and effective decision-making (Dossey, Luck, Schaub, & Keegan, 2013). It is a learning strategy which builds up knowledge and enhances effective and efficient nursing practice in pre-qualification nurses. It is suggested that future research can focus on the use of high-fidelity simulation to educate the nursing students to reinforce their clinical decision-making skills (Cohen & Boni, 2016).

Researchers need to explore the understanding of both the process and outcomes in the simulation experiences if the educators add simulated training as an active learning strategy in the undergraduate nursing curriculum (Cohen & Boni, 2016). It is also imperative to explore the transferability of acquired knowledge and skills from simulation experiences to the acquisition of competence and proficiency in clinical practice (Murray, Grant, Howarth, & Leigh, 2008). High-fidelity simulation learning can have a high similarity to clinical settings by using technology. The authenticity of the HFPS, therefore, is an essential element for success in innovation in nursing education which is the focus for the future research (Cohen & Boni, 2016).

Conclusion

Through this analysis, we are able to recognize that the concept of HFPS has several essential elements and the fidelity of simulations can be influenced by different factors that the instructors and users have to be aware of and monitor. We have defined HFPS in terms of the use of computerized and life-sized mannequins with a complex electronic multisystem model which are able to provide a high level of realism and interactivity between them and the users. With advanced technology, the definition of HFPS has becomes vague. The use of static mannequins has moved to computerized mannequins, and then the full scale of computerized mannequins and virtual reality were developed. Nowadays, we focus more on the higher level of realism and the interactivity. These two essential components become significant characteristics of HFPS.

Through a systematic analysis of the case studies in this article, a more fundamental view of the essential concept of HFPS is provided. In model case, the simulated patient demonstrates the characteristics of HFPS, thus allowing users to successfully acquire knowledge on managing a patient with pneumonia with confidence in a realistic environment. In borderline case, related case and contrary case, the lack of either
one of the characteristics meant that the user could not learn the skills and acquired the knowledge from the simulation. In illegitimate case, the characteristics of HFPS are out of context. In order to enhance the fidelity of the simulations, users should be introduced to clear learning objectives and outcomes to help them to achieve a higher level of realism. An organized debriefing session, including reflective thinking, should be provided for maximizing their learning experience.

This analysis of HFPS characteristics and case studies focused mostly on clinical simulated learning by nursing students, and did not include high-fidelity simulation in other healthcare professional fields.

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Prebriefing in Simulation-based Education: A Summative Review

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Abstract

Simulation has emerged as an innovative and effective educational strategy and is becoming increasingly prevalent in nursing education. Issues related to simulation scenarios and debriefings have been widely reported in the literature, but little research has been done to explore the prebriefing component in simulation-based education. A summative review was conducted to examine the existing evidence on the theoretical foundations and strategies of prebriefing in simulation-based education. The findings from this study suggested that prebriefing is an integral part in simulation-based education, which contributes to a successful debriefing. Reflection theory underpins prebriefing in simulation. Strategies for optimal prebriefings were identified, including (1) creating a psychologically safe environment for learning; (2) establishing a “fiction contract” with learners; and (3) providing essential prebriefing activities. These essential prebriefing activities encompass an orientation session and clarification of the learning objectives, expectations and roles. Further research should be carried out on the impact of prebriefing on the outcome measures.

Keywords: briefing, prebriefing, simulation, education
Introduction

Simulation has been adopted as an effective pedagogy in nursing for decades (Jeffries, 2012). According to the International Nursing Association for Clinical Simulation and Learning (INACSL), simulation experience consists of three components: prebriefing, scenario and debriefing (INACSL Standards Committee, 2016). Many studies have been conducted on the scenario and the debriefing following it (Dieckmann, Friis, Lippert, & Ostergaard, 2009; Dreifuerst, 2012; Neill & Wotton, 2011; Shinnik, Woo, Horwick, & Steadman, 2011). It has been well documented that debriefing is a crucial step in simulation-based education (Rudolph, Simon, Rivard, Dufresne, & Raemer, 2007). However, little is known regarding prebriefing (Chamberlain, 2015; Rudolph, Raemer, & Simon, 2014).

In this article, prebriefing is defined as all the activities carried out prior to the start of the simulation scenario. The aim of this study is to review the existing evidence on the use of prebriefing in simulation-based education. The following questions guided the review:

1. What are the theoretical foundations of prebriefing in simulation-based education?
2. What are the best strategies for prebriefing in simulation-based education?

Method

Electronic databases Pubmed, ProQuest and EBSCOhost were used in conducting this summative review. The search terms used to identify potentially relevant studies included “prebrief*” or “presimulation” or “briefing” or “prescenario” and “simulat*”. The search focused on studies published in the last ten years. Language was restricted to English.

Results

Importance of Prebriefing

Prebriefing is of vital importance in simulation-based education. In a recent Delphi study (McDermott, 2016), all the panellists agreed that prebriefing was essential for learners’ success in simulation-based education. Also, the majority of the panellists agreed that prebriefing was beneficial to the learners on aspects such as enhancing their decision-making (78%); improving their ability to provide competent care (84%); raising their confidence (86%); and reducing their anxiety (95%). As it had been widely published that debriefing is a crucial component in simulation-based education, the majority of the panellists (81%) also pointed out that prebriefing would contribute to successful debriefing. The purpose of prebriefing is to provide a safe environment which may help the learners to achieve the objectives and outcomes of the simulation experience (INACSL Standards Committee, 2016).
Theoretical Foundations of Prebriefing in Simulation-based Education

It has been well documented in the literature that debriefing is an essential component in simulation-based education since significant learning will occur when learners go through the reflection process (Rudolph et al., 2007). However, few studies have addressed the underpinning theory of prebriefing in simulation-based education. Reflection on one’s own practice is an essential element in the experiential learning process (Rudolph et al., 2007). Reflective learning encompasses reflection-in-action (Schon, 1987), reflection-on-action (Schon, 1987), reflection-beyond-action (Dreifuerst, 2009) and reflection-before-action (Greenwood, 1998). Reflection-in-action refers to the reflection that occurs when the learners are participating in the simulation scenario; and reflection-on-action is the reflection that occurs when the learners go into the debriefing phase and think back on what they did in the scenario (Schon, 1987). Reflection-beyond-action is the reflection that takes place when the learners proceed to the post-simulation activities during debriefing (Dreifuerst, 2009). Finally, reflection-before-action is the reflection which takes place in the prebriefing phase (Greenwood, 1998). Reflection-before-action involves the learners in thinking through what they intend to do and how they intend to do it prior to the simulation. Errors may occur if they fail to go through this step (Greenwood, 1998). One recent experimental study, in which the principle of reflection-before-action and concept-mapping were incorporated in the prebriefing activity, had a positive impact on nursing students’ competency and clinical judgement (Page-Cutrara & Turk, 2017).

Strategies for Prebriefing in Simulation-based Education

Strategies for prebriefing in simulation-based education have been identified in the literature (INACSL Standards Committee, 2016; Leigh & Steuben, 2018). The strategies include (1) creating a psychologically safe environment for learning, (2) establishing a “fiction contract” with learners, and (3) essential prebriefing activities.

Creating a psychologically safe environment for learning

A psychologically safe environment refers to a climate or atmosphere where the participants are able to speak up and take risks without fear of embarrassment, judgement or retribution (INACSL Standards Committee, 2016; Lopreiato et al., 2016; Turner & Harder, 2018). The literature has revealed that creating a psychologically safe environment is a crucial concept in simulation (Leigh & Steuben, 2018; McDermott, 2016; Rudolph et al., 2014; Turner & Harder, 2018). If one feels psychologically safe, one is able to fully engage in the simulation experience and be willing to take interpersonal risks during both the scenario and debriefing. This is because the learners perceive that they will be viewed positively, even if they make mistakes – the learners are allowed to make mistakes without consequences (Rudolph et al., 2014; Turner & Harder, 2018).

It has been suggested that psychological safety is the positive influencing factor for learning-oriented behaviours, such as asking questions, seeking help and sharing
one’s thinking (Rudolph et al., 2014; Turner & Harder, 2018). Also, it helps to prevent defensive behaviours such as obstructing and withdrawing which are triggered by feelings of personal threat (Rudolph et al., 2014). Nevertheless, this does not indicate that creating a psychologically safe environment is aimed at avoiding completely the negative emotions associated with learners’ mistakes. Instead, it has been argued that limited doses of negative emotions can help to motivate learning (Zhao, 2011), foster collaboration, and enhance innovation (Turner & Harder, 2018). Hence, creating an environment which is psychologically safe for the learners is important as it allows them to engage actively in the simulation activity, which may ultimately enhance their learning (Rudolph et al., 2014; Turner & Harder, 2018).

In order to establish and maintain a psychologically safe learning environment, it is imperative to develop a trusting relationship between the learners and instructor (Rudolph et al., 2014). Ensuring confidentiality is the determinant in building trust. When the learners are asked to participate in the simulation activity, they are placed in a psychologically vulnerable situation (INACSL Standards Committee, 2016). Learners should be informed about who would be the observer in the scenario and who would be notified of their performance in the scenario and debriefing (Leigh & Steuben, 2018). They should also be told if their performance is to be video-recorded (Arafeh, Hansen, & Nichols, 2010; Leigh & Steuben, 2018). In addition, learners should be asked not to share details with other learners in the simulation (Arafeh et al., 2010; Leigh & Steuben, 2018). Ensuring confidentiality during the prebriefing helps the learners to feel safe, be more willing to take risks and more likely to engage in the simulation (Leigh & Steuben, 2018). As the learners realize that their performance will be respected, this will foster a trusting relationship between the instructor and learners (Turner & Harder, 2018). Finally, reiterating the issue of confidentiality during the prebriefing helps to build trust and promote mutual respect between the instructor and learners (Turner & Harder, 2018).

**Establishing a “fiction contract” with learners**

The literature has revealed that establishing a “fiction contract” with learners is important in prebriefing (Leigh & Steuben, 2018; McDermott, 2016; Rudolph et al., 2014). A “fiction contract” is a form of psychological contract which describes the mutual agreement that the instructor and learner create (Rudolph et al., 2014). An explicit and collaborative agreement should be made between them and both parties make commitments (Dieckmann, Gaba, & Rall, 2007). The instructor conveys the message to the learners that the simulation is as real as possible, but cannot be exactly the same as the real situation as there are limitations, such as the manikin’s skin colour not changing (Leigh & Steuben, 2018; Rudolph et al., 2014). The instructor then invites the learners to do their best to act as if it was the real situation since the quality of the learning experience depends on the learners’ willingness to participate in the simulation activity (Rudolph et al., 2014). Conveying this message of interdependence may help in building an effective learning contract as the learners have an idea of how the learning
process will go. Rudolph et al. (2014) pointed out that the fiction contract plays an important role in preventing the occasional shame or humiliation that the learners may feel if they do not perform well during the simulation; and by establishing the fiction contract, the learners are more likely to fully engage in the simulation.

**Essential prebriefing activities**

**Orientation**

An orientation should be taken place before the simulation-based learning experience (INACSL Standards Committee, 2016; Leigh & Steuben, 2018; McDermott, 2016; Turner & Harder, 2018). The content of the orientation should include the simulated environment, such as the setting, the location of the apparatus, the functions of the manikin, background information on the scenario and logistics details of the simulation activity. It is preferable to provide a hands-on experience for the learners during the orientation rather than a demonstration by the instructor as this may help the learners to retain knowledge (Leigh & Steuben, 2018; Page-Cutrara, 2015). The duration of the orientation depends on the level of the learners, learners’ previous exposure to simulation, and the complexity of the simulation-based learning experience (Leigh & Steuben, 2018). To ensure consistency, it is also suggested that a script is developed for the orientation if the session is to be repeated (Leigh & Steuben, 2018; McDermott, 2016). Studies have also shown that, for graduating medical students, a pre-simulation orientation decreased their anxiety, while increasing their confidence and improving their clinical performance (Bommer et al., 2018).

**Clarifying learning objectives, expectations and roles**

Besides orienting the learners to the simulation environment, prebriefing activities should also include clarifying the learning objectives, expectations and roles with the learners (McDermott, 2016; Rudolph et al., 2014). Evidence has been shown that if the learners have a clear idea of what they are expected to do in the scenario and debriefing, they will be more likely to engage in the simulation activity (Rudolph et al., 2014). Moreover, this will enhance their learning as they are more likely to meet those expectations.

Clarifying the learning objectives and expectations will lead to positive emotions in the learners, which will help to inspire them, stimulate their reflection and enhance the integration of new knowledge (Rudolph et al., 2014). The instructors are usually clear about the aims and objectives of the simulation activity; however, it is not uncommon for them to assume that the learners are also clear about this (Smith, 2008). In order to minimize the discrepancy between the learners’ observed and expected performance in the simulation, it is important to clarify the learning objectives and expectations explicitly during the prebriefing (Dismukes, McDonnell, & Jobe, 2000; Issenberg, McGaghie, Petrusa, Gordon & Scalese, 2005; McDermott, 2016; Turner & Harder, 2018). Prebriefing activities should also include clarifying the roles, especially when
learners participate in the scenario as a team (INACSL Standards Committee, 2016). Previous studies have shown that learners report less anxiety and enhanced learning if clear roles were identified before the scenario took place (Elfrink, Nininger, Rohig, & Lee, 2009).

Furthermore, the literature suggested that learners should be informed during prebriefing if formative or summative assessment will be conducted in the simulation activity as this is important for establishing a psychologically safe learning environment (Leigh & Steuben, 2018; McDermott, 2016; Rudolph et al., 2014). Learners may worry that their mistakes will be criticized and that formative or summative assessment is a threat (Rudolph et al., 2014). Thus, by addressing clearly and transparently how the performance will be evaluated during the prebriefing, this will help to maintain a psychologically safe environment (Rudolph et al., 2014).

**Conclusion**

Simulation has evolved as an educational strategy in nursing over the past 10 years, but the concept of prebriefing in simulation-based education was still unclear. This review contributes to a growing body of knowledge about the use of prebriefing in simulation by offering a greater understanding of the theoretical foundations and strategies of prebriefing. It further supports the position that prebriefing can add value to simulation-based education as it enhances reflective learning and contributes to successful debriefing. In addition, it provides information for educators about the optimal delivery of prebriefing in simulation to facilitate learning.

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**References**


Nursing Simulation Curriculum Evaluation Using the CIPP Model at the Programme Level

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Abstract

A curriculum evaluation model offers a conceptual framework for the evaluator and all the stakeholders involved in a course or programme to have a systemic review of its design. Stufflebeam (2003) introduced the CIPP Model (Context, Input, Process, and Product) which aims at suggesting improvements, not just showing the outcomes and quality. It is based on various observations, feedbacks, and discussions among evaluators and stakeholders throughout the whole evaluation process. Nursing simulation has been widely incorporated into various types of nursing programmes at undergraduate and postgraduate level. However, few research studies have focused on the evaluation of the nursing simulation curriculum, and how to apply the CIPP model to evaluating the courses/programs. This article discusses the local development of the nursing curriculum, nursing simulation, and the applicability of the CIPP model for curriculum evaluation.

Keywords: nursing simulation, nursing curriculum, CIPP model
Introduction

In Hong Kong, the design of the nursing education curriculum is guided by the requirements of the Nursing Council of Hong Kong. With the evolution of nursing services in hospitals, there was a need to develop the nursing programmes with enhanced professional competences in line with international standards. Therefore, the training of nurses shifted in 2002 from a hospital-based three-year higher diploma to a university-based four-year full-time bachelor’s degree; and, in 2012, the bachelor’s degree nursing programme was further expanded into a five-year curriculum (The Nursing Council of Hong Kong, 2018).

Within the scope of professional practice indicated by the Nursing Council, the nursing education curriculum had to be revamped and updated in order to equip nurses with competencies aligned with the changing healthcare demands. The core competencies that a registered nurse (RN-general) should possess include: (1) being professional, complying with legal and ethical requirements; (2) the ability to perform health promotion and deliver health education; (3) management and leadership skills; (4) the ability to conduct research; and (5) personal effectiveness and professional development.

Nursing training includes two main components- theoretical subjects and clinical practicums. For the theoretical requirements, the overall contact lasts for 1,250 hours. “Contact hours” are measured as the number of hours spent by a student in direct contact with the teachers or training staff of a programme. The forms of contact include the dynamics in classrooms lectures, tutorials, nursing laboratory practice, conducting experiments in the laboratory, and supervised sessions in clinical practicums. Nevertheless, other modes of learning are subject to the assessment of the Nursing Council of Hong Kong in each case, with consideration of the structured content with learning outcomes as well as assessment components.

The purpose of adding simulation training to the course design is to develop students’ ability to apply the knowledge and skills learned in the class and laboratory sessions to their nursing practices in real-life clinical situations. The scenario design can also be adjusted for the different levels of students and train their problem-solving and communication skills in a team. Simulation training in the healthcare system is very common nowadays. By definition, “simulation” is the replication of an event or task for training or assessment purposes (Curtis, Diaz Granados, & Feldman, 2012).

The major challenges faced simulation training is the process of designing scenarios and scripts by transforming physical simulators from passive objects to meet the learning outcomes through students’ experiences during the scenarios, pre-briefing, de-briefing, and assessment. The scenarios can range from fundamental and simple concepts and skills at the junior undergraduate level in general nursing to very complex postgraduate advanced level concepts and skills when teaching specialty nursing training. As simulation was not traditionally incorporated into nursing education; it is often perceived as an additional task, involving a high demand for resources. However,
the nursing curriculum has changed recently and a strong effort is being made to design an innovative and effective nursing simulation curriculum incorporating high technical computer programs and manikins which can communicate, express some emotion, and readily respond to students’ decisions and interventions during the scenario.

**Discussion**

The CIPP model was originally developed to provide information systematically for curriculum evaluation and decision-making (Stufflebeam, 2003). The context, input, process, and product (CIPP) evaluation model provides a conceptual framework which guides the evaluation of the quality of a programme in a systematic and concise way.

The nursing programme should maintain a high quality and evidence-based curriculum for professional baccalaureate nursing students. First, context evaluation provides information on the strengths and weaknesses of the system to assist in planning improvement-oriented objectives at each level. The methodology during the context evaluation phrase includes a survey, document review, interviews, and system analysis.

Second, input evaluation helps to bring about needed changes in the programme. This stage aims to identify and assess the system’s capabilities and constraints – such as the environment and resources – and develop alternative strategies, a budget plan, and a schedule, and avoid potential failed or wasteful practices. It provides a basis for Schools to be accountable for their choice of one action over others, with justifications. Also, it enables the proposal preparation for submission to the funding agency. The methodology during the input evaluation phrase is an inventory which analyzes available human and material resources, and advocates team techniques, pilot trials, and a literature search.

Third, process evaluation provides an ongoing check on the implementation process. It aims to identify the defects in the procedural design; to record and assess whether the participants in the programme can carry out their roles; and guide the modification and explication of the plan when necessary. The process evaluation provides a log of the actual process for later use in interpreting the programme outcomes. The methodology adopted during the process evaluation includes visiting and observing the center of activities; interviewing participants; attending staff meetings; describing the actual process; continuously interacting with and observing the activities of the staff involved; and monitoring the programme’s potential procedural barriers.

Lastly, the product evaluation is to determine whether the objectives have been achieved and interpret their value (meeting the needs of the targeted beneficiaries), merit (their quality), probity (their honesty) and significance. Also, it aims at identifying the effects of the programme, including the intended and unintended, and positive and negative, outcomes. As a result, decisions are made on continuing, modifying or terminating a programme; and on institutionalizing the programme and adjusting the funding amount. The methodology adopted during the product evaluation includes collecting judgements on outcomes from stakeholders, defining operations and measuring outcome criteria, and conducting qualitative and quantitative data analysis.
Stufflebeam (2003) designed a CIPP Model checklist which can be applied for evaluating the curriculum initiatives at the programme level in schools. The checklist consists of 10 components, including contractual agreements which guide the evaluation, followed by context, input, process, impact, effectiveness, sustainability, and transportability evaluation components. The last two components are meta-evaluations (evaluation of evaluation) to be carried out throughout the evaluation process. The seven components can be selectively employed in sequence or simultaneously, depending on the needs of the evaluations. The checklist provides checkpoints on the left for evaluators and checkpoints on the right for evaluation participants.

First, the contractual agreement is an essential component. An agreement on their activities should be reached in advance by the evaluators, clients and stakeholders (school principals, programme leaders, course coordinators, teaching team members, technical staff, and students). Meetings should be held with all the evaluators and stakeholders present, which can clarify with the evaluators what and when it is going to be evaluated, for what purpose, and by what criteria. Moreover, the contractual agreement aims to ensure that the evaluators’ report is consistent with the institutional protocol, and the reporting schedule meets the needs of the programme.

Second, the context evaluation is to assess the needs, assets, and barriers within the programme. The evaluators should assess the programme goals in light of the beneficiaries’ needs and potentially useful assets. A data collection specialist should engage in monitoring and recording data on the programme’s environment, setting, equipment (manikins, and computer system), staff and student needs, problems encountered, and the political dynamics. It is important for the evaluators to get preliminary information on the use of simulation training programmes and teaching scenarios in order to have an all-round understanding, and evaluation throughout their implementation. Also, the evaluators should request the programme staff to make information available to them regularly; and also to deliver a draft context report to the stakeholders which provides the updated programme-related needs, problems and assets, together with an annual assessment of the programme’s goals and priorities. The stakeholders should then use the findings of the context evaluation to review and revise the programme’s goals to ensure that they target the assessed needs properly, and assess the programme’s effectiveness and significance throughout and at its end. As simulation training usually involves different program software and technical use of the connections to the manikins, it monitors the data inputs from the software programs.

Third, the input evaluation is to assess the programme’s work plans, strategies, and budgets. The evaluators should assess the programme’s proposed strategies for the adequacy of their responsiveness, feasibility and work schedule. Also, they should assess the programme’s strategy against research on the development of simulation training. For the stakeholders, the findings of the input evaluation can be used to devise a programme strategy that is evidence-based practice economically, socially (i.e. teamwork, a multidisciplinary approach) and technologically (i.e. more interactive
and stimulating students’ responses). Also, the results of the input evaluation should be used to support funding requests and be accountable for reporting the rationale for the operational plan and programme strategies.

Fourth, the process evaluation aims to monitor, document, and assess programme activities. The evaluators should monitor, observe and maintain a photographic record of the programme. Also, they should interview the programme leaders, staff and students to obtain their assessments of the programme’s progress. Regular feedback workshops should be held to discuss the findings of the process evaluation. Each process evaluation report and related visual aids should be finalized and be provided to the clients and stakeholders. The stakeholders can use the findings of the process evaluation to coordinate the programme’s design and the adequacy of the staff training activities. Also, they can use the process evaluation findings to help to maintain a record of the programme’s costs and prepare a report to its financial sponsor and other developers.

Fifth, the impact evaluation aims to assess whether the programme can reach the target audiences. The evaluators should engage the programme staff in maintaining a directory of the people served, making notes on their needs, and recording the programme’s impact on them. They should make a judgement of the extent to which the target audiences are consistent with the programme’s intended beneficiaries. They also need to conduct periodic interviews with the teaching staff and students to learn about their perspectives on how the programme influences their learning outcomes. Finally, they should draft an impact evaluation report and provide it to the clients and stakeholders. The stakeholders can then control who is served, and they can use the results of the impact evaluation to judge the extent to which the programme addresses their needs, and for accountability purposes.

Sixth, the effectiveness evaluation assesses the quality and significance of the programme outcomes. A goal-free evaluator, who is a contracted evaluator, is prevented from learning about a programme’s goals and is charged to assess what the programme is achieving, irrespective of its aims. Stufflebeam (2007) stated that this technique is powerful for identifying side-effects or unintended outcomes (both positive and negative) and for describing what the programme is doing, irrespective of its stated procedures. The goal-free evaluators should conduct interviews with the key stakeholders to determine their assessments of the programme’s positive and negative outcomes. They should also obtain information on the nature, cost, and success of similar programmes conducted elsewhere and compare the current programme’s effectiveness with identified “competitors.” The stakeholders can use the findings of the effectiveness evaluation to gauge the programme’s positive and negative effects on beneficiaries; and they can also sort out and judge the important side-effects or which activities needed to be changed. Also, based on the needs assessment data from the context evaluation findings and the effectiveness evaluation results, they can contrast the programme with similar programmes elsewhere to make a bottom-line assessment of the programme’s significance.
Finally, the sustainability evaluation assesses the extent to which a programme’s contribution can be institutionalized successfully and continue over time. The evaluators can review the data on programme effectiveness, costs, and beneficiaries in order to judge what should be changed or sustained. Plans, budgets and other relevant information should be obtained and examined to gauge the sustainability of the programmes. In the feedback sessions, there should be discussion of the sustainability findings and the possible need for a follow-up study to assess the long-term implementation. The stakeholders can use these findings to determine whether there is a need for sustaining the programme, and set goals and plans for future activities.

The meta-evaluation is an assessment of an evaluation. The evaluators reach an agreement with the client that the evaluation will be guided and assessed against the Joint Committee’s programme evaluation standard. They should encourage and support the stakeholders to obtain an independent assessment of the evaluation plan, process, and reports. The stakeholders can consider contracting an independent assessment of the evaluation to see whether the Joint Committee’s programme evaluation standard has been reached and make an agreement with the evaluators that this standard will be used to guide and judge the final evaluation work.

The final synthesis report pulls together the evaluation findings to inform the full range of audiences about what has been done and the goals accomplished. The final report should include three parts i.e. the programme’s antecedents, implementation, and results. The programme’s antecedents section should report, for example, the organization which sponsored the programme, the organization which is to conduct the evaluation procedures and background information on the programme. The programme implementation should include the details of how the programme was planned, funded, staffed and carried out, so that other groups can replicate its activities if they are interested. The programme results section of the report should consist of the findings and, conclusions of the evaluation (i.e. its strengths, weaknesses, and lesson learned), and a bottom-line assessment of the programme’s merit, worth, significance and probity. At the end of the report, some photographs, graphic representations, interview protocols, feedback session agendas, data tables, and the on-site evaluator’s procedural handbooks can be included as appendices to provide a more all-round description of the whole programme.

Finally, the stakeholders can summarize the programme’s final report and be assured that its content is usable and appeals to the full range of audiences. Also, they can inform the audiences about which goals have been accomplished, any failures and shortfalls which have occurred, how the outcomes compare with similar programmes elsewhere, and the lessons to which they should pay attention.

**Literature Review on Related Research Studies**

The keywords “nursing programme”, “CIPP evaluation”, “model”, and “nursing simulation” were used during the literature search. There were only about ten research
studies related to nursing programme curriculum evaluation using the CIPP model, but no study was identified which was related directly to nursing simulation and the CIPP evaluation model. However, the references in the literature review for understanding the concepts and methods for applying the CIPP model will be very useful for the development of the nursing simulation training programme as the CIPP evaluation model (Stufflebeam et al., 1971) provides a theoretical framework which guides the evaluation of a programme’s overall merit and quality. Lippe and Carter (2018) utilized the CIPP model to evaluate the integration of End of life (EOL) care content within an undergraduate nursing programme. In conducting the input evaluation process, the researchers adopted the nationally recognized gold standard of EOL education (AACN, 2016) to design the End-of-life (ELNEC) curriculum. The essential elements of the ELNEC curriculum were identified using the decomposition model (Borich & Jemelka, 1982). Thus, a faculty member survey was developed to identify EOL content integration throughout the programme (Lippe, Volker, Jones, & Carter, 2017).

For the process evaluation, the evaluators conducted classroom observations and the analysis of field notes in order to assess the delivery of EOL content (Lippe & Carter, 2017). Surveys of all students in the programme provided product evaluation data such as the perceived competence, attitudes towards death and care of the dying using the perceived competences in meeting ELNEC’s standard instrument (Lippe & Becker, 2015) and knowledge using the ELNEC knowledge assessment test (Wallace et al., 2009). Surveys were distributed to students at the beginning and end of the semester, which provided cross-sectional data on students’ outcomes within each level of progression. The product evaluation findings gave valuable insights into the degree of preparation of the students to care for dying patients throughout their learning and practice during their clinical practicum.

For the simulation training programme, the duration of each course lasted for 14 weeks in one semester. Also, it was developed to fit different levels of students. The simulation training was useful for preparing students’ knowledge and skills before they went to the hospital for the clinical practicum. The CIPP evaluation model was applied to the simulation curriculum using a mixed method descriptive design. Data were obtained from the stakeholders, including the programme leader, course coordinator, teaching team, technical staff and nursing students using the CIPP survey, focus group interviews and an open-ended questionnaire.

The context evaluation was conducted using the CIPP survey to obtain information on needs assessment as it served as the foundation from which the curriculum flowed. Afterward, the curriculum goals and learning objectives were designed based on the results of the needs assessment. The learning objectives of the simulation should be clear and use observable action verbs (Brindley, Paton-Gay, & Gillman, 2016). The objectives should describe “who” they are intended for, especially when the simulation sessions involve multiple learners at different levels; provide a time reference during which the learning occurs (i.e. a single simulation session or a series of sessions); and
give a performance description of what the learner should be able to do using action verbs such as “identify”, “list” or “demonstrate”.

During the input evaluation, the evaluators should go through and investigate the design of the simulation scenario and provide feedback to the stakeholders before the process evaluation. Another major component of simulation training is the quality of the debriefing after each simulation session (Brindley, Paton-Gay & Gillman, 2016).

The product evaluation can be conducted at the end of the semester, when students will be presented with both the old and modified versions of the simulation training course and discuss the areas of modification being made during the feedback session. Then, the students are asked to evaluate which version they preferred and complete the survey at the end of the course. The modifications could have an impact on their participation, perception of the usefulness of the course, and competence level on the course. Also, the students’ responses could provide suggestions for additional modifications and encouragement when revising similar programmes.

**Recommendation**

“Evaluation’s most important purpose is not to prove, but to improve.” (Stufflebeam, 2007). The strength of the CIPP model lies in the specificity of each phase of the evaluation process. It allows the evaluators to enter throughout the whole programme instead of just at a few points of time. It also provides formative evaluations for decision-making and summative evaluation for future improvements and accountability.

The CIPP model also allows variability in assessment methods such as single type or with a combination of the needs of the audiences during the feedback session at each phase of evaluation. In addition, it allows ongoing evaluation services to the decision-makers in an institute; and it enables a more efficient evaluation service in figuring out some problems and targeting areas for improvement by evaluating the institution’s strengths and weaknesses. Therefore, the evaluation of the programme or institution can be more comprehensive.

However, there are some limitations to the CIPP model. Its approach tends to focus on the need for administrative and programme planning instead of serving the needs of the frontline teaching staff. The CIPP approach appears to be a means of “quality control” and may involve some “unwarranted assumption of orderliness and predictability in decision-making.” Curriculum evaluation is essential for stimulating changes and improvement, and the CIPP model can be a useful strategy. However, the administrative staff and programme evaluators should also consider the needs of the teaching and technical staff during the evaluation process.

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References


Standardized Patients in Nursing Education: Challenges Ahead

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Abstract

Simulation training encompasses different modalities, such as low-fidelity simulation manikins, high-fidelity human simulators, virtual reality and standardized patients. Among these modalities, the standardized patient method has been integrated into nursing education as a teaching and evaluation method for many years, even though educational technologies are well developed nowadays. One of the reasons for this is the benefit the standardized patient method provides to different stakeholders. In this article, the purposes of applying the standardized patient method in nursing education are discussed. Its benefits and challenges are also analysed to explore why the standardized patient method is still worth continuing and how to maximize this teaching and evaluation method in nursing education.

Keywords: standardized patient, simulation training, nursing education
Introduction
The integration of the standardized patient in simulation training has been developed for more than 50 years and this method has been used in both medical and nursing schools. In spite of the development of educational technologies, the standardized patient is still commonly incorporated in both medicinal and nursing education. This article aims to review the integration of the standardized patient into nursing education and analyse its benefits and challenges. Before doing this, however, the term “standardized patient” is defined.

Standardized Patient
The terms “standardized patient” (SP), “simulated patient”, and “patient simulator” have been used interchangeably since the acceptance of an SP as an educational approach, but SP is prevalent and internationally accepted (Owens & Gliva-McConvey, 2015). SPs are not simply models for others to use but have developed as a teaching methodology that enlightens the larger field of simulation, as well as healthcare education more broadly (McNaughton & Anderson, 2017). Therefore, when discussing an SP as a part of an educational approach, it was suggested that the word “uses” should be replaced by other phrases such as “engages” or “live simulation” to reflect the value of SPs as contributors to learning more than just tools (ibid.).

The SP method was originally developed by Dr. Howard Barrows in the 1960s in Los Angeles, California (Owens & Gliva-McConvey, 2015). He defined an SP as an individual who presents an illness in a systematic, unvarying manner after being carefully trained (Barrows, 1993; Becker, Rose, Berg, Park, & Shatzer, 2006; Distlehorst, Dawson, Robbs, & Barrows, 2005). An SP is not only trained to consistently reproduce patient history, but also displays body language, emotions, a communicative style and personality characteristics (Howley, 2013; Owens & Gliva-McConvey, 2015). Through the integration of an SP, a patient’s problems can be presented in a clinically relevant and realistic way (Becker et al., 2006).

The Association of Standardized Patient Educators (2011) defined an SP as an individual who is trained in order to portray the physical presentation and health history of a patient consistently for different purposes, including teaching, assessment and evaluation. Also, through the use of an SP, a consistent scenario can be reproduced that allows learners to practise clinical skills and faculties to assess numerous students within a short period of time. To provide opportunities for students to meet people who act like patients in a real setting is another main purpose of the SP method (Yoo & Yoo, 2003). This purpose also aligns with the definition of simulation training which is seen as an educational method that replaces or amplifies experiences that reproduce substantial aspects of the real world in an interactive fashion (Gaba, 2004). Thus, an SP is engaged solely, or together with a manikin, as a hybrid simulation, which means more than one type of simulator is used in simulation training (Issenberg, McGaghie, Petrusa, Gordon, & Scalese, 2004). The combination of a manikin with one or more SPs
is the most common hybrid simulation because it enhances the realism of the scenario and allows the students to develop a sense of urgency which is difficult to present through a simulator or manikin alone (Schocken & Gammon, 2015). This explains why the SP method is still commonly integrated into medicinal and nursing education even after different kinds of manikins or simulators have been developed. Following the development of simulation training, the SP became one of its modalities. The integration of SP in simulation training is also recognized as an effective method since students can learn in a controlled and safe environment (Jin & Choi, 2018).

The Integration of Standardized Patients into Nursing Education

In recent years, due to awareness of patient rights and safety issues, only limited educational opportunities for nursing practice have been provided for nursing students during clinical nursing practicums (Allen, 2018). The SP method not only offers another opportunity for situational learning for nursing students to practise clinical skills but also provides a standard assessment format for faculties to assess different kinds of clinical skills of nursing students.

Simulation training is one of the solutions for overcoming the limitations of traditional nursing education (Tanner, 2006). In traditional nursing education, nursing students practised clinical nursing skills – such as mouth care, wound dressing, position change, history-taking and physical assessment – in nursing laboratories with their classmates pretending to be a patient or by using manikins. This traditional laboratory training method cannot provide opportunity for nursing students to learn or adapt their skills to interact with patients in a real clinical setting (Beeson & Kring, 1999). The SP method is more effective than the traditional method (Yoo & Yoo, 2003). A study by Bornais, Raiger, Krahn and El-Masri (2012) found that the performance of nursing students who practised assessment skills on SPs was better than those who practised on peers. Many studies (Arthur, 1999; Colletti, Gruppen, Barclay, & Stern, 2001; Konkle-Parker, Cramer, & Hamill, 2002; Schwind, Boehler, Folse, Dunnington, & Markwell, 2001) have also reported the effectiveness of the SP method with nursing students, especially on psychomotor skills, knowledge acquisition and communication skills (Yoo & Yoo, 2003). Owing to the increased opportunity for applying and integrating theoretical knowledge into practice through the SP method, students’ abilities in critical thinking and problem-solving are improved and, as a result, their clinical judgements are enhanced (Bornais et al., 2012). Nevertheless, the SP method is commonly used in teaching communication, and clinical and physical examination skills (May, Park, & Lee, 2009).

Besides teaching and learning, the SP method is also effective in assessment and evaluation, either formative or summative. Faculty staff can provide immediate feedback on students’ performance and offer opportunities for nursing students to practise improving their skills through the SP method (Becker et al., 2006). Bornais et al. (2012) reported that the confidence level of nursing students was greatly increased.
by using the SP method in formative evaluation. In the United States and Canada, many medical licensing and specialty boards are using SPs to certify physicians’ competencies and numerous healthcare education programmes also use SPs as an assessment method (Howley, 2013). These studies show that the SP method is not only reliable for teaching and learning, but also for assessing and evaluating the clinical nursing skills and clinical competence of nursing students.

**Benefits of Using a Standardized Patient**

The SP method is still commonly used in different healthcare programmes nowadays because it has benefits for students, faculties, and the healthcare programmes or curricula. The advantages of using SP for different aspects are discussed below.

As mentioned in an earlier section, the SP method is more effective than the real clinical settings as it provides a sense of reality and meets the specific needs of the students when the simulation training is well organized and planned (Kolb & Shugart, 1984). Students can learn and practise different clinical skills in a less threatening and controlled environment, and so can overcome their feelings of anxiety and nervousness, and eliminate risks to real patients (Owens & Gliva-McConvey, 2015). Through deliberate and repeated exposure, students can focus on the acquisition of clinical skills and be comfortable in managing sensitive patient issues (Becker et al., 2006). A well-trained SP or faculty member can even record the performance of students and provide constructive feedback to them (Howley, 2013), which offers direct, interactive and engaging learning opportunities to students (Becker et al., 2006; Owens & Gliva-McConvey, 2015) and also enhances their learning through reflection (Robinson-Smith, Bradley, & Meakim, 2009). A well-trained SP can even tell students from a patient’s perspective how they are perceived, how they can improve and how effective they are (Vessey & Huss, 2002). All these aspects help students to perfect and transfer their nursing care skills to real patients.

For faculty staff, simulation training provides an opportunity for direct observation of nursing students’ performance which allows them to focus on the students’ performance rather than protecting the patient from possible student error at the same time, as in a real clinical setting (Robinson-Smith et al.; McKenzie, Noone, Markle, Frazier, & Sullivan, 2013). The SP method has the same advantage. Faculty members can provide quantitative, objective and immediate constructive feedback on the students’ performance through the SP (Howley, 2013; Owens & Gliva-McConvey, 2015). In addition, by using the SP method, they can develop a broad collection of clinical presentations or a core set of patient-centred problems scenarios according to different learning objectives or assessment goals (Becker et al., 2006; Howley, 2013). These different scenarios can be reproduced consistently and allow a large number of students to be taught or assessed in a standard environment. As a result, the faculty can control the content and complexity of the clinical problems and provide students with the equivalent patient experiences without relying on the random patient experiences which
are received in hospitals or outpatient settings (Becker et al., 2006). The SP method not only relieves and reduces time-consuming problems in real-time and multiple observations in hospital settings, but also provides a fair and equal learning opportunity, as well as a fair assessment of students’ clinical competency.

Due to the feasibility of providing different scenarios at any time and in any location, SP training or assessment can be arranged for students according to the curriculum schedule instead of waiting for patient availability (Becker et al., 2006). The course or programme objectives can be predefined and reliable experience can also be fairly reproduced for all students in core to complex skills and fulfil different needs at all levels of healthcare programmes (Owens & Gliva-McConvey, 2015). Consequently, the curriculum is reinforced and strengthened to enhance students’ learning at different levels of the programmes.

**Challenges of Integrating the Standardized Patient in Nursing Education**

Although the SP method has been integrated into nursing education, it has not yet been fully involved (Becker et al., 2006; Bornais et al., 2012) because there are still many challenges.

The success of the SP method depends on a well-trained SP. Ha (2018) stated that well-trained SPs boost nursing students’ self-confidence, improve their problem-solving, and enhance their critical thinking and clinical judgement. This reflects the importance of having a well-trained SP as this affects the quality of the SP method. In fact, the SP training is a main factor that contributes to the performance of SPs (Liao, Kao, Liang, & Hsieh, 2015). However, there is a lack of evidence on the best training practices and there is limited research on the best practices for the recruitment, training and retention of SPs for simulation-based learning experience in nursing education (Keiser & Turkelson, 2017). Expertise is also required for recruiting, training and evaluating SPs and developing related training materials (Howley, 2013). Different challenges are encountered in the whole process of training SPs which are discussed below.

The recruitment of a qualified SP is the first challenge. Faculties have to consider the minimum qualifications for the SP which depend on the nature of the role and the SPs encountered (Howley, 2013). For instance, if the SP needs to portray a highly emotional patient, an applicant with acting or previous SP training experience would be beneficial. Howley (2013) pointed out that potential SPs should also be screened for any bias against medical professionals or any negative experiences with the roles they are being recruited to portray – otherwise, they may disrupt or detract from the encounters. Nevertheless, it is difficult for faculties to consider and identify all of the above issues when recruiting sufficient SPs due to the limitation of time, lack of applicants or financial concerns.
After the recruitment of an SP, the next challenge is the training process. It is a multistep process to ensure reliable, consistent and accurate portrayal of a case or character (Owens & Gliva-McConvey, 2015). Usually, sufficient information related to the scenario and the role of the SP – included the behaviours, signs and symptoms which he/she should present to students – should be provided to the SP before the training session starts. Also, the SP should be reminded about the speech patterns, emotional expressions, make-up and clothing to be used. All these issues depend on the communication between the SP and faculty to ensure that the SP is cooperative and well prepared. On the other hand, it is also necessary for the SP to be given sufficient time to ask questions to clarify the scenario and practice. The length of training time and number of training session to successfully train an SP for a case varies among educators depending on the complexity of the scenario (Owens & Gliva-McConvey, 2015). Moreover, there is insufficient evidence to support any specific method for training SPs (Howley, 2013). Although there are different training models or manuals describing how to train SPs to perform objective structured clinical examinations independently in medical education, very limited information has been published on how to train SPs for the low-stakes simulation-based learning experiences in nursing education and other healthcare disciplines (Keiser & Turkelson, 2017).

Another challenge is that the standard of an SP has to be evaluated, especially when more than one SP is being hired to portray the same scenario. In this case, the SPs recruited should be trained as a group, with clearly defined standardization. The impact of their performance should also be made explicit throughout the training (Howley, 2013). Faculties have to use more time for working with the SPs who portray the same scenario in such situations.

Last but not least, the whole SP training process and integration of the SP method into the curriculum also has a financial impact. For the planning of the SP method and the recruitment and training of SPs, the amount paid to SPs varies according to the role, encounter format, expectations and geography (Howley, 2013). Even after the SPs have been well trained, the pool of available trained SPs may be insufficient to meet the increased demand from different programmes (Keiser & Turkelson, 2017).

**Conclusion**

The integration of the SP method into nursing education is useful and benefits the students, faculties and curriculum, which explain why the SP method is still commonly used in different healthcare programmes – even with today’s development of educational technologies. Nevertheless, there are still many challenges ahead in integrating the SP method into nursing education which the curriculum designers have to seriously consider and resolve when planning the SP method. Further investigation on the SP training process would also be worthwhile.
References


A Simulation-based Health Assessment (SBHA) Programme: Design and Implementation

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Abstract

The increasing demand for safe practice by nursing graduates has resulted in additional authentic learning during their education. Simulation technology is an effective instructional method for preparing nursing students for exposure to their clinical practicums with safe hand-on practice on patients. However, the breadth and nature of simulation-based learning for the best nursing education practice is limited and not clarified with evidence in the Hong Kong context. In 2013, a simulation-based health assessment (SBHA) programme was designed based on the \textit{Standards of Best Practice: Simulation} from the International Nursing Association for Clinical Simulation and Learning (INACSL). The crucial fidelities for the physical, psychosocial, cultural and cognitive aspects were identified to construct the SBHA programme that aligned with the intended learning outcomes. This paper presents a justification for – and discusses how to design and implement – this programme for enhancing nursing students’ clinical competence.

\textbf{Keywords}: fidelity, instructional approaches, nursing education, simulation, simulation-based learning
Introduction

Nursing merely refers to the practice of health assessment with provisional care for the sick, and nursing students require both authentic and clinical learning opportunities before entering the profession. *Simulation-based learning* (SBL) refers to the physical resemblance of a simulator, or a simulated patient, requiring nursing actions in alignment with learning objectives. There is growing evidence that SBL experiences are valuable for enhancing nursing students’ clinical competence. However, challenges associated with the breadth and quality of SBL require evaluation with improved clarity and rigour to guide its appropriate use in nursing education (Kunst, Henderson, & Johnston, 2018).

Integrated simulation-based learning has been adopted as a convenient tool for consolidating what junior nursing students have learned at the mid-term of a nursing core course on health assessment in a teaching university in Hong Kong. Integrated simulation-based learning aims to consolidate taught knowledge and skills through hands-on practice in a session of simulation (Sinclair & Ferguson, 2009).

Sequential simulation-based learning consists of ensuring learners’ deep learning through several sessions of simulation, with realistic expectations. Sequential sessions provided by a SBL programme will be effective in facilitating learning transfer and enhancing clinical competence among junior nursing students (Cook et al., 2011; Weller, Nestel, Marshall, Brooks, & Conn, 2012). This paper justifies and describes the design and implementation of an SBL programme to enhance undergraduate nursing students’ clinical competence in health assessment based on the *Standards of Best Practice: Simulation* developed by the International Nursing Association for Clinical Simulation and Learning (INACSL) (Borum, 2013), and also guides the implementation of such a plan. This is followed by a discussion on the fidelity (realism) of SBL in health assessment which aims to justify the use of sequential simulation activities to facilitate learning (Meakim et al., 2013). The last section concludes with a discussion of how to implement SBL programmes for enhancing students’ clinical competence.

Conventional Education Practice

Undergraduate nursing students are training to be clinically competent in an authentic learning environment before they participate in clinical settings to provide safe patient care. Health assessment has been an integral part of the nursing process for identifying health problems. Nurses perform daily health assessments to make clinical judgements on various client health problems or levels of wellness. The course on *Health Assessment* aims to introduce a comprehensive and focused health assessment of individuals through developing skills in interviewing and performing a physical examination to collect nursing data for the documentation of their health status. The fundamental concepts and methods of health assessment for human body systems are presented using lectures, laboratories and a practical assessment with simulators.
A health assessment involves complex tasks of collecting subjective and objective data, with the application of appropriate methods depending on different situations. In conventional education practice, an instructor plans and designs a one-time integrated SBL for students’ application of all learned health assessment skills at the mid-term of the course. Two nursing students pair up in role-playing a nurse and a patient in practising their clinical judgements in laboratory sessions. Students can differentiate clinical conditions and attempt to solve them in a one-time integrated SBL. Their clinical competence is to be evaluated in a practical assessment after attending the integrated SBL.

The course contents of health assessment are rich in information that is essential for successful clinical performance in both the integrated SBL and the practical assessment. However, the course materials on all body systems are delivered via four hours of lectures and limited hands-on practice arranged in an hour-long laboratory session in each of the 13-week periods. Therefore, the vast amount of information in the course may cause cognitive overload so that only a few nursing students know how to organize their assessment findings in their practical assessment after the integrated SBL. With instructors’ observation and reflection, the weaker nursing students are still unable to assess and select the relevant information for decision-making in the integrated SBL activity. Students have commented that they were unable to react adequately to the scenario and required more preparation before attending the integrated SBL. The one-time integrated SBL developed along with technology results in inexperienced junior nursing students facing difficulty in being clinical competent because they only receive feedback in the debriefing without a second chance to transfer what they have learned in the next SBL. Repetitive practice in sequential SBL activities is one of the solutions.

Method

Meakim et al. (2013) defined fidelity as “the degree to which a simulated experience approaches reality; as fidelity increases, realism increases.” (p. S6). With the deployment of essential fidelity components, a believable and practical SBHA programme can be designed to engage nursing students’ learning. An SBHA programme considers various fidelity components, viz. (1) physical factors, such as the clinical learning environment, equipment, and assessment tools; (2) psychological factors, such as the self-awareness of participants’ roles; (3) social factors, such as the roles of instructors and the instructional approach they use for motivating students; (4) the culture of the group; and (5) cognitive aspects, such as participants’ modes of thinking. These five types of fidelity inform the outline of an SBHA programme.

Results

A simulation-based health assessment (SBHA) programme aims to enhance undergraduate students’ clinical competence in an authentic learning environment, which is relatively practical, safe and interactive, and incorporates scaffolded scenarios in sequential SBL activities. The SBHA programme refers to the sequential SBL that can
help nursing students to engage in an authentic learning process with adequate levels of fidelity that are defined by INACSL (Meakim et al., 2013).

**Physical Fidelity**

The clinical environment is set at a medical ward in an acute hospital where nursing students approach newly admitted simulated patients and simulators. The simulated patients are trained for two hours to become familiar with their demographics, present health concerns, past health and family health history, and lifestyles and health practices. Scripts are provided for their rehearsal with the instructors. The simulator is a life-like mannequin with an audio-visual real-time live session recording to present the pre-set physical parameters for students to assess vital signs and make objective findings.

A template of the nursing documentation form is designed to enhance understanding of the health assessment process, interview the simulated patients in a private room, and perform a physical assessment on the simulators at the bedside. The nursing documentation form consists of five parts including nursing health history, a general survey, physical assessment, investigation and results, and progress and intervention. It directs nursing students towards sophisticated uses of nursing knowledge, skills of health assessment and clinical reasoning. Also, it integrates all the tasks in a health assessment and their records for making a clinical judgement and learning transfer.

**Psychological Fidelity**

Nursing students are informed of their assigned roles in psychological fidelity before their SBL activities. The undergraduate nursing students are categorised into three roles of learners in either performing various clinical skills, observing peer performances to reflect on their actions in debriefing sessions, or partnering with teammates to provide collaborative care. They participate in SBHA programmes to enhance their clinical competence and play the roles of “Performer,” “Observer,” and “Partner,” (POP) in rotation.

**Performers**

The performers are expected to apply nursing concepts in practice, conduct assessments, learn about the clients’ nursing goals and outline and implement a nursing care plan (Hoffmann, O’Donnell, & Kim., 2007; Kaplan & Ura, 2010; Ko & Kim, 2014; Meyer, Connors, Hou, & Gajewski, 2011; Swenty & Eggleston, 2011). Nursing students with roles as performers are instructed to be interactive with the simulated patients and simulators by performing assessments. They must also determine priorities in giving appropriate care and health education that are indicated.

**Observers**

The observers can critique the paired-up nursing students’ actions in a distant classroom via wireless audio-visual real-time monitors or in an adjoining room via a one-way mirror (Alinier, Hunt, Gordon, & Harwood, 2006; Badir et al., 2015; Kaplan &
Ura, 2010; Hoffmann et al., 2007). They are instructed to take notes on their peers’ performances and critique such actions in the debriefing (Alinier et al., 2006; Badir et al., 2015; Swenty & Eggleston, 2011). Observers are recommended to observe specific areas, including peers’ communication, teamwork, situational awareness, decision-making, and clinical skills. Student observers can be exposed to a wide range of cases in a relatively short period of SBL learning experiences (Alinier et al. 2006).

**Partners**

Nursing students must work with their peers in partnership with at least one or more students in a group so that the pair or small group can be interactive with the simulated environment and instructors during SBL. Hoffmann et al. (2007) reported that partners are encouraged to exchange knowledge to solve the authentic problems and engage in dialogue with the performer, interpreting embedded information during the SBL, so that collaboration and cooperation are enhanced.

**Social Fidelity**

While an SBL session is running in real-time, instructors can promptly create cognitive challenges that motivate nursing students to communicate ideas and solutions with their partners. Therefore, nursing students are allowed to receive hints on their actions rather than delaying feedback until the end of a debriefing. During an SBL, instructors are responsible for enhancing the social interaction similar to the mentoring or coaching in a clinical practicum.

**Roles of instructors**

In contrast to conventional education practice, instructors need to apply instructions appropriately for preparing, implementing and evaluating a sequential SBL programme. For example, an instructor “scaffolds” a given situation to make appropriate, timely prompts before, during and after the SBL (Issenberg, McGaghie, Petrusa, Gordon, & Scalese, 2005; Ko & Kim, 2014). Therefore, the instructor plans and designs the topics/situations of the SBHA programme from simple to complex for nursing students to accumulate health assessment experience.

**The deployment of instructional approaches**

The application of instructional approaches requires awareness of where in an SBL session a question should be raised to guide or probe students’ responses. Examples of interactive questions can be seen in Table 1 as the facilitation process before and during the SBL. The approaches adopted by the instructors behind the sequential SBL programme might contribute to enhancing clinical competence. The SBL environment helps the instructors to differentiate the critical teaching moments in clinical performance.
Information with an advanced organizer which occurs in an experiential learning environment can allow students time to process and consolidate new knowledge and skills, as well as develop clinical judgement (Ko & Kim, 2014). Instructors deploy the advanced organizer to give a sense of direction to students so that they know how they are expected to act the roles of “POP” in a sequential SBL activity.

Drills and practice must start at the onset of the course and before each of the SBL activities to reduce students’ anxiety and confusion, as well as during the SBL. By having students’ skills prepared well before attending the SBL, there will be more time for them to spend on smoothly collecting data and making clinical judgements collaboratively during the SBL (Mikkelsen, Reime, & Harris, 2008).

Experiential learning extends from a sole to a social perspective with situated learning in contexts that emphasize what is to be learned at a specific point in time for the problems to be resolved (Kaplan & Ura, 2010). Kaplan & Ura (2010) illustrate how instructors have somehow changed their approaches to facilitating SBL effectively. Instructors have reported that they can address student misunderstanding more easily because of their social presence for real-time feedback at the bedsides during simulation rather than being stationed in the control room (Coffman, 2012; Meyer et al., 2011; Swenty & Eggleston, 2011). The instructor’s social presence in the scenario benefits students to provide immediate feedback when performers and partners are unable to progress in the task.

Cultural Fidelity
Expert performances from the instructors allow the performers, observers, and partners to learn from the professional modelling. The instructor offers the social presence of professional nursing staff as one of the distinct cultural fidelities for mentoring students on their roles in “POP”. This situation gives multiple opportunities with known tasks for a demonstration of clinical competence, and allows for a sort of collaboration as teamwork with students’ roles in “POP”; and it encourages nursing students to learn from others with meaningful reflection and familiarization in the nursing professional field (Issenberg et al., 2005).

Cognitive Fidelity
The cognitive fidelity allows the performers, observers, and partners to accumulate strategies for problem-solving in the SBL activities and debriefing. By applying a few interactive questions during the simulation session, the instructors can guide and probe the nursing students’ performance and clinical judgement. Interactive questions from instructors can help more passive students to prepare and engage in the SBL in a less threatening manner (Coffman, 2012; Issenberg et al., 2005).

With the explanation of participants’ objectives, students should have multiple opportunities to engage in activities which require the concurrent execution of the three roles of “POP” for different aspects of the situation. Instructors can work with
students to mould their thinking clinically and encourage a collaborative searching for suggestions and solutions from the SBL environment to promote clinical judgments and clinical competence (Coffman, 2012; Meyer et al., 2011; Swenty & Eggleston, 2011). As noted before, examples of interactive questions based on difference instructional approaches can be seen in Table 1.

**Outline of the SBHA Programme**

The SBHA programme is constructed by five fidelities to facilitate students to act roles in “POP” in an authentic clinical environment with a simulated patient and simulator in simple to complex situations. Students receive real-time responses from the simulated patient and simulator, immediate feedback from the instructor, and achieve the pre-set participant objective (Meakim et al., 2013). Each student plays the roles in ‘POP’ alternatively; responds to a simulated patient via a health history interview; performs a physical examination on the simulator; presses on the patient’s monitor touch screen that corresponds to the pre-set physical signs of the simulator; and documents all the findings with sensible decisions. The instructor’s computer captures students’ responses and actions via the cameras at the bedsides where aggregated results can be presented for debriefing. Therefore, the instructional approaches occur once learners access the course in health assessment to go through the SBHA programme.

The particular instructional approaches – such as advanced organizers, drills and practice – are vital features for engaging learners in a challenge that emphasizes more sophisticated uses of knowledge and skills, as well as inquiring collaboratively, to solve simple to ambiguous problems via situated and experiential learning. Also, the instructor directs students to transfer learning on attributes of clinical competence into new situations at the debriefing. Through the use of these instructional approaches, five scaffolding scenarios with intended learning outcomes are designed in the sequential SBL programme. The key fidelities of the SBHA programme aligned with the learning objectives are illustrated in Table 2. The SBHA programme is presented in loops by going through the three phases as the arrows shown in Figure 1.

**Discussion**

One of the primary objectives for instructors implementing the SBHA programme is to engage learners in the briefing. Instructors should provide an advanced organizer with a rationale to engage learners in their roles for “POP”; help their understanding of social fidelities and the importance of participation in the SBHA programme; and show how it will benefit them after each of the activities. Students must be told the prerequisite requirements of the concepts taught, procedures and principles, and the learning objectives before each of the SBL activities so that they can check whether they are ready psycho-socially.

Since the health assessment course contains skills for taking health history and physical examinations that are new and unfamiliar to students with no previous clinical
placement, drills and practice can be used to practise the sense of psychological fidelities before the SBL activities. Instructors must group all the information provided to prevent information overload and allow adequate opportunities for drills and practice.

Instructors should design and use test questions to activate the prerequisite knowledge before each SBL activity, so that students are motivated and engaged in the SBL experiences. Performers can connect new skills and knowledge in a SBL experience with appropriate physical fidelities to what they have learned in lectures on health assessment.

During participation in SBL activities, performers and partners are expected to complete and interact with proper social fidelities to achieve the intended learning outcomes. The attributes of the SBL activities and social intersection are the purpose of situated experiential learning, viz. to bridge the theory-practice gap in healthcare and nursing education (Bradley & Postlethwaite, 2003; Gaba, 2004; Weller, 2004). The intended objectives focus on the application of health assessment in scaffolded topics to mould nursing students to think clinically. The simulated patient or simulators need to be adopted and considered for writing appropriate scripts for teaching purposes. The SBL activities should allow social interaction to proceed simultaneously in the scaffolded scenarios. Performers should be able to conduct health assessment by collaborating with partners, performing physical examinations and making sound clinical judgements in SBL activities. Observers can provide peer feedback with instructor’s facilitation to improve all participants’ performance in the next cycle of SBL with learning transfer.

In addition to the social interaction in the situated and experiential learning, SBL can promote the construction of an active professional identity and socialization by observing the instructor’s professional behaviours (Bligh & Bleakley, 2006). Through encountering each of the SBL activities, the performer and partners collaborate in working with instructors so that they can benefit from each other’s strengths. Observers are provided with a good model from the social environment to appreciate the importance of health assessment and to engage in the enhancement of clinical competencies at the next SBL. A well-designed scaffolding scenario in the SBL is a key for physical fidelities to connect classroom-based and work-based learning, incorporating not only the acquisition of knowledge and skills but also the cultural and professional practices that are present in actual healthcare work environments (Bligh & Bleakley, 2006).

Lastly, instructors should provide a debriefing after each of the SBL activities which students need to guide their reflection and increase their chances of success in the next SBL activity. When students accumulate their SBL experiences, they should have experienced all of the three roles for POP in sequential SBL activities. They will be able to evaluate their performance in a scenario-based application on the attributes of clinical competence as a learning transfer. The SBHA programme offers the opportunity to enhance clinical competence in various simulated contexts for those who begin and
continue their professional training. Its effectiveness can also be evaluated against the standard criteria of clinical competence.

Clinical competence can be objectively measured through a summative assessment, using the objective standards of professional nursing practices, including knowledge, skills, clinical judgement, satisfaction and self-confidence that are highly correlated constructs of clinical competence. These can reflect and predict a student’s quality of performances (Prion, 2008).

**Conclusion**

This paper has discussed the evidence that could inform the design of an SBHA programme to enhance clinical competence in health assessment. The application is a modification of instructional approaches, as well as an inclusion of simulation technology, to cater to students’ need for active, diverse and interactive learning in an authentic clinical environment. As with the necessary instruction approaches for the design of the sequential SBL activities, the SBHA programme is incorporated into one of the core nursing courses – *Health Assessment* – in a teaching university in Hong Kong. Further empirical research is required for evaluating the effectiveness of SBL programmes for developing participants’ clinical competence.

**References**


Table 1. Respective instruction approaches with examples of interactive questions.

<table>
<thead>
<tr>
<th>Instruction approach</th>
<th>Benefits</th>
<th>Instructor’s responsibility</th>
<th>Examples of interactive questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced organizer</td>
<td>Provide “POP” with a sense of direction</td>
<td>Keep “POP” focused on the relevant information before the SBL</td>
<td>“As you describe patient’s feelings of dull chest pain, what might make this pain show vital signs or else change?”</td>
</tr>
<tr>
<td>Drills and practice</td>
<td>Provide “Performers” to do assessment systematically</td>
<td>Help “Performers” to develop skills of assessment and nursing documentation before the SBL</td>
<td>“Should we select a nursing assessment form to assist assessment and documentation for a client with chest pain?”</td>
</tr>
<tr>
<td>Situated experiential learning</td>
<td>Facilitate “POP” understanding of new information linking it to clinical judgement</td>
<td>Work with “POP” to establish criteria for comparison and reflection during and after the SBL</td>
<td>“Chest pain caused by a heart attack or acid reflux feels partly similar: Let’s recognize the possible cause of chest pain based on our collected data.”</td>
</tr>
<tr>
<td>Collaborative inquiry</td>
<td>Take “POP” to see the whole learning process using a simulation</td>
<td>Provide immediate sources of information that “Performers and Partners” can use when making a clinical judgement during and after the simulation</td>
<td>“What information should we look for now?”</td>
</tr>
</tbody>
</table>
Table 2. Alignment with SBHA programme’s learning objectives

<table>
<thead>
<tr>
<th>Physical fidelity code</th>
<th>Intended learning outcomes code</th>
<th>Psychological fidelity</th>
<th>Social fidelity</th>
<th>Learning objectives</th>
<th>Alignment with codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Overview of health assessment in ward settings</td>
<td>1. Reconstruct new nursing knowledge</td>
<td>Performer</td>
<td>Advanced organizer</td>
<td>Review key information/knowledge before attending the SBL</td>
<td>A, 4</td>
</tr>
<tr>
<td></td>
<td>2. Demonstrate correct psychomotor skills</td>
<td></td>
<td></td>
<td>Practise taught skills</td>
<td>B, 2</td>
</tr>
<tr>
<td></td>
<td>3. Demonstrate logical clinical judgement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Increase self-satisfaction and confidence to transfer learning</td>
<td>Situated and experiential learning</td>
<td>Perform assigned tasks and solve the problems</td>
<td>C, D, E, 1, 2, 3 &amp; 4</td>
<td></td>
</tr>
<tr>
<td>B. Interview with a simulated patient with discomfort</td>
<td></td>
<td>Drill and practice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Admit a heart attack patient</td>
<td></td>
<td>Situated and experiential learning</td>
<td>Reflect on the interaction between instructors and the small group</td>
<td>C, D, E, 1 &amp; 3</td>
<td></td>
</tr>
<tr>
<td>D. Admit a patient with epigastric discomfort</td>
<td></td>
<td>Collaborative inquiry</td>
<td>Work with the performers and instructors</td>
<td>C, D, E, 1, 2, 3, &amp; 4</td>
<td></td>
</tr>
<tr>
<td>E. Admit a patient with severe pain</td>
<td></td>
<td>Situated and experiential learning</td>
<td>Reflect on the interaction between instructors and the small group</td>
<td>C, D, E, 1 &amp; 3</td>
<td></td>
</tr>
</tbody>
</table>

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Figure 1 Phases of the SBHA Programme

Abbreviations: P = Performer, O = Observer, P = Partner
Student Satisfaction and Self-confidence towards Simulation among University Nursing Students in Hong Kong

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Abstract

Nursing is a profession which delivers high-quality patient care with a strong knowledge base and refined skills. Practicing in a clinical environment can be affected by many uncontrollable factors, such as issues of patient safety, unscheduled scenario or limited venues for clinical practice. Simulation has been widely used with nursing students as it provides unlimited chances for practice in a safe and programmed environment. It has been found that simulation is advantageous in nursing education for ensuring learning opportunities and avoiding harm to patients. In this survey, nursing students’ perceptions of simulation in a local university are explored. Year 1 university nursing students on a pre-registration nursing programme for Registered Nurses in a university in Hong Kong were surveyed by convenience sampling. The participants included 152 female and 41 male students. A questionnaire – the Student Satisfaction and Self-Confidence in Learning Scale (SCLS) – was used. Students reported a high level of satisfaction and confidence on the simulation session in the nursing courses.

Keywords: simulation, student satisfaction and self-confidence, university nursing students
Introduction

Expanding Use of Simulation in Nursing Education

Nursing is a healthcare profession which delivers patient care through the integration of theoretical knowledge and nursing skills. High-quality patient care requires not only knowledge and skills, but also a caring heart. The transformation of nursing students into nurses who are able to deliver high-quality patient care takes time. Clinical practice is an arena for such development. Simulation has been widely used with nursing and other health professionals as one of the teaching and learning strategies. It is considered as an integration of theory and practice by mimicking real-life situations to facilitate student learning (Moule, Wilford, Sales, & Lockyer, 2008). Simulation is used to promote active participation of students in delivering patient care or management in a safe environment by providing room for knowledge construction and psychomotor skills development (Sinclaire & Ferguson, 2009).

The expanding use of simulation in nursing education is driven by factors such as an inadequate number of clinical placement venue (Richardson & Claman, 2014) and issues of patient safety (Rakshasbhuvankar & Patole, 2011; Schubet, 2012). Firstly, insufficient clinical placement venues limits students’ exposure to adequate clinical experience because opportunities for hands-on practice are reduced. Secondly, patient outcomes are another dilemma which needs to be considered before nursing students learn in certain situations, such as the resuscitation of patients with cardiac arrest. The need for resuscitation happens without a warning sign, and may finish in a short time with all the staff being occupied during the procedure. In such a process, students can hardly be expected to raise questions, and integrate knowledge and practice. However, with simulation, students’ exposure to such events can be greatly enhanced by unlimited mimicked sessions without any worries about the issue of patient safety (Nagle, McHale, Alexander & French, 2009).

Simulations Mimicking the Clinical Environment at Different Levels

There can be different levels of resemblance to the clinical environment – from low-, medium- to high-fidelity – depending on educational needs (Jeffries, 2007; Weller, Nest, Marshall, Brooks, & Conn, 2012). Low-fidelity simulation refers to the most basic level of resemblance such as the administration of an injection to an intravenous training arm or an intramuscular injection to the hips which are less similar to reality. A medium-fidelity simulation requires a higher level of resemblance. For example, a demonstration of cardio-pulmonary resuscitation needs a full body mannequin that shows the chest rising during resuscitation, with the students giving breath to the mannequin. Most simulation takes place at low- and medium-fidelity levels. High-fidelity simulation provides the most authentic experience for students. For example, a demonstration of intubation requires a computer-generated simulation to show physiological and pharmacological responses, such as oxygen saturation, with which students can interact. Simulation can be used to replace some clinical hours (Hayden & Gross, 2014) by using...
low-fidelity, medium-fidelity, high-fidelity, or even hybrid simulation which is a mix of different fidelities to re-create the required clinical environment.

**Advantages of Simulation to Healthcare Professionals**

Studies have found that simulation can benefit healthcare professionals by improving performance in clinical practice (McCaughey & Traynor, 2010); critical thinking (Schubet, 2012; Secomb, McKenna, & Smith, 2012); self-confidence and satisfaction (Raman, Noronha, Michael, Madhavan, & Ramasubramaniam, 2014); communication skills (Young, Eun, & Sook, 2012); and clinical decision-making (Powell-Laney, Keen & Hall, 2012).

Nurses need to interact with people in daily work such as when they perform health assessments, deliver nursing interventions, and perform teamwork, and lack of self-confidence is detrimental (Hart, Spira, & Moreno, 2014). Simulation has been found to be beneficial to nurses and is widely used in training nursing students. Students’ satisfaction with simulation is a significant indicator in the nursing education industry. Some studies have shown that nursing students are highly satisfied with simulation training (Laschiniger et al., 2008). However, a paper by Yuan and colleagues (2011) indicated that the outcome of simulation on enhancing students’ confidence is inconsistent.

**Methods**

**Aims and Objectives**

This study aims to survey university nursing students’ experience of simulation learning with regard to their satisfaction with instruction and self-confidence in learning. The study’s objectives are (1) to measure student’s levels of satisfaction and self-confidence in simulation and (2) to explore the relationship between satisfaction and self-confidence.

**Study Design, Setting, Sample and Sampling**

A cross-sectional survey was carried out in the School of Nursing and Health Studies in the Open University of Hong Kong. The School offers training programmes for nurses, including at bachelor’s level. Low- to medium-fidelity simulations are used in the junior nursing courses. The nursing student participants were gathered by convenience sampling, and questionnaires were distributed to students after the simulation training sessions.

**Data Collection and Data Analysis**

The data collection tool was a self-reported questionnaire, which was composed of demographic data – including year of study and gender – and a Student Satisfaction and Self-confidence in Learning Scale (SCLS). SCLS was composed of two subscales, including five items measuring student satisfaction with simulation instruction and eight items measuring student self-confidence in learning. The reliability of SCLS
was satisfactory with Cronbach’s alphas of 0.94 and 0.87 for student satisfaction and self-confidence in learning respectively (Jeffries & Rizzolo, 2006). The subscale for satisfaction with instruction measured satisfaction with teaching methods, the diversity of learning materials, facilitation, motivation and the overall suitability of simulation. The self-confidence in learning subscale measured self-confidence in mastering content, content necessity, skills development, available resources and knowledge of the way to seek help to manage the clinical scenario. Students responded by using a 5-point Likert Scale. The response options were (1) “strongly disagree”, (2) “disagree”, (3) “undecided”, (4) “agree” and (5) “strongly agree”. The scores were summed up, with the higher scores being interpreted as showing more student satisfaction and confidence.

The data were analyzed by IBM SPSS Statistics version 22. For demographic data, percentages were used to describe the proportion for each gender. Descriptive statistics, such as range, mean and standard deviation, were used to describe the scores on the SCLS. The relationship between satisfaction and confidence was analyzed by Pearson’s correlation.

**Ethical Considerations**

Ethical approval for this study was obtained from the university. Explanation of the survey, voluntary participation and the right to withdraw were mentioned in advance. No names were required for this survey.

**Results**

**Demographic Characteristics**

The total number of participants in this survey was 193. The questionnaires were distributed after a simulation training session and were collected right away. The response rate was 100%. Of these Year 1 nursing students, 152 (78.8%) were female.

**SCLS Scores**

For satisfaction with simulation instruction, scores ranged from 12 to 25 out of 25 (M = 19.21, SD = 2.22). Students mostly agreed with the statement “The simulation provided me with learning materials and activities to promote my learning”. The statement which had the lowest level of agreement was “The teaching materials used were motivating and helped me to learn”. “Self-confidence in learning” ranged from 21 to 40 out of 40 (M = 30.10, SD = 3.304). Most students agreed with the statement “It is my responsibility to learn what I need to know from this simulation activity”, while the lowest level of agreement was on the statement “The simulation covered critical content necessary for mastery”.

The mean scores on the five items on student satisfaction with simulation ranged from 3.80 to 3.87 out of 5, while the mean of the eight items on self-confidence in learning ranged from 3.64 to 3.94 out of 5. The range of the response on the 5-point Likert scale was as follows: “strongly disagree” – 0% to 0.5%; disagree” – 0% to 3.6%;
“neither agree nor disagree” – 12.4% to 35.2%; “agree” – 59.1% to 79.8% and “strongly agree” – 3.6% to 13.5%. For student satisfaction with simulation instruction, the mean scores for males and female were 19.51 (2.087) and 19.13 (2.254) respectively; and for self-confidence in learning, the means for males and females were 30.24 (3.285) and 30.07 (3.319) respectively. No statistically significant difference was found on gender: student satisfaction (t (191) = 0.974, p > .05) and self-confidence (t (191) = 0.306, p > .05).

The relationship between student satisfaction with simulation instruction and self-confidence in learning was investigated using Pearson’s correlation coefficient. Preliminary analyses were performed to ensure that there was no violation of the assumptions of normality, linearity and homoscedasticity. There was a strong, positive correlation between student satisfaction and self-confidence (r = 0.749, n = 193, p < .0001).

Discussion

Overall, the results showed students’ satisfaction with simulation and self-confidence in learning. These results are consistent with the previous literature (Agha, Alhamrani & Khan, 2015; Mould, White, & Gallagher, 2011; Omer, 2016). The high score in SCLS indicated students’ acceptance of simulation as one of the teaching and learning strategies, with their responses heavily skewed on “Agree”. However, as Year 1 students, they might have tended to rank the score higher to the expected level, so this study should be replicated in other years to survey students’ attitude towards simulation. Furthermore, simulation with different fidelities has different resource implications. While high-fidelity simulation may require more costly equipment, it provides advanced level training in clinical scenario management; and low-fidelity simulation is more cost-effective, but is less authentic. A survey could be carried out after simulations with different levels of fidelity to explore students’ perceptions at different fidelity levels and get information on resource allocation for teaching and learning strategies in different years of study.

This study had several limitations. It did not use probability sampling which may have affected the generalizability of the results. Also, the results may not be generalized to the whole nursing student population as the data were obtained from junior year nursing students from one university. Lastly, the findings from this survey were based on self-reported data which might be subjective.

Conclusion

Simulation is widely used in the training of health care professionals because of limited venues for clinical practice and for the safety of patients. The results of this study reinforced the view that students accept simulation as a teaching and learning strategy in university nursing education. Further studies are needed to provide information on resource allocation in simulation design in nursing education.
References


Substitution of Traditional Clinical Experience with Simulated Clinical Experience in Pre-licensure Nursing Programmes: A Scoping Review

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Abstract

There is increasing pressure for local nursing boards and accreditation bodies to undergo transformation, with simulated clinical experience (SCE) being seen as a substitute for traditional clinical experience (TCE), i.e. direct patient care, because of the shortage of clinical supervisors and limited practice opportunity in the complex healthcare environment. This is reflected in the rise of simulation-based training in the nursing profession. The purpose of this scoping review is to provide an overview of the relevant literature on the emergence of the substitution of TCE with SCE in pre-licensure nursing programmes and to identify the gaps in the literature. Electronic databases, Pubmed, Medline and CIHNAL, and searching by hand for research studies were adopted. The search identified 13 articles published from 2005 to 2019. Four themes emerged from reviewing this literature, including learning outcomes and assessment, matters related to simulation scenarios, administrative considerations and students' learning experience in the SCE.

Keywords: simulation, traditional clinical experience, substitution, nursing
Introduction

Clinical practice has been a traditional and fundamental component in the nursing curriculum for developing various professional competencies of nursing students worldwide. The requirements for clinical practice in various clinical areas and the practice hours are regulated by the local nursing board or accreditation bodies (Bowling, Cooper, Kellish, Kubin, & Smith, 2018; Nursing Council of Hong Kong, 2014).

Despite the stipulated quantity of the practice hours in specific clinical areas, the quality of clinical experience has been affected by the limited opportunity for hands-on practice by nursing students in the complex healthcare environment. Safety issues have become a matter for concern, with a shortage of nurse human resources compromising their roles in clinical teaching and supervision (Sportsman et al., 2009).

Some Western countries have adopted simulation to create a simulated clinical learning environment for the practice hours in the nursing curriculum in an effort to combat the suboptimal clinical experience of nursing students in the clinical settings (National Council of State Boards of Nursing, 2016). However, the amount of simulation, and how it can be a successful substitute for the clinical practice of nursing students, remains controversial (Larue, Pepin, & Allard, 2015). Also, little focus has been placed on how simulation could be adopted locally to raise the quality of the clinical experience. Therefore, this scoping review aims to: (i) provide the overall view in the current literature on substituting simulated clinical experience (SCE) for traditional clinical experience (TCE) in pre-licensure nursing programmes; (ii) identify the components of the simulation substituting or augmenting the clinical experience of nursing students; and (iii) explore the challenge ahead with the actualization of the substitution of simulation for TCE.

Methods

The methodology of this scoping review was underpinned by the five-stage framework of Arksey and O’Malley (2005), namely, (i) identify the research question; (ii) identify relevant studies; (iii) study selection; (iv) chart the data; and (v) collating, summarizing and reporting the results.

Identify the Research Question

This review was guided by the question, “In the literature, what are the characteristics and scope of substituting SCE for TCE in the pre-licensure programmes?”

Identify Relevant Studies

The studies were identified by an online search in three electronic databases for all years, including MEDLINE (1946+) via Ovid, CINAHL Complete via EBSCOhost and PubMed. Search terms included combinations of the following keywords: nursing, simulation, undergraduate, baccalaureate, pre-license, pre-registration, student,
substitute, alternative, replace, experience, practice, skill, placement, hour. Also, an additional manual search was performed with other resources, e.g. reference list of identified articles. The search process ended on 26 January 2019.

Studies were included in the scoping according to the following prior criteria for eligibility: (i) the article reported a primary study; and (ii) simulation clinical experience was used as a substitute for traditional clinical placement. Peer-reviewed articles not written in English or articles without full-text for examining were excluded. Since this review is targeted at identifying the current knowledge on substituting simulated clinical experience (SCE) for traditional clinical experience (TCE), studies were included in the review process when faculty preparation was measured as an outcome.

**Study Selection**

Using the key search descriptors, 227 articles were retrieved, of which 122 were excluded as being identified as duplicated articles. A further 87 articles were then identified as not relevant to the topic with reference to the inclusion and exclusion criteria. These articles were excluded because simulation was used as an additional teaching strategy instead of an alternative to tradition clinical experience. Eighteen articles were included at the stage of full-text screening. Among these 18 peer-reviewed articles, one was not in English (Kim, Lee, & Chae, 2012); two reported simulation experience being used to accompany traditional clinical experience (TCE) or as an additional learning experience (Hansen & Bratt, 2017; Woda, Hansen, Paquette, & Topp, 2017); and another two reported simulated experience not being used as an alternative to traditional clinical experience (Gates, Parr, & Hughen, 2012; Williams, French, & Brown, 2009).

Finally, 13 articles were included in this review (Badowski & Oosterhouse, 2017; Bearnson & Wiker, 2005; Curl, Smith, Chisholm, McGee, & Das, 2016; Hayden, Smiley, Alexander, Kardong-Edgren, & Jeffries, 2014; Lambton, 2008; Meyer, Connors, Hou, & Gajewski, 2011; Richardson, Goldsamt, Simmons, Gilmartin, & Jeffries, 2014; Schlairet & Fenster, 2012; Sears, Goldsworthy, & Goodman, 2010; Simonelli & Paskausky, 2012; Singleterry, 2019; Soccio, 2017; Woda, Schnable, Alt-Gehrman, Bratt, & Garnier-Villarreal, 2018). The process of article selection followed the Preferred Reporting of Items for Systematic Reviews and Meta-analysis (PRISMA) Statement (Moher, Liberati, Tetzlaff, & Altman, 2009). Figure 1 below shows a flowchart of the studies included in this review.

**Data Charting and Collation**

Data were charted in a prior designed table according to the following categories: (a) authors and year of publication, and location; (b) study design; (c) sampling method and venue of recruitment; (d) characteristics of participants; (e) characteristics of the nursing programmes; (f) simulated clinical experience; (g) outcome measuring instruments; and (h) important results. The table was refined during the review process, particularly in the categories of outcomes of simulated clinical experience.
Results

Of the 13 studies, 12 were conducted in the United States, the exception being Sears, Goldsworthy and Goodman (2010) which was carried out in Canada. The studies were published between 2005 and 2019.

A total of 3,024 participants took part in the 13 studies. The sample size ranged from 29 to 1451, with this not being reported in one study (Bearson & Wiker, 2005). The participants were students in Bachelor of Nursing or Associate Degree programmes in universities or community colleges.

In terms of research design, there were eight quasi-experimental studies (Badowski & Oosterhouse, 2017; Curl et al., 2016; Lambton, 2008; Meyer et al., 2011; Sears et al., 2010; Simonelli & Paskausky, 2012; Singleterry, 2019; Woda et al., 2018); two descriptive studies (Bearson & Wiker, 2005; Richardson et al., 2014); two mixed-method studies (Schlairet & Fenster, 2012; Soccio, 2017); and one longitudinal randomized controlled study (Hayden et al., 2014). The studies ranged in length from one semester to two years.

Substituting SCE for TCE was adopted in several nursing procedures and clinical specialties. It was used in medication administration and safety procedures (Badowski & Oosterhouse, 2017; Sears et al., 2010); the nursing management of post-operative pain (Bearson & Wiker, 2005); nursing assessment (Hayden et al., 2014); medical-surgical nursing (Hayden et al., 2014; Richardson et al., 2014; Sears et al., 2010); obstetrics nursing (Curl et al., 2016; Hayden et al., 2014; Simonelli & Paskausky, 2012); paediatric nursing (Curl et al., 2016; Hayden et al., 2014; Lambton, 2008; Meyer et al., 2011); community nursing (Hayden et al., 2014); mental health nursing (Curl et al., 2016; Hayden et al., 2014; Soccio, 2017); critical care or advance medical-surgical nursing (Curl et al., 2016; Hayden et al., 2014; Singleterry, 2019). Also, the overall does and sequence of substituting SCE for TCE was evaluated in Schlairet & Fenster’s work (2012).

An overview of the 13 studies is presented in Table 1. Despite the variation in the articles, the characteristics of simulated clinical practice sessions were shared among the studies in Table 2.

Learning Outcomes and Assessments of SCE

The number of clinical incidents and effects of simulation were investigated in a quasi-experimental study by Sears et al. (2010). It focused specifically on the influence of SCE on students’ ability to administer medication safely. Students with SCE prior to clinical placement made fewer medication errors than those without SCE. Although SCE was substituted for some TCE early in the term, the number of simulated clinical hours and the clinical specialty were not reported. Students’ knowledge on patient safety and
communication skills, together with their attitudes in teamwork, were another concern for safe clinical practice (Badowski & Oosterhouse, 2017). While improvement in these areas were detected in the SCE group, the results were not statistically significantly different before and after the SCE.

Recent studies have shifted the focus to examining the effects of substituting SCE for TCE by evaluating the intended learning outcomes. Badowski and Oosterhouse (2017) reported improvements in knowledge and psychomotor skills in both the TCE and SCE groups by using an instructor-rated checklist at the end of an 8-week course, though the difference between the groups was not significant. When integrating SCE into the nursing curriculum, Schlairiet and Fenster (2012) used the final examination score in a basic nursing course to measure the knowledge level of students after receiving clinical experience of various designs of simulated schemes or direct patient care. Also, national standardized assessment – for example, the National Council Licensing Examination for Registered Nurses (NCLEX-RN) and Health Education Systems Inc. specialty exam (HESI) – was used for evaluating nursing knowledge and clinical competence after SCE, in particular for specialty nursing, such as mental health nursing, paediatric nursing, and maternal nursing and newborn care (Curl et al., 2016; Hayden et al., 2014; Soccio, 2017).

With the intention of evaluating the transfer of learning from simulated experience to clinical practice, there was another shift in focus – from psychomotor skills to a broader scope, including the evaluation of students’ clinical competency, critical thinking, and clinical judgement. This could be done by direct observation of the clinical performance and behaviours of students in simulated clinical and traditional clinical environments (Hayden et al., 2014; Schlairiet & Fenster, 2012; Woda et al., 2018). Woda et al. (2018) compared the clinical decision-making, self-confidence and anxiety of nursing students in two cohorts in a quasi-experimental study. Nursing students in the first cohort received SCE on medical-surgical nursing, while those in the second cohort received a supplementary SCE in addition to TCE. The result demonstrated that students in the second cohort performed better in patient assessment than those in the first cohort.

There is limited evidence on the long-term influence of substituting SCE for TCE. Hayden et al. (2014) reported that there was no statistically significant difference in clinical competency, comprehensive nursing knowledge assessment and NCLEX passing rate among 666 nursing students who received different proportion of SCE substitution of 0% to 10%, 25% and 50% randomly. The participants in this study were recruited from 10 nursing programmes across the USA and the outcomes were measured at three different time points, i.e. at 6 weeks, 3 months, and 6 months of practice as a newly registered nurse. Specifically, no difference was found in clinical managers’ ratings of the overall clinical competency and readiness for practice of the participants after registration.
Simulation Scenarios

Pre-SCE activities

Preparatory work before clinical experience, which has been described in several studies, may synergize the effect on learning. Pre-simulation learning activities, such as practising psychomotor skills in skill practice sessions (Badowski & Oosterhouse, 2017; Meyer et al., 2011), and discussing assigned case studies with the nursing faculty (Curl et al., 2016), were organized with the aim of facilitating the acquisition of the required fundamental skills and knowledge in the planned simulated scenarios (Badowski & Oosterhouse, 2017; Curl et al., 2016).

Also, unfolding the case scenarios were reported in the literature. In these studies, the scenarios were described and explained to the students to prepare them for success in the SCE. This happened one or two days before the SCE, via email or an online education platform, such as Blackboard, or on the same day as the SCE (Hayden et al., 2014; Schlairet & Fenster, 2012; Singleterry, 2019) or immediately before the start of the SCE (Sears et al., 2010; Simonelli & Paskausky, 2012).

Design and duration of simulation scenarios

The actual duration of simulation session varied among the studies. Curl et al. (2016) adopted 15 sessions of 30–45 minutes high-fidelity simulation (HFS) over a semester. In each session, a debriefing double the simulation time and a 30–60 minutes pre-simulation assignment discussion were also included. Apart from scattering multiple sessions across a semester, Badowski and Oosterhouse (2017) modified well-established case scenarios from the National League for Nursing (NLN) for student practice in three simulated clinical days, each of seven hours. The scenarios were also unfolded in those three simulated clinical days across a three-week period. Bearnson and Wiker (2005), however, adopted a much shorter period for substituting simulated experience for a traditional clinical day – only a two-hour session of simulated experience substituting for one clinical day after a five-week clinical rotation, with two consecutive clinical days in each week. Positive student perceptions on their learning experience were reported.

Some studies, on the other hand, reported the proportion of substitution instead of the actual hours of substitution and attempted to compare the effect from different proportions of substitution. Schlairet and Fenster (2012) investigated the effects from various proportions of simulation – 0%, 30%, 50% and 70%, in substituting for the traditional clinical weeks in a mixed-method study. Complemented with qualitative data, a 50% substitution with SCE might be most suitable for the students. In contrast, another multi-site study comparing three different combinations of substitution – with less than 10%, 25%, and 50% of SCE for TCE within a two-year programme – revealed no significant differences on nursing knowledge, clinical competency, and critical thinking. Although similar educational outcomes were produced among the groups, this might support the transfer of learning in simulated experience into clinical practice, despite the
different proportion substituting for traditional clinical hours (Hayden et al., 2014). With the current level of evidence, the answer to what is an effective duration of simulation or the amount substituting for clinical experience remains unclear.

**Modality of simulation adopted in SCE**

The selection of simulation modality, for example, high- and medium-fidelity manikins, role-playing, and computer-based critical thinking simulation, should be based on the objectives of the simulation scenarios (Hayden et al., 2014). A simulation curriculum was developed in their study, within which a series of simulation scenarios consistent with the NLN/Jeffries Simulation Framework were developed for use in the participating nursing programmes. This ensured the standardization of the quality of simulation scenarios among study sites.

Curl et al. (2016) also adopted multiple modalities when conducting SCE. In addition to the use of HFS for enhancing the knowledge level of students, self-paced simulation activity with written case studies or virtual simulations on computers were also included. Similarly, a single group pretest-posttest study by Singleton (2019) adopted both human patient simulators and actors to set up the scenario of pediatric nursing where the participating students needed to direct a mother’s first visit to her critically ill child who required multiple advanced monitoring equipment. This hybrid use of different simulation modalities could enhance the training on outcomes such as self-perceived confidence and communication skills.

The use of standardized patients solely for role-playing in the scenarios on psychiatric nursing was also essential, given the nature of the training for mental health students (Soccio, 2017).

**Expected student participation in the SCE**

Most studies have assumed the active participation of students, with different nurses’ roles assigned in the simulation scenarios. The roles of primary and secondary nurses, confederates as patients or relatives, peer coaches and observers were commonly found in the articles. Curl et al. (2016) reinforced students’ active participation in HFS as one of the criteria for successful substitution of HFS for TCE. The performance of students who assumed the active nurse roles was evaluated as their clinical competence, and a rotation of student roles involving various active caring activities was also common (Hayden et al., 2014). Badowski and Oosterhouse (2017) even took a proactive approach in introducing a peer coaching strategy during simulated practice to encourage students with observer roles to engage in the atmosphere of practice and share information with the students taking direct care roles.

**Debriefing after SCE**

Debriefing has been mostly reported as an essential component within a simulation module for reflecting their SCE together with the nursing faculty. Curl et al. (2016)
reinforced a debriefing duration by doubling it or making it equivalent to the duration of the simulated experience; and they specified its focus on clinical reasoning. Other studies attempted to use semi-structured questions or well-developed debriefing methods – for example, the Debriefing for Meaningful Life© method – with prior mandatory training on proficiency for faculty members to ensure the consistency and uniformity of interventions carried out in multiple study sites (Hayden et al., 2014; Singleterry, 2019).

Administrative Considerations

Scheduling of the SCE and TCE

The scheduling of TCE and SCE is mostly constrained by the existing curriculum design and the availability of clinical sites. In order to achieve the intended learning outcomes of courses, a match between SCE and the curriculum’s course content is preferable, but challenging. SCE could be used to compensate for the valuable opportunity of learning in the traditional clinical environment where the patients’ conditions were unpredictable, which hindered the students’ learning (Curl et al., 2016). Echoing the findings of Curl et al. (2016), students preferred undergoing the SCE prior to the TCE (Soccio, 2017). In this study, the students in a psychiatric-mental health nursing programme commented that SCE helped them to prepare better for communicating with and responding to patients, and managing patients’ behaviour in a traditional clinical environment. Further, in a randomized-controlled, longitudinal study involving multiple study sites – although flexibility was granted for each study site to schedule its own arrangement of simulated clinical experience throughout the nursing curriculum (Hayden et al., 2014) – matching the progression of study and complexity of clinical placement remained as the unavoidable consideration when planning TCE and SCE schedules.

On the other hand, three studies investigated the effect of varying the sequence and schedule of the simulated clinical experience. A mixed-method study in the United States compared various sequencing and percentage of simulated and traditional clinical days (Schlairet & Fenster, 2012), with seven sequencing patterns of clinical experience designed for comparison. In brief, clinical placement on a block or interleaved pattern was adopted within a six-week placement period. In the block pattern, students underwent (i) two weeks of TCE followed by another four weeks of SCE; (ii) two weeks of SCE followed by another four weeks of TCE; (iii) four weeks of TCE followed by another two weeks of SCE; (iv) four weeks of SCE followed by another two weeks of TCE; or (v) six week of TCE. For the interleaved pattern, students underwent SCE and TCE in alternate weeks with either TCE or SCE being started in the first week. Students were randomly assigned to one of the above clinical placement patterns where the substitution proportion ranged from 0 to 70% – specifically, 0%, 30%, 50% and 70%. A significant improvement in students’ clinical judgement levels was revealed in the interleaved type of clinical placement with 50% substitution of the SCE. Richardson et al.’s (2014) evaluative study also adopted an interleaved pattern in building its clinical teaching model and reported that students’ development of clinical skills, interpersonal
skills, and self-confidence improved. Furthermore, Curl et al.’s (2016) rotation of TCE and SCE approach was found to be effective in knowledge improvement. Such an approach not only got students ready to apply learned knowledge from SCE to TCE, but also helped them to utilize better the limited clinical placement quota.

**Human resource and faculty capacity in the SCE**

Faculty members play an important role in facilitating the students’ practice and debriefing during the SCE. With the substitution of SCE for TCE, some of the faculty’s human resources can be reallocated from supervision in clinical settings to simulated clinical experience. Many studies reported a student to faculty ratio of 4-6:1: in simulated clinical experience, but not in the clinical setting (Richardson et al., 2014; Schlairet & Fenster, 2012; Sears et al., 2010). Richardson et al. (2014) compared the utilization of faculty staff when different proportions of traditional clinical hours were substituted. In their paper, they argued that a well-designed clinical teaching model with up to a 49% increase in faculty capacity could be achieved over five years; while the student to faculty ratio could be reduced so as to enhance the quality of supervision in both traditional clinical and simulated settings.

**Students’ Learning Experience in SCE**

Students’ perceptions of their learning experience have mostly been positively evaluated, as supporting their knowledge, ability and confidence in performing various psychomotor skills and essential nursing procedures (e.g. the administration of medication) (Bearnson & Wiker, 2005). A mixed-method study by Soccio (2017) also attempted to compare the SCE and TCE of mental health nursing students with a qualitative questionnaire. The results showed positive student comments and the study supported the benefits of SCE over TCE because of its more diverse and intense learning opportunities, and first-person management.

Apart from the learning experience, whether the learning needs of students can be met in the learning environment is another concern in determining if the substitution with simulated experience is feasible. Hayden et al. (2014) compared the simulation and traditional clinical environment through students’ self-reported data. Those who received 50% substitution with SCE tended to rate the simulation environment better than those without any substitution, and vice versa. This probably reflects that students were receptive to the simulated environment as well as the traditional clinical environment in meeting their learning needs.

**Discussion**

The purpose of this article was to provide an overview of the replacement of TCE by SCE in pre-licensure nursing programmes. The researchers found that SCE was mostly adopted in replacing direct patient care of some clinical specialties, such as paediatric nursing, obstetric nursing, and mental health nursing. This may be due to a smaller number of clinical hours being required to fulfil registration in clinical nursing
specialties than medical-surgical nursing; and newly graduated nurses are likely to work in medical and surgical settings, where authorization bodies may be more likely to accept the substitution plan.

The introduction of the SCE as a substitute for TCE varied from 25% to 70%. Based on the findings of the studies included, the SCE enhanced students’ development in terms of their knowledge level, self-confidence, clinical performance and competency, critical thinking and judgement in a series of diverse and intense simulation scenarios. Also, students valued SCE as preparatory work and experience before TCE. While the difference between SCE and TCE on students’ development appeared to be minimal for pre-licensure nursing students, SCE may be a possible solution for addressing the shortage of faculty staff and clinical sites.

The preparatory work for conducting an SCE appeared to be greater than for supervising students in a traditional clinical environment. Although, pre-SCE activities could simply involve a mini revision of skills learned in nursing laboratories or describing the case to students before the SCE via an online platform, it could also be as complex as a pre-conference or a thorough discussion with the teaching faculty staff. However, which kind of pre-SCE activities benefit the students most is not yet known.

As noted from the studies covered, a combination of simulation modalities was used when implementing the SCE. This leads to an unavoidable initial investment of resources and faculty time. Adequate support for maintaining the simulation space and keeping equipment functioning is necessary. Moreover, faculty training on the use of different modalities of simulators, how to conduct a simulation session and debriefing skills is essential and guidance on its provision is crucial for SCE and students’ learning.

Students’ learning – specifically the integration of learned knowledge and clinical practice during the study programmes, and their readiness to practise – is no doubt an important issue when considering the schedule of the SCE and TCE. The findings of this review suggested that it is preferable for the SCE to be conducted before the TCE so as to get students ready for the precious time spent on direct patient care.

**Strengths and Limitations**

A scoping review was considered to be an appropriate methodology for describing the overall picture from a diversity of literature and heterogeneous body of knowledge. Quality assessment was not conducted, but it is infrequently performed in scoping reviews. However, with the development of a screening and data characterization form by the research team that, each citation and article was reviewed by two independent reviewers to ensure the relevancy and accuracy of the findings. The search was done on three databases, but ‘grey’ literature and articles not written in English were excluded, so relevant knowledge from these sources may not be reflected in this review. However, despite this, this scoping summarized the current knowledge on substituting SCE for TCE in an accessible way.
Conclusion

A review of literature found that substituting SCE for TCE has been adopted in a variety of nursing specialties of pre-licensure nursing programmes for. Four themes were identified from the literatures which may facilitate the planning of substitution SCE with TCE and be prepared for the challenges, including learning outcomes and assessment, matters related to simulation scenarios, administrative considerations and students’ learning experience in the SCE. Also, this review has described the current knowledge on adopting SCE to replace TCE, but almost all the studies were conducted in the USA, and so the results might not be generalizable to nursing programmes advised by different authorization bodies. Future studies are needed to explore the possibility of substituting SCE for TCE in other curricular models, as well as the ratio of traditional clinical hours to simulated clinical hours. The ratio of student to faculty staff should also be studied further to identify the most appropriate model of supervision. Finally, more studies could be carried out to supplement the limited evidence from medical-surgical nursing and other clinical settings or specialties.

References


### Table 1. An overview of the articles included (n=13)

<table>
<thead>
<tr>
<th>Author(s) (year)</th>
<th>Location</th>
<th>Study design</th>
<th>Sampling/Setting/ Sample size</th>
<th>Nursing programme/ Yr of study of programme/ Previous clinical or healthcare experience</th>
<th>Traditional clinical experience (TCE) Replaced</th>
<th>No. of hours/ % of programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badowski &amp; Oosterhouse (2017)</td>
<td>US</td>
<td>QE</td>
<td>Convenience/ 1U/ 29</td>
<td>ADN/ NR/ Y</td>
<td>Fundamental psychomotor skills (teamwork attitudes, head-to-toe assessment, &amp; AOM by enteral &amp; IM routes)</td>
<td>21 hr (7hr x 3 clinical days)/ 43%</td>
</tr>
<tr>
<td>Bearnson &amp; Wiker (2005)</td>
<td>US</td>
<td>Descriptive</td>
<td>Convenience/ 1U/ NR</td>
<td>BN/ Yr-1/ Y</td>
<td>Post-operative pain management</td>
<td>1 clinical day/ NR</td>
</tr>
<tr>
<td>Curl et al. (2016)</td>
<td>US</td>
<td>QE</td>
<td>Convenience/ 1U &amp; 2 colleges/ 124</td>
<td>ADN/Final year/ Y#</td>
<td>4 specialties: OBS, Pediatric, CC, MH</td>
<td>80hr/ 50%</td>
</tr>
<tr>
<td>Hayden et al. (2014)</td>
<td>US</td>
<td>Randomized controlled study (2yrs)</td>
<td>Convenience/ 10U/ national (10U)/ 666</td>
<td>BN &amp; ADN/ entire programme/ Y#^</td>
<td>Nursing assessment med-surg, OBS, Paed, MH, community nursing, CC</td>
<td>NR/ 25% or 50%</td>
</tr>
<tr>
<td>Lambton (2008)</td>
<td>US</td>
<td>QE</td>
<td>Convenience/ NR/ 96</td>
<td>NR/ NR/ NR</td>
<td>Paed</td>
<td>(same as clinical hours)/ 25%</td>
</tr>
<tr>
<td>Meyer et al. (2011)</td>
<td>US</td>
<td>QE</td>
<td>Convenience/ U/ 116</td>
<td>BN/ Yr-3/ Y</td>
<td>Paed</td>
<td>24hr/ 25%</td>
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<tr>
<td>Richardson et al. (2014)</td>
<td>US</td>
<td>Comparative evaluation</td>
<td>Convenience/ 2 U/ 1451</td>
<td>BN/ NR/ NR</td>
<td>Med-surg</td>
<td>NR/ 50% (interleaved pattern)</td>
</tr>
<tr>
<td>Schlairet &amp; Fenster (2012)</td>
<td>US</td>
<td>Mixed-method</td>
<td>Convenience (2 cohorts)/ college/ 78</td>
<td>BN/ junior/ N</td>
<td>NR</td>
<td>NR/ Varies from 0 – 70% (interleaved / blocked pattern)</td>
</tr>
<tr>
<td>Author(s) (year)</td>
<td>Location</td>
<td>Study design</td>
<td>Sampling/Setting/ Sample size</td>
<td>Nursing programme/ Yr of study of programme/ Previous clinical or healthcare experience</td>
<td>Traditional clinical experience (TCE) Replaced</td>
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<td>Sears et al. (2008)</td>
<td>Canada</td>
<td>QE</td>
<td>Convenience/ 54</td>
<td>BN/ Yr 2/ NR</td>
<td>Medicine administration in Med-surg or Maternal child</td>
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<tr>
<td>Simonelli &amp; Paskausky (2011)</td>
<td>US</td>
<td>QE</td>
<td>Convenience (2 cohorts)/ U/ 281</td>
<td>BN/ NR/ NR</td>
<td>OBS</td>
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<tr>
<td>Singleterry (2019)</td>
<td>US</td>
<td>QE</td>
<td>Convenience/ 1 U/ 37</td>
<td>BN/ final year/ NR</td>
<td>CC</td>
<td></td>
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<tr>
<td>Woda et al. (2016)</td>
<td>US</td>
<td>QE</td>
<td>Convenience (2 cohorts)/ 1 college / 71</td>
<td>BN/ senior years (final semester)/ Y</td>
<td>Med-surg</td>
<td></td>
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</tbody>
</table>

Note. NR: not report; QE: Quasi-experimental; U: university; BN: Bachelor of Nursing Programme; ADN: Associate Degree Programme of Nursing; Yr: year; hr: hour(s); wk: week(s); Med-surg: medical-surgical; MH: mental health; OBS: obstetric nursing; Paed: paediatric nursing; CC: critical care; #: have prior credential of vocational/technical certificate, or was a nurse assistant; ^: partly; Sim: simulation; AOM: administration of medication; Y: yes; N: no; #: health care working experience.
<table>
<thead>
<tr>
<th>Author(s) (Year)</th>
<th>Sim modality</th>
<th>Pre-SCE activities</th>
<th>SIM-D #Scenario DB: Y/N; duration SF ratio</th>
<th>S: Sim scenario matters, R: students’ role</th>
<th>Comparison group(s)</th>
<th>Outcomes measurements (Instrument)</th>
<th>Important findings</th>
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</thead>
<tbody>
<tr>
<td>Badowski &amp; Oosterhouse (2017)</td>
<td>Students acted as SP</td>
<td>(i) Scenario unfolded to students over the SIM days (ii) Practice taught skills in lab (both groups)</td>
<td>SIM-D: 7-hr x 3 days (sim) + 7-hr x 4 days (TCE) #Scenario: NR DB: Y/ NR SF ratio: NR</td>
<td>S: 3 modified NLN Advancing Care Excellence for Seniors cases R: primary or secondary nurse, patient, family member, observer, peer-coacher</td>
<td>TCE (7hr x 7 days)</td>
<td>(i) Psychomotor skills – AOM by enteral &amp; IM, head-to-toe assessment (skills checklist^) (ii) Knowledge of psychomotor skills, communication skills &amp; safety (exam^) (iii) Teamwork attitude (T-TAQ)</td>
<td>(i) No significant difference from pre-test to post-test on knowledge or skills acquisition and teamwork attitudes.</td>
</tr>
<tr>
<td>Author(s) (Year)</td>
<td>Sim modality</td>
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<tr>
<td>Bearnson &amp; Wiker (2005)</td>
<td>HPS6 [made by Medical Education Technologies, Inc (n.d.)]</td>
<td>NR</td>
<td>SIM: 2-hr #Scenario: 3 DB: Y/ NR GP: NR (2gp) vs 2 SF ratio: NR</td>
<td>S: pre-programmed post-operative pain management scenarios R: provide nursing care</td>
<td>NA</td>
<td>(i) Perceived knowledge level of medication side-effect, patient responses and perceived ability and confidence in AOM (survey) (ii) Student’s learning experience of SIM (3 open-ended questions)</td>
<td>(i) Students perceived positive learning experience with increased self-confidence. (ii) Simulation sessions should be used in addition to a regular clinical experience.</td>
</tr>
<tr>
<td>Author(s) (Year)</td>
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<td>Curl et al. (2016)</td>
<td>HFS, V-SIM, role-playing</td>
<td>Pre-lab case studies &amp; discussion with faculty for 30-60 min</td>
<td>SIM-D: 30-45mins/ module (5 modules x 4hr x 4 specialties = 80 hr)</td>
<td>S: Paed trauma &amp; accident, self-paced V-SIM on computers or written case studies</td>
<td>TCE in OBS, Paed, MH &amp; CC</td>
<td>(i) Nursing knowledge (HESI exit exam – Med-surg, OBS, Paed, MH)</td>
<td>(i) Sim group was significantly more knowledgeable than comparison group in HESI exit exam – Med-surg (post-test).</td>
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<td></td>
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<td></td>
<td>#Scenario: NR</td>
<td>R: team leader, assessment nurse, medication nurse, family care nurse, family member (roles rotation amongst students)</td>
<td></td>
<td>(ii) Program benchmark (passing rate of NCLEX-RN)</td>
<td>(ii) Insignificant different of exit exam score (HESI-OBS, Paed &amp; MH) between SIM group &amp; comparison group (post-test).</td>
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<td>DB: Y; 45-90mins</td>
<td>SF ratio: 4-5 students vs NR</td>
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<td>(iii) Simulation effectiveness (Student Evaluation of Clinical Simulations Effectiveness Tool^; Faculty Evaluation of Clinical Effectiveness Tool^)</td>
<td>(iii) Comparable passing rate of NCLEX-RN between Sim group and TCE group</td>
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<td>(iv) Students evaluated the effectiveness of SIM was overwhelming positive.</td>
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<td>(v) Half students demonstrated above average critical thinking competency.</td>
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<td>Author(s)</td>
<td>Sim modality</td>
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<tr>
<td>Hayden et al. (2014)</td>
<td>MPS, HPS, SP, role-play, skill stations, V-SIM</td>
<td>Same day pre-conference</td>
<td>SIM-D: 75min</td>
<td>3 groups: i) TCE (&lt;10% SCE)</td>
<td>i) Nursing knowledge (ATI RN-CP &amp; CMS Content Mastery Series)</td>
<td>(i) Completion rate 79%</td>
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<td>#Scenario: 4 Sim + V-SIM</td>
<td>ii) SCE 25% gp</td>
<td>ii) Clinical competency (CCEI; NGNPS; GACCPR; NCLEX)</td>
<td>(ii) SCE 50% gp scored higher in ATI, yet between group differences was minimal &amp; insignificant with small effect size.</td>
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<td>DB: Y; 30 min SF ratio: NR</td>
<td>iii) SCE 50% gp</td>
<td>iii) Critical thinking (CTD)</td>
<td>(iii) Students were rated as clinically competent by their preceptors or instructor (NGNPS &amp; GACCPR) &amp; no significant between group difference.</td>
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<td>S: consistent with NLN/Jeffries SIM Framework R: primary &amp; secondary nurses, family member, observers</td>
<td>iv) Learning needs comparison (CLECS)</td>
<td>(iv) Critical thinking: SCE 25% gp scored slightly higher than others</td>
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<td>(v) Student rated themselves as clinical competent with a significant higher score in CTD &amp; insignificant higher scores in NGNPS &amp; GACCPR.</td>
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<td>(vi) NCLEX: 86.8% pass and above rational average</td>
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<td>(vii) Clinical managers rated new graduates were ready to practice and no between group difference was noted at 3 FU (6wk, 3m, 6m).</td>
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<tr>
<td>Author(s) (Year)</td>
<td>Sim modality</td>
<td>Pre-SCE activities</td>
<td>SIM-D #Scenario &amp; DB: Y/N; duration SF ratio</td>
<td>S: Sim scenario matters, R: students’ role</td>
<td>Comparison group(s)</td>
<td>Outcomes measurements (Instrument)</td>
<td>Important findings</td>
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<tr>
<td>Lambton (2008)</td>
<td>Sim, case studies</td>
<td>N</td>
<td>SIM-D: same length as clinical day #Scenario: 8 simulation + 2 case studies DB: Y/ NR SF ratio: 8 students vs NR</td>
<td>S: emergency scenarios (researcher developed) R: charge nurse, bedside nurse, physician, respiratory therapist, “worried patient”</td>
<td>NA</td>
<td>i) Midterm &amp; end-of-semester evaluation (5 open-ended question, researcher developed) (ii) End-of-semester evaluation: case scenarios &amp; objective was preferred to be provided ahead of sim; length of sim was too long; recognized sim as an “excellent” addition and hope to continue in the following semester. (iii) Faculty evaluation: increased students’ confidence and ability to perform assessment was observed.</td>
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<tr>
<td>Meyer et al. (2011)</td>
<td>Mannequin</td>
<td>i) Patient information was received via email 24-48 hr in advance ii) Pre-sim mini skills review</td>
<td>SIM-D: 20 min # Scenario: 8 DB: Y/ 20-30 min SF ratio: 6 students vs 1 faculty</td>
<td>S: infant and child scenarios were written by content experts &amp; pediatric practice nurse practitioners R: provide nursing care and patient teaching</td>
<td>NA</td>
<td>Students’ performance (adapted from Massey &amp; Warblow, 2005) (i) Students achieved higher scores more quickly with sim and maintain high performance level. (ii) Sequence of sim experience and clinical experience had no significant effect on students’ overall performance.</td>
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<tr>
<td>Author(s) (Year)</td>
<td>Sim modality</td>
<td>Pre-SCE activities</td>
<td>SIM-D #Scenario DB: Y/N; duration SF ratio</td>
<td>S: Sim scenario matters, R: students’ role</td>
<td>Comparison group(s)</td>
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<tr>
<td>Richardson et al. (2014)</td>
<td>NR</td>
<td>NR</td>
<td>SIM-D: NR (TCE:SCE hr = 1:2)</td>
<td>S: NR R: NR</td>
<td>SCE + TCE with SF ratio 1 student vs 1 faculty</td>
<td>i) Faculty capacity (SF ratio per faculty day) ii) Student/faculty views on clinical teaching approaches (survey*) iii) Perception on work &amp; workload affected by integration of sim (semi-structured interviews)</td>
<td>(i) Faculty capacity increased 45-49% in sim gp and no change in comparison group (ii) Faculty and students valued TCE the most, followed by sim &amp; classroom activities (iii) Faculty supported SCE because it lowered the SF ratio in TCE supervision, which benefits to the concern of patient safety.</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Sim modality</td>
<td>Pre-SCE activities</td>
<td>SIM-D #Scenario</td>
<td>Duration SF ratio</td>
<td>S: Sim scenario matters, R: students' role</td>
<td>Comparison group(s)</td>
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<td>Schlairet &amp; Fenster (2012)</td>
<td>HPS</td>
<td>Pre-clinical preparation the day before</td>
<td>SIM-D: 2 hr</td>
<td>DB: Y; NR</td>
<td>S: METI – scenarios within Program for Nursing Curriculum Integration</td>
<td>8 gps</td>
<td>i) CJ (LCJR) &amp; CT (CT examination)</td>
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<td>DB: Y; NR</td>
<td>SF ratio: 4-5</td>
<td>R: primary nurse, resource nurse, medication nurse</td>
<td>ii) Sim effectiveness: confidence &amp; learning (SET)</td>
<td>ii) Increased CT post interventions, no difference between groups</td>
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<td></td>
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<td></td>
<td>NR</td>
<td>student vs 1</td>
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<td>iii) Knowledge (course exam &amp; standardized nursing exam scores)</td>
<td>(iii) Perceptions for learning: inadequate SCE or TCE for learning if &lt; 30%</td>
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<td></td>
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<td>NR</td>
<td>faculty</td>
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<td>iv) Perceptions of learning (survey&lt;sup&gt;a&lt;/sup&gt;)</td>
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<td>NR</td>
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<tr>
<td>Sear et al.</td>
<td>NR</td>
<td>1 hr preparatory time after receiving handover report</td>
<td>SIM-D: NR</td>
<td>DB: Y; 2hr</td>
<td>S: patients in obstetric or MS setting requiring AOM, written by experts&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Non-sim group</td>
<td>Number of AOM error&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>(2008)</td>
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<td></td>
<td>NR</td>
<td># Scenario: NR</td>
<td>R: assess, plan &amp; perform together</td>
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<td>NR</td>
<td>SF ratio: 5</td>
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<td>NR</td>
<td>students vs NR</td>
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<td>Author(s) (Year)</td>
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<tr>
<td>Simonelli &amp; Paskausky (2011)</td>
<td>Simulator</td>
<td>2hr orientation on simulator, nursing care, case scenario</td>
<td>SIM-D: 15-30min</td>
<td>S: skill acquisition before and after each sim session (NCLEX-style test)</td>
<td>i) Significant within group improvement was found in NCLEX-style in both sim and non-sim gp. ii) Sim gp had significant higher clinical performance grades than non-sim gp. iii) Sim gp had significant higher final examination score than non-sim group.</td>
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<tr>
<td>Singleterry (2019)</td>
<td>HPS, role play</td>
<td>Assignment (purpose, objective &amp; background reading for sim)</td>
<td>SIM-D: 60 min</td>
<td>S: monitoring in critical care^</td>
<td>Students perceived confidence in describing technology, equipment &amp; technology competency as caring in CC setting (VAS^)</td>
<td>Students perceived significant higher confidence after SCE.</td>
<td></td>
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<tr>
<td>Author(s) (Year)</td>
<td>Sim modality</td>
<td>Pre-SCE activities</td>
<td>SIM-D #Scenario DB: Y/N; duration SF ratio</td>
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<td>Soccio (2017)</td>
<td>SP</td>
<td>NR</td>
<td>SIM-D: NR</td>
<td>Non-sim control gp (student received no sim)</td>
<td>i) MH knowledge (ATI RN MH Mastery Examination) ii) MH Self-confidence (MHNCCS) iii) Benefits from SCE (open-ended survey)</td>
<td>(i) Significant increase in self-confidence after SCE and TCE, yet no between group difference on MH knowledge and self-confidence (ii) Students perceived SCE support learning on handling and interacting with patients via varied, intense sim with DB. (iii) Students commented sim should not be used as a replacement for TCE.</td>
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<tr>
<td>Woda et al. (2018)</td>
<td>NR</td>
<td>NR</td>
<td>SIM-D: 25min</td>
<td>Supplementary SCE, online activities &amp; case studies in addition to original TCE</td>
<td>i) Perceived CDM (CDMNS) ii) Perceptions on level of CDM-related self-confidence &amp; anxiety (NASC-CDM) iii) Performance on expected nursing behaviours (CCEI)</td>
<td>(i) Significant higher CCEI total &amp; assessment subscale in comparison gp (ii) Similar CDMNS &amp; NASC-CDM in 2 gps with small effect size</td>
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</table>
Note. NR: not report; NA: not applicable; Sim: simulation; SIM-D: duration of simulation session; SF ratio: no. of students vs no. of faculty in each simulated clinical experience session; DB: debriefing; Y: yes; N: no; hr: hour(s); min: minute(s); wk: week(s); exam: examination; gp: group; HPS: Human Patient Simulator; HFS: High fidelity simulator; MPS: Medium fidelity simulator; V-SIM: virtual simulation (on computers or written case studies); SP: Standardized patient; TCE: Traditional clinical experience; Sim: simulation; SCE: simulated clinical experience; NLN: National League for Nursing; CT: critical thinking; CJ: clinical judgment; CDM: clinical decision making; ATI RN-CP: ATI RN Comprehensive Predictor ® 2010 (Assessment Technologies Institute, LLC); ATI-CMS: ATI Content Mastery Series ®; NCLEX-RX: National Council Licensing Exam for Registered Nurses; CCEI: Creighton Competency Evaluation Instrument; NGNPS: New Graduate Nurse Performance Survey; GACCRP: Global Assessment of Clinical Competency and Readiness for Practice; CLECS: Clinical Learning Environment Comparison Survey; CTD: Critical Thinking Diagnostic ©; LCJR: Lasater Clinical Judgment Rubric; HESI: Health Education Systems Inc medical-surgical (MS) specialty exam; CDMNS: Clinical Decision-Making in Nursing Scale; SET: Simulation Effectiveness Tool;

^ researcher developed; # Scenario: number of scenario(s)
Figure 1. A flowchart of the inclusion of studies
Effects of Simulation on the Anxiety of Nursing Students: Low-fidelity versus High-fidelity

Chan Hoi Man, Jackie; Tsang Yat Kwan, Alan; Wong Suet Lai; Tong Ying Ting, Mavis; Lo Ka Yee, Cora; Cheung Pui Han, Alison; Charm Yee Chong, Caroline; Gill, Kaur Baljit; Lam Ching Yee
School of Nursing and Health Studies, The Open University of Hong Kong

Abstract

The purpose of this study was to determine the effects of simulation on students’ anxiety related to clinical practicums. A total of 193 first-year baccalaureate nursing students attended a clinical practicum course and were assigned to either low- or high-fidelity simulation groups before their first experience of a human patient. Pre- and post-simulation anxiety levels and the effectiveness of simulation were compared. The anxiety level of students was measured using the short form of the State-Trait Anxiety Inventory; and the effectiveness of simulation was measured by the modified-Simulation Effectiveness Tool. Lower anxiety levels were demonstrated in the high-fidelity simulation group, though this was not statistically significant. A significant increase in anxiety level after low-fidelity simulation was revealed (13.8 ±1.9 vs 14.3 ± 2.4, p=0.01). The overall effectiveness of simulation was higher in the high-fidelity simulation group, and the mean score on the debriefing subscale, in particular, was significantly higher (12.3± 2.0 vs 11.4±1.9, p= 0.02).

Keywords: baccalaureate nursing programme, simulation, anxiety, clinical practicum
Introduction

Baccalaureate nursing students experience anxiety to varying degrees throughout the nursing programme. Among all the components of a nursing programme, clinical experience produces the highest level of anxiety in students, particularly on the first clinical practicum (Hart & Rotem, 1994; Sharif & Masoumi, 2005; Sun et al., 2016). Therefore, it is a top priority of a nursing faculty to prepare nursing students better psychologically. High-fidelity simulation (HFS) as an educational strategy has been increasingly incorporated into nursing programmes. Knowledge retention, learning in a safe environment without the fear of harming patients, and increasing confidence have been well documented as among the benefits of HFS, while evidence on reducing student anxiety related to clinical practicums has been increasing. The use of HFS may be an effective educational strategy for reducing anxiety related to the clinical practicums of baccalaureate nursing students.

Literature Review

Overview of Anxiety in the Nursing Field

Nurses are undoubtedly vulnerable to job-related psychological distress. A recent study revealed that 37% of nurses working in Hong Kong experienced anxiety, and 35% had depression (Cheung & Yip, 2015). China and South Korea have consistently reported the prevalence of depression among nurses as 61.7% and 38%, respectively (Gao et al., 2012; Yoon & Kim, 2013). Novice nurses in particular experienced acute anxiety, which could be due to low self-confidence during the transition from being a student to becoming a qualified nurse (Cheung & Yip, 2015). Undergraduate nursing students also have mental health issues, with 16% reported to have experienced severe and extreme anxiety levels in Canada, while moderate levels of stress were reported in the USA (Chernomas & Shapiro, 2013; Williams, 2014). These results are alarming, because stress and anxiety could have been embedded early during undergraduate training, and continued to grow and extend into work.

Sources and the Downside of Anxiety among Nursing Students

Clinical practicums, academic concerns, and personal matters were the three main sources of stress among nursing students (Jimenez, Navia-Osorio, & Diaz, 2010). Clinical practicum contributed the highest level of anxiety, especially when experienced for the first time (Hart & Rotem, 1994; Sharif & Masoumi, 2005; Sun et al., 2016). Sun et al. (2016) showed that nursing students started to feel anxious about a week before a clinical practicum, and the anxiety level heightened when the practicum approached. Also, a significant increase in the degree of anxiety was expressed during the practicum, which decreased or even disappeared after its completion. Such exacerbated anxiety during clinical practicums impeded nursing students’ learning, clinical performance, and satisfaction with the clinical experience (Cheung & Au, 2011; King, 2010).
Lack of confidence, fear of failure, and the unpredictability of the hospital environment and the condition of patient have been consistently reported as sources of anxiety during clinical practicums (Sharif & Masoumi, 2005; Sun et al., 2016), which may lead to a loss of focus, failure to establish a therapeutic relationships, and ultimately inability to attend to the needs of patients (Szpak & Kameg, 2013; White, 2003). Therefore, reducing and managing students’ anxiety related to the clinical practicum is of paramount importance. The provision of an effective teaching strategy for reducing student anxiety related to the clinical practicum is a top priority of nursing faculties.

Simulation Fidelity

Fidelity describes the extent of realism and accuracy that a simulation system can provide, and is usually categorized as low, moderate, or high. Traditionally, low fidelity simulation (LFS) was used to train psychomotor skills in nursing education. A rubber body part for practise injection is an example of low-fidelity simulator, because it is static and lacks the detail of a real situation (Kim, Park, & Shin, 2016; Seropian, Brown, Gavilanes, & Driggers, 2004).

A moderate-fidelity simulator is a body-sized manikin run by a computer program that can give breath and heart sounds, but lacks response fidelity.

High-fidelity simulation (HFS) comprises a computerized patient simulator, with the incorporation of clinical scenarios, which mimics different parameters of human physiology in real time and provides experiential learning in a safe environment (Alinier, Hunt, Gordon, & Harwood, 2006). HFS offers the most realistic simulated-patient experience, and has been increasingly adopted in nursing education. The literature suggests positive outcomes from using HFS, such as improving critical thinking skills, filling the theory-practice gap, and promoting knowledge retention. Kim et al. (2016) added that HFS-based nursing education was more effective than low and intermediate-fidelity simulations or standard patients for improving undergraduate nursing students’ psychomotor skills, as well as cognitive and affective outcomes.

According to Yuan, Williams, Fang and Ye (2012), students’ scores on knowledge increased after HFS training. Increased self-confidence and decreased anxiety levels related to clinical practicums have also been reported consistently in nursing students after simulation training (Bremner, Aduddell, & Amason, 2008; Gore, Hunt, Parker, & Raines, 2011; Khalaila, 2014; Szpak & Kameg, 2013).

Hypotheses

This study tested the following hypotheses: The first-year baccalaureate nursing students who received high-fidelity simulation will report (1) a significantly lower anxiety level and (2) significantly higher effectiveness in learning than those who received low-fidelity simulation.
Methods

Study Design and Participants

The study was designed within an existing course, the clinical practicum, which was one of the foundation courses in the first year of study. A total of 193 first-year baccalaureate nursing students attending the course were assigned to HFS or LFS sessions during the summer semester in 2016, and this setup yielded a convenience sample. All the students completed the simulation sessions before the start of the clinical practicum. The students were asked to complete a questionnaire before the start (T1) and at the end of the session (T2). The completion of the questionnaires implied consensus among the students to participate in the study. The members of the two groups were then exchanged to ensure that all the students completed the two simulation sessions. All the participants had completed courses in fundamental skills and health assessment. The study was approved by the University’s Research Ethics Committee.

Procedure

The students were assigned to HFS or LFS sessions. The questionnaire comprised three parts, namely, demographic information, the State Trait Anxiety Inventory (STAI) pre- and post-simulation, and the modified Simulation Effectiveness Tool (SET-M) after the simulation. In the HFS session, SimMan™ was used, and clinical scenarios on pneumonia, myocardial infarction, heart failure, and syncope were incorporated. These components were used in the pre-programming of the simulator and in providing respective abnormal physiological parameters.

The day before the HFS session, students attended an orientation session to familiarize them with the simulation equipment and expectations for each clinical scenario. Medical charts, as well as patient and drug administration records, were explained. A group of four to five participants conducted simulation training and performed appropriate nursing assessments or interventions according to specific clinical scenarios. The sessions lasted for 20 minutes. A nurse instructor evaluated the performance of the participants during the sessions according to the learning objectives, viz. patient safety, communication, assessment, interventions, and documentation. A 20-minute structured debriefing was conducted to provide feedback on the strengths and weaknesses of the students’ performance.

For the LFS session, students practised different nursing skills, such as urinary catheterization, injection, or drug administration on static manikins under the supervision of nurse instructors. Demonstrations and return demonstrations were conducted. Feedback was given during and at the end of sessions.
Instrumentation

Demographic Characteristics

Before the simulation session, factors including gender and prior nursing-related work experience were assessed (Table 1).

Anxiety

The anxiety of students was measured at T1 and T2 by using the six-item STAI, which was modified by Marteau and Bekker (1992) and was based on the Spielberger STAI (1983). The original STAI consisted of 40 items that measured state anxiety (how one feels at the moment) and trait anxiety (how one generally feels) with a 4-point Likert scale. Scores range from 6 to 24, with low scores suggesting mild anxiety; median scores suggesting moderate anxiety; and high scores suggesting severe anxiety. To the author’s knowledge, no cut-off scores have been validated for this six-item STAI. The briefer questionnaire may boost response rates, minimize the rate of response errors, and reduce missing items, which could improve the generalizability of baccalaureate the findings. The six-item STAI achieved acceptable reliability and validity (α=0.82).

Effectiveness of the Simulation Experience

The extent of students’ confident in making clinical decisions and responding to patients’ conditions reflect the effectiveness of the simulation experience. This was evaluated at T2 by using SET-M, which was modified by Leighton and colleagues (2015), and was based on SET (Elfrink Cordi, Leighton, Ryan-Wenger, & Doyle, 2012). SET-M covers three areas, namely, the prebriefing, scenario, and debriefing. A total of 19 items were scored on a 3-point Likert scale. Questions such as “Prebriefing increased my confidence”, “I am more confident in my ability to prioritize care and interventions”, and “Debriefing was valuable in helping me improve my clinical judgement” evaluated how confident the students were in making clinical decisions and responding to patients’ conditions. A higher total score indicated greater effectiveness of the simulation experience. Six items evaluating the effectiveness of the prebriefing and debriefing of the simulation were added to the 13 items in SET, which measured mainly the effectiveness of learning and confidence. SET-M achieved a good overall internal consistency reliability (α=0.936).

Data analysis

The data were analyzed using SPSS version 22. Descriptive data were analyzed with non-parametric tests and were presented as percentages. The mean scores on STAI at T1 and T2 were tested within groups by a paired-sample t-test, and the mean scores on STAI at T2 and SET-M were compared between groups by an independent-sample t-test. Incomplete questionnaires were excluded in the analysis, thereby yielding a sample size of 190, a 98% response rate.
Results

The mean STAI scores of the LFS group (n=93) at T1 and T2 were 13.8 (±1.9) and 14.3 (±2.4), respectively, indicating a significant increase of 0.5 points (p=0.01). No statistically significant difference was detected between the mean STAI scores of the HFS group (n=97) at T1 and T2 (13.9±2.0 vs. 13.9±2.3). Although the mean STAI score at T2 was higher in the LFS group, this result was not statistically significant (Table 2).

The mean SET-M score was higher in the HFS group (43.3±6.0 vs. 42.9±6.1). Although no statistically significant difference was detected in the total score, the mean score on the debriefing subscale was significantly higher in the HFS group (12.3±2.0 vs. 11.4±1.9, p=0.02) (Table 3).

Discussion

This study revealed mild to moderate anxiety levels related to clinical practicums among first-year baccalaureate nursing student. Such levels were similar to those reported in previous studies. Easterbrook (1995) suggested that anxiety improved performance by focusing attention on the most threatening aspects of the environment. Similarly, Ganley and colleagues (2012) reported that experiencing a certain level of anxiety in the simulation was healthy. In contrast, high levels of anxiety could lead to a decrease in students’ confidence and critical thinking (Horsley, 2012). Khalaila (2014) noted a negative correlation between the baseline anxiety level and caring ability, self-confidence and caring efficacy in students after having the HFS. Therefore, we infer that the baseline anxiety level could be a determinant of simulation effectiveness. However, the dose-response relationship between the baseline anxiety level of students and the effectiveness of simulation remains under-researched. Further studies would help to direct teaching strategies and understand students’ needs.

As noted above, this study found a lower anxiety level in students who received the HFS than those who received LFS, but this result was not statistically significant. The significant increase of anxiety level in the LFS group and the unchanged anxiety level in the HFS group may explain the relatively lower anxiety level in the HFS group.

Faculty staff supervised the LFS session with a demonstration of skills and a return-demonstration was done by students. Fear of making mistakes may lead to increased anxiety when students perform in front of their peers in simulation (Paskins & Peile, 2010). Moreover, students may feel a sense of unfairness when they are the focus of attention, which may increase their anxiety level and interfered with their learning (Elfrink, Nininger, Rohig, & Lee, 2009). These situations may explain the heightened anxiety level in students after having LFS. There were 8 to 10 students in each LFS group in the current study. We suggest that a smaller group such as 3 to 4 students should be used to facilitate learning and reduce anxiety during simulation.

No change was recorded in the anxiety level in the HFS group before and after simulation sessions in the current study. This finding was inconsistent with similar
studies, which showed a significant reduction in the anxiety level after an HFS session. Bong and colleagues (2010) pointed out that the HFS could induce an elevated anxiety level, the causes of which may be apprehension related to unknown expectations, intimidating faculty staff, and confidentiality not being respected (Ganley & Linnard-Palmer, 2012). In the present study, orientation to the simulated environment and scenarios, prompts during sessions, and positively constructive criticism in the debriefing was provided to facilitate learning. The use of such measures could have counterbalanced the anxiety brought about by the HFS, and allowed students to learn in a supportive environment without increasing their anxiety level.

This was supported by the higher mean SET-M score of students in the HFS group. Students valued the debriefing on the HFS in particular, as reflected in the significantly higher debriefing subscale score. Jeffries (2007) argued that a simulation debriefing should focus on the assessment of performance, and a discussion of the participants should be conducted for students to realize what they had done correctly or incorrectly, and what would be done the next time. Students’ performance was evaluated and debriefed according to the learning objectives of patient safety, assessment, interventions, documentation, and communication. These aspects were based on the study by Arafeh (2010), who indicated that cognitive, technical, and behavioural aspects should be the learning objectives for debriefings following a scenario-based simulation. Therefore, the debriefing method in the current study could effectively facilitate learning in the HFS environment.

Limitations

The small sample size was one of the limitations of this study. Also, students were not assigned randomly to simulation groups, but instead alphabetically by their names. Also the teaching style of different nurse instructors may have varied slightly. However, measures were taken to minimize the differences, such as the use of the standardized evaluation tool and debriefing format. The conduct of the simulation sessions by the nurse instructors involved was also guided by researchers at least once to maintain consistency in teaching.

Conclusion

Overall, a higher level of effectiveness in the simulation experience was demonstrated in the high-fidelity simulation. Students could gain knowledge without increasing unnecessary anxiety which might have arisen from the unfamiliar equipment or environment. Further research is necessary to demonstrate the effectiveness of simulation wards in reducing student anxiety in clinical practicums.

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References


Performance in High-fidelity Simulation Training on Respiratory Failure Management: An Evaluation Study

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Abstract

Nursing education aims to equip nursing students with the essential skills for being a competent professional nurse, who provides quality care to patients even in critical conditions. Acute respiratory failure is a critical condition which demands immediate detection and intervention by healthcare professionals – otherwise a fatal outcome becomes imminent. The development of the skills required for acute care management demand nurses’ clinical experience. However, it is doubtful that nursing students have enough opportunities to develop these skills in the clinical learning environment. High-fidelity simulation training can provide a well-controlled simulated clinical environment for nursing students to enhance their experience and abilities in assessing patient conditions, practise critical thinking and psychomotor skills, and communicate with the healthcare team when managing a deteriorating simulated patient. The simulated clinical environment also allows for progressive and timely feedback and reflection on students’ performance in the learning process. An evaluative research design was adopted in this study to assess the students’ performance in high-fidelity simulation training on acute respiratory failure clinical scenarios, and its feasibility as a teaching strategy. Fifty-one undergraduate nursing students participated in the study. The findings revealed the overall performance of the students in managing patients with acute respiratory failure. The students tended to be more conservative in evaluating their performance than the faculty members were, which was possibly related to a lower level of self-confidence. The adoption of high-fidelity simulation training was also highly recommended by the students for adoption in future practices.

Keywords: high-fidelity simulation, nursing competency, deteriorating condition
Introduction

Nurses play an important role in providing quality care for various patient conditions. To become a competent professional nurse, nursing students have to be equipped with the theoretical knowledge, practical skills, and critical thinking ability that are essential for safe and high-quality nursing practice (Oremann & Gaberson, 2006). Clinical experience plays a vital role in the development of the affective, cognitive and psychomotor domains of nursing students in their course of training to prepare them to be qualified nurses on graduation (Jeffries & Norton, 2005). Despite being a core component in training for nursing students, the opportunities for learning in the clinical environment have always been difficult to control because of their fluctuating nature. The role of nursing students in the healthcare team has further limited their opportunities to practise, especially with deteriorating patient conditions (Gaba, 2004; Jeffries, 2007). These factors may compromise their competency level, affect their capacity to transit to the role of Registered Nurses, and plan and practise nursing care independently and safely with deteriorating patient conditions soon after their graduation (Kardong-Edgren, Adamson, & Fitzgerald, 2010).

Acute respiratory failure is an emergency clinical situation that can occur in any patients from different healthcare settings, including the acute, chronic, and even mental healthcare, settings (Peralta et al., 2013). Patients with acute respiratory failure often deteriorate abruptly, leading to fatal clinical outcomes. The management of such patients requires competent nurses to detect their condition promptly; respond to deteriorating clinical conditions; utilize various psychomotor skills in airway management and respiratory care for patient support; and communicate clearly and collaborate with other members of the healthcare team to facilitate a smooth management process (Lynes & Kelly, 2013; Rose & Ramagnano, 2013). Otherwise, adverse patient conditions and life-threatening clinical outcomes might be imminent.

The opportunity to encounter patients with acute respiratory failure could facilitate the building up of nursing students’ competence for prompt recognition and response. However, they are unlikely to encounter such clinical conditions daily to learn and practise repeatedly all the required nursing skills for detecting and managing the situation of acute respiratory failure. Indeed, it has been found that abnormality in vital signs – such as respiratory rate, oxygenation, pulses and the mental status of patients – have been commonly missed or misinterpreted in the early stage of deterioration, causing suboptimal care provision and a wrong direction in patient care management (Goldhill, 2000).

Learning in a realistic clinical learning environment alone seems to be insufficient for nursing students to achieve the intended competence levels. As long as repeated exposure to deteriorating patient conditions is essential for acquainting students with the desirable nursing skills for managing conditions such as acute respiratory failure, a recreated clinical learning environment for scheduled training is necessary.
High-fidelity simulation is a teaching strategy which has been commonly adopted in nursing education in recent years for recreating a clinical learning environment for students to gain experience and learn in a systematic manner in the simulated environment (McGaughey, 2009; Meyer, Connors, Hou, & Gajewski, 2011; Purling & King, 2012; Smithburger, Kane-Gill, Ruby, & Seybert, 2012). With high-fidelity simulation, the real clinical environment can be imitated and brought alive. This involves the use of realistic clinical scenarios; human-sized patient simulators featuring changes in various physiological signs; real-time interactions with the simulated patient and other healthcare professionals; and a ward-like physical environment (Laschinger et al., 2008). All these factors can enhance the realism of the simulated clinical learning environment and promote the immersion of nursing students for practising critical thinking skills, and applying the knowledge and psychomotor skills learned in resolving the emergence of deteriorating patient conditions (Bradley, 2006; Jeffries, 2007). The opportunity for hands-on practice in a safe simulated environment also promotes the self-confidence of the students in managing such conditions (Benner, Stephen, Leonard, & Day, 2010; Feng et al., 2013; Liaw et al., 2010; Liaw, Rethans, Scherbier & Piyanee, 2011; Lindsey & Jenkins, 2013).

With a systematic learning schedule in the simulated clinical environment, the students’ performance can improve progressively and comprehensively in a timely manner, allowing prompt feedback and reflection on performance for continuous improvement (Adamson & Kardong-Edgren, 2012; McGaughey, 2009; Mikasa, Cicero, & Adamson, 2013; Wolf et al., 2011). This is of vital importance if high-fidelity simulation training is to be integrated into the nursing curriculum for supplementing the clinical experience.

Methods
An evaluative research design was adopted in this study to assess the performance of undergraduate nursing students in managing patients with acute respiratory failure using high-fidelity simulation. The feasibility of adopting high-fidelity simulation in the training of nursing students in deteriorating patient conditions is also explored.

The final year undergraduate nursing students from a full-time pre-registration Bachelor of Nursing degree programme in a university in Hong Kong were invited to participate in the study, and a convenience sampling method was adopted. Ethical approval for conducting the study was obtained from that university. Participants joined the study on a voluntary basis, and those who did not participate in the study continued to receive the normal teaching and learning strategies on respiratory care in the curriculum.

The high-fidelity simulation training on care for patients with acute respiratory failure was conducted in the university’s Clinical Simulation Laboratory, which is equipped with human-sized patient simulators, computers with simulation programmes
for the development of clinical scenarios, and items in the physical setting, such as patients’ bed units and various medical consumables. The 40-minute high-fidelity simulation training was composed of a prebriefing, a simulated experience, and a debriefing. Participants were divided into groups of four when receiving the training. In the prebriefing, the settings and equipment in the simulated ward, and the clinical scenario, were introduced to the participating group; and they were allowed to have a brief discussion among themselves on their roles and responsibilities. The participants then proceeded to the simulated experience.

The participants were required to manage a deteriorating patient with acute respiratory failure in a 10-minute simulated clinical scenario. During this, two faculty members role-played the nurse-in-charge and a medical doctor to enhance the realism of the scenario. Lastly, the participants reflected on their performance in the simulated experience during the debriefing. The debriefing was moderated by one of the faculty members involved in the simulated experience for constructive evaluation and the provision of immediate feedback to the participants.

The performance of the student in the high-fidelity simulation training was measured with the Seattle University Simulation Evaluation Tool© developed by the Seattle University College of Nursing. The tool is a 6-point Likert-type scale, with a potential score ranging from 0 to 25. It has good reliability, with an internal consistency with a Cronbach’s alpha of .965; an intra-class correlation of .900 to .907 for test-retest reliability; and an inter-rater reliability of .858 (Adamson & Kardong-Edgren, 2012; Mikasa et al., 2013). An outcome-based evaluation tool was developed according to the American Association Colleges of Nursing Baccalaureate Competencies and the clinical course objectives from a college of nursing in the United States. A total of five categories of behaviours were measured by the tool: assessment/intervention/evaluation; critical thinking/clinical decision-making; direct patient care; communication/collaboration; and lastly professional behaviour (Mikasa et al., 2013). The faculty member evaluated the student performance through observation on three to five listed behaviours within each category as demonstrated by the students during the simulated experience. Self-evaluated data from the participants were also collected for comparison with the faculty observations, except for the category of professional behaviour.

The Student Satisfaction and Self-Confidence in Learning Scale is a validated and common tool adopted for collecting student self-reported satisfaction (Cronbach’s alpha = .94) on simulation training activity, and self-confidence in learning (Cronbach’s alpha = .87), when applying the skills and knowledge to provide care for the simulated patient in the clinical scenario (National League for Nursing, 2016). The scale consisted of 13 items, including five items on satisfaction with current learning and the rest of them on self-confidence in learning. It has a 5-point Likert-type scale – from “strongly disagree” (1 mark) to “strongly agree” (5 marks) – for student to self-report their attitudes after the debriefing.
The data collected were analyzed by the Statistical Package for the Social Sciences (SPSS) software (Version 24), with the statistical significance level set at an alpha level of .05. Descriptive statistics were adopted for analyzing the demographic data, students’ performance scores from the Seattle University Simulation Evaluation Tool©, and student self-reported scores on satisfaction and confidence in learning. A t-test was used to analyze the comparison between the faculty evaluation of student performance and students’ self-evaluated scores. The difference in the level of self-confidence in learning before and after the training was also analyzed with a t-test. For analyzing the relationship between the students’ satisfaction and confidence in learning, and their performance, Pearson’s correlation was adopted.

Results

Fifty-one undergraduate nursing students participated in the study and all of them completed the study. The mean age of the participants was 23.5 and the majority of them were female (82%).

For the student performance in managing patients with acute respiratory failure during the simulated experience – as measured with the Seattle University Simulation Evaluation Tool© – the total mean score of the participants’ self-evaluation was 9.63 (S.D. = 3.25) out of 20. On the other hand, the evaluation by the faculty member on the same four categories was higher, with a total mean score of 11.75 (S.D. = 3.39). The category on professional behaviour was evaluated only by the faculty member and had a total mean score of 14.81 (S.D. = 3.64) out of 25, revealing a more comprehensive view on the overall performance of the participants.

As regards the participants’ satisfaction with the simulation training activities and self-confidence in learning – as measured on the Student Satisfaction and Self-Confidence in Learning Scale – the mean satisfaction score was 22.37 (S.D. = 2.05); while the mean self-confidence in learning score was 32.29 (S.D. = 3.25) before, and 32.44 (S.D. = 2.82) after, the training. No statistically significant difference was found for the self-confidence in learning scores before and after the training (t = -.327, df = 51, p = .745).

A small positive relationship was detected between the post-training level of self-confidence in learning and the participants’ self-evaluated performance score (r = .401, p = .004).

Discussion

The present study has provided insight into the performance of local undergraduate nursing students in managing patients with acute respiratory failure within a simulated clinical learning environment, through the adoption of high-fidelity simulation. The performance score achieved by the students in the current study was about half the total
score, reflecting that they were likely to have met the expectations for nursing students, from the professional nurses’ perspective. However, being senior-year students who would soon become Registered Nurses, more emphasis could be placed on the adoption of high-fidelity simulation for enhancing their level of competence in critical thinking ability, and cognitive and psychomotor skills before their graduation (McGaughey, 2009; Meyer et al., 2011; Purling & King, 2012; Smithburger et al., 2012).

The current study revealed that the faculty member evaluated the students’ performance as higher than the student self-evaluation. As the faculty staff’s rating was through observation of the students’ behaviour during the simulated experience, it should be a more valid and objective evaluation of the expected performance. A similar finding was also reported in a previous study (Mikasa et al., 2013).

Although the students’ self-evaluation might not have shown the actual standard of performance required, it served as a good opportunity for students to reflect on the extent to which the learning outcomes had been achieved in the learning process. Together with the discussion of the strengths and weaknesses of students with faculty members during the debriefing, the students could learn through reflection on their learning experience in the simulated clinical learning environment (Dreifuerst, 2012; Kelly, Hager, P., & Gallagher, 2014; Mariani, Cantrell, Meakim, Prieto, & Dreifuerst, 2013).

The students’ lower self-evaluated performance score than the faculty member’s rating might have been affected by other factors. In the current study, a small positive relationship was revealed between the students’ self-evaluation on performance and their level of self-confidence in learning after receiving the training, which suggests that their low self-evaluated score was related to their low self-confidence level – particularly since no statistical improvement in their self-confidence was detected after the training. This result was unlike previous studies which found a tendency for the self-confidence of nursing students to increase after receiving high-fidelity simulation training (Gordon & Buckley, 2009; Thomas & Mackey, 2012). This difference might suggest that the amount of the current training was not sufficient for students’ practice before they could be confident in mastering the required skills. Further studies employing the pre-test and post-test study design for examining the effectiveness of adopting high-fidelity simulation training in the local context may be warranted.

The use of high-fidelity simulation as the teaching strategy was considered highly satisfactory by the students in the current study. This supports the feasibility of incorporating the current mode of training into the future planning to augment the clinical experience of nursing students on the management of deteriorating patient conditions. The evaluation method on students’ performance by both the faculty members and student self-evaluation could be adopted as a formative assessment strategy, in order to provide a more comprehensive view of students’ performance.
Conclusion

In conclusion, the present study has provided insight into the performance of undergraduate nursing students in Hong Kong in managing acute respiratory failure in the simulated clinical environment. The feasibility of adopting an outcome-based evaluation tool in high-fidelity simulation training to assess the student performance has also been explored. Further studies with pre- and post-tests, and a repeated measurement design, should be adopted to further testify to the effectiveness of the training and its long-term effect on the performance of student across the curriculum. Consideration can also be given to incorporating simulation training activity into the nursing curriculum of baccalaureate programmes for continuous assessment of student performance in psychomotor, cognitive, critical thinking, and communication skills.

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References


Innovative Technology Emerging in Healthcare Education: Establishment of a Virtual Reality Education Unit

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Abstract

The application of innovative technology to healthcare education is growing. The most typical applications involve three-dimensional (3D) teaching, simulation-based learning and virtual reality-based learning. Evidence has shown that these innovative pedagogical approaches are effective in improving student learning outcomes. This paper first attempts to focus on the demands of their application in healthcare education. The understanding of technological innovation is then discussed and, finally, the establishment of a Virtual Reality Education Unit in the University is presented.

Keywords: nursing, education, technological innovation, three-dimensional (3D) imaging, virtual reality (VR) learning.
Introduction

Healthcare education involves the theoretical and practical training provided to clinical staff with the purpose of preparing them for their duties as health professionals. In recent years, healthcare education has been facing many problems, including limited budgets for teaching activities, limited clinical placements and inconsistency in students’ learning experiences in clinical settings (Krautseheid & Burton, 2003). The introduction of technological applications in support of classroom and clinical education – together with the great demand for enhanced quality and safety in health care – is playing an important role in reducing these barriers and increasing educational efficiency (Wong & Chung, 2002). In this paper, the justification for applying technological innovations to healthcare education is addressed; and the establishment of a Virtual Reality Education Unit is illustrated.

Necessity for Technological Innovation in Healthcare Education

Health care is growing increasingly complex. Patient care is undergoing continuous changes in order to deliver an enhanced quality of nursing practice. To meet such challenges, healthcare practitioners’ working environments are changing with technological advances. The clinical profession has to respond and learn the appropriate technologies. Among healthcare practitioners, nurses spend most clinical time with patients. This includes activities such as performing bedside nursing care and monitoring, educating and training patients about their health, and promoting health in the community – and consequently the nursing sector needs to change most and integrate relevant information technology skills (Benner, Sutphen, Leonard, & Day, 2009). Advanced technologies embody all digital technologies that support the electronic capture, storage, processing, and exchange of information in order to promote health, prevent illness, treat disease, and manage chronic illness (Rouleau, Gagnon, & Cote, 2015). The Institute of Medicine (2003), the American Association of Colleges of Nursing (2005), and the National League for Nursing (2008) have advocated the incorporation of technology into healthcare education. Academic institutions educating healthcare students should be responsive to the rapidly changing healthcare environments, and it is strongly recommended that these institutions focus on the use of health information technologies as they educate future clinicians (cited in Gonen, Dgaanit, & Lev-Ari, 2016).

Without competencies in informatics and technology, health professionals were limited in their ability to make effective use of communication and information technology skills in their practice. The application of modern technologies has been playing an important role in enhancing patient care. It is well understood that continuous monitoring of patients requires the use of information and technology devices, and facilitates clinical documentation for the effective provision of health care, especially easier access to the patient’s history of care. Clinical staff analyze clinical data and convert them into useful information which effectively affects the quality
of patient care (Jelec, Sukalic, & Friganovic, 2016). To prepare nursing students to learn such competencies, nursing education should be enhanced with the integration of technological innovations. Innovative educational technology can facilitate nursing students’ learning by promoting critical thinking and improving clinical judgement (Cheeseman, 2011; Gardner & Jones, 2012; Jensen, Meyer, & Sternberger, 2009), and train them for “high-touch, high-technology” care (Edwards & O’Connor, 2011; Hebda & Calderone, 2010).

Technological Innovation Applied in Healthcare Education

Technological innovations are similar across medical and nursing higher education. Explanation of the term “technological innovation” in healthcare education is subjective and varies. We firstly examine the definition of “innovation”. The term “innovation” means something new or different being introduced (Innovation Nation, 2009). The project on Innovation in Learning and Teaching in Higher Education defined technological innovation as a new and sustainable approach that leads to an overall improvement in the students’ experience, and which is supported by evidence (Carpenter, 2012). The literature on technological innovations in the teaching and learning of medical students in healthcare education is related to simulation, three-dimensional (3-D) digital teaching aids, e-learning, virtual learning environments, and the use of social media. Dearnley, McClelland and Irving (2013) suggested that advanced technology in higher nursing education and practice includes informatics, telehealth, mannequin-based and patient simulators, computer-based instruction, virtual simulation, interactive simulated case studies, advanced 3-D graphics, and e-learning technologies. The use of technology in nursing education could improve nursing students’ learning and academic performance. Nursing students could have access to online education, live and web-based simulations, apps, 3-D animation, and electronic textbooks on mobile devices (Oermann, 2015). From the above review, most examples of innovative technology applied to healthcare education were 3-D imaging, simulation, and virtual reality learning. The following section presents the establishment of a Virtual Reality Education Unit in our Clinical Nursing Education Centre at the University.

Establishment of a Virtual Reality Education Unit

Nursing education in Hong Kong faces similar challenges and demands as overseas nursing education. We have limited resources for arranging effective and efficient opportunities for nursing students to learn nursing knowledge, and to practise their nursing skills. For example, when nursing students are learning anatomy and physiology, the educators have mainly relied on the traditional teaching strategies, such as 2-D pictures, texts, and videos. Nursing students have already complained that it is hard for them to imagine 3-D human body structures with 2-D pictures of human organs. Together with their difficulty in understanding pathophysiology, their academic performance in studying anatomy and physiology and other courses related nursing has often been unsatisfactory.
On the other hand, to become professional nurses in Hong Kong, students need to attend the required clinical learning hours to experience real-case caring skills. However, in practice, there have not been enough clinical venues to meet nursing students’ learning needs, particularly in specialty nursing care. Although nursing students are allocated to clinical settings to practise what they have acquired in the classroom, due to the different duties assigned to them in the clinical practicums, they may not encounter the same learning opportunities. As a result, the required standard, consistency and predictability of clinical experience cannot be ensured.

Another difficulty nursing students faced was having less confidence in handling some high-risk clinical procedures. From our observation and students’ feedback after clinical practicums, nursing students worry that they are not competent in critical nursing skills which have to be applied in life and death situations. This indicated that there was no good pre-clinical preparation of nursing students to practise their high-volume nursing skills, particularly for high-risk scenarios. Traditionally, these hands-on skills were all only explained separately, not for application together. As a result, nursing students expressed anxiety when going through a real crisis in clinical settings.

In fact, Hong Kong is now facing a rapidly ageing population and an increasing prevalence of non-communicable diseases, as well as mental illness. In view of the current situation, a recent Policy Address supported the concepts of “Ageing in Place” and “Community Rehabilitation” (The Chief Executive’s Policy Address, 2016). To support the government’s initiatives and enable the elderly, people with non-communicable diseases and physical or mental disabilities to be properly cared for in the community, there has been an upsurge in the need for healthcare providers who are capable of, and responsible for, delivering care on health maintenance, disease prevention and rehabilitation. To address the above challenges, our School needed to optimize the educational pedagogy in its training programmes by using technological innovations. Three dimensional imaging and virtual reality learning were mainly adopted to establish the Virtual Reality Education Unit. This Unit can provide the platform for delivering the training of essential clinical knowledge and skills to our nursing students, who then become more competent in providing healthcare within the clinical and community settings.

Three-dimensional Imaging

A 3-D image is described as an image that provides the perception of depth. A 3-D object is solid rather than flat, because it consists of a number of techniques such as interferometry and focuses in three different directions – height, length, and width (Shen, 2018). It creates 3-D objects with a realistic representation of depth, shape, and texture, producing a sharp, precise copy of portrayed objects. Sorel, Olliver and Mano (2010) argued for the introduction of 3-D technology into healthcare practice and education. It is a safe and affordable technique which is capable of producing 3-D imaging of objects
or constructed designs. Such 3-D imaging of anatomic pathology specimens can be used for teaching medical and nursing students at undergraduate and postgraduate levels.

We knew that teaching the structure of 3-D objects with traditional 2-D pictures and graphics was extremely difficult. Students commented that they could not handle explanations of those 3-D shapes of organs inside the human body. Most of them complained that it was boring and very difficult to understand the structures of the body in terms of fundamental levels of organization that increase in complexity. However, after 3D viewing was applied, this was significantly enhanced, with students being offered a sense of depth and understanding of complex structural relations (Fairén, Farrés, Moyés, & Insa, 2017). Estevez, Lindgren and Bergethon (2010) mentioned that teaching human neuro-anatomy to nursing students with a 3-D tool had positive outcomes in terms of improved academic performance and student satisfaction. Moreover, Sorel et al. (2010) claimed that 3-D imaging technology could improve and support students’ learning on diagnosis because it could help to protect them from making faulty assessments on the basis of information provided by routine 2-D X-rays. In 2015, our School was the pioneer in Hong Kong in developing the technology of the 3D Model and Animation for teaching anatomy and physiology. With the 3D Model and Animation used in teaching, students’ interest and learning have been enhanced. They noted that this model could facilitate their learning by providing more views of objects displayed. This suggests that 3-D imaging technology is relevant for enhancing our healthcare education.

Virtual Reality Learning

The use of virtual reality (VR) as a pedagogical tool is considered as practical and essential. It is usually associated with flight simulators, enjoyment and leisure, but no longer serves only these purposes. The term “VR” has been treated as a three-dimensional, computer-generated environment that enables a person to immerse him/herself in the virtual world (Mantovani, Castelnuovo, Gaggioli, & Riva, 2003). He/she can explore, interact with or manipulate any objects which are generated by the computer. It is commonly believed that VR has been widely acknowledged for its effectiveness in enhancing clinical skills training.

Applying VR for training was started in the 1990s by NASA. VR is known to have been used in training in the medical area for years, such as in performing kidney biopsy, cardiac catheterization and other high-risk procedures that required more practice before application to real patients. It allows the students to be immersed in a virtual environment but have experiences similar to the real world at the same time. VR can be used to teach a whole range of concepts that were previously difficult or even impossible to demonstrate. The possibilities are almost endless because VR education and training allows students more exposure to interactive learning in a VR environment, so that they gain first-hand knowledge of what such an experience is like. Students can practise skills in a safe environment, especially in high-risk skill training, such as
practising mental health nursing skills. The benefits of VR in nursing education are that it enabled role-playing, collaboration, real-time interactions between students and faculty staff, and experimentation. VR application can facilitate students’ learning of high-risk nursing procedures without distress (Jenson & Forsyth, 2012; Kilmon, Brown, Ghosh, & Mikitiuk, 2010). As a result, students’ performance in clinical practicum can be enhanced; and their tension and fear towards challenging clinical practice and medical incidents can be minimized.

In 2015, our School first applied the technology of immersive virtual reality to train psychiatric nursing students in supporting patients with anxiety disorder, and suicide risk assessment. More than 70% of the students provided positive feedback on VR-based teaching technology. Also, through the immersive virtual reality system, nursing students were trained in how to manage patients’ anxiety at various levels that appeared in the virtual environment. This was successful in enhancing nursing students’ interest in learning and knowledge retention. It created a more frightening and flexible reality that was useful in minimizing the anxiety patients suffered. In the virtual environment, nurses learned how to nurse patients in unexpected situations. The higher efficacy of the virtual reality environment as a therapeutic and learning platform could be identified for caring for patients with psychological problems. Finally, empathy towards patients could be achieved so that nursing students could have a greater understand of their patients’ thoughts and experience.

In 2018, the technology of four-sided VR CAVE was introduced in our VR Education Unit. The four-sided CAVE is an immersive VR system used for informed virtual environments. It is typically a video theatre situated within a larger room with the capability of offering both a closed configuration (U-shaped) and an open one (L-shaped). Nursing students used 3D glasses inside the VR CAVE to watch 3D objects generated. Using the VR CAVE, they could see objects, such as “virtual” patients apparently floating in front of them or staying close together, and they could walk around as they liked, getting a proper view of what the patients would look like in reality (Kral, Mehrle, Kikinis, & Freysinger, 2004). In this way, nursing students were able to practise what they had learned in class, such as communication or breakaway skills, in the virtual environment. Compared with the traditional role-play teaching and learning, the VR CAVE provides a more real sense and feeling to nursing students’ learning. In generally, the VR mode involves the creation of a virtual environment presented to our senses in such a way that nursing students experience it as if the patients were really there. The tailor-made pedagogical use of VR can effectively provide healthcare professionals with clear visualization and realistic images which can enhance their knowledge and skills.

**Conclusion**

Technological innovation has been introduced in healthcare education. 3-D imaging and VR learning could resolve the challenges of limited resources and preparation for clinical knowledge and practising skills. The establishment of a VR Education Unit
aims to facilitate the development of innovative technology in nursing education. The development of VR-based teaching technology can help to resolve the problems of a lack of hands-on experience and risks from real practices. Scenarios in virtual worlds can be standardized; and, thus, learner performance can be monitored, recorded, and evaluated. In the long run, 3D and VR has the potential to cross geographical barriers as a tool for other teaching applications. It is not surprising that 3D/VR-based teaching technology is regarded as the cornerstone of today’s healthcare education. Innovative educational technology is strongly supported in the School through relevant academic research.

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**References**


Develop Suicide Assessment Skills of Nursing Students Through a VR-based Learning Environment

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Abstract

Suicide is a sad but highly preventable event. A sound suicide assessment certainly plays an important role in managing this desperate situation. Although standardized assessment tools can help, they cannot replace a clinician’s face-to-face assessment. It is certainly a task which demands a high level of skill. Traditional classroom teaching can convey the principles of assessment and related questioning skills, but it lacks the opportunity for student to practise before entering clinical assessment. This paper reports on the learning experience of a group of 40 students in a higher diploma mental health nursing programme using a virtual learning (VR) environment to develop suicide assessment skills based on Shea’s “chronological assessment of suicide events, CASE”. The initial feedback from the students was encouraging. It is necessary to carry out more studies in this area to elaborate further the benefits of using a VR learning environment.

Keywords: VR learning environment, virtual patients, suicide assessment, chronological assessment of suicide events, mental health nursing
Introduction

Suicide is a heartbreaking phenomenon, creating not only a fatal outcome for those who die but also has a significant impact on survivors. The World Health Organization (2014) was alarmed that more than 800,000 deaths resulted from suicide and 20 times that figure attempt suicide each year. Suicide prevention through careful assessment is therefore a serious matter of concern for health care professionals (NSW Health, 2005). Mental health care professionals, in particular, assume an important role in conducting specialized assessment of the risk of suicide. Therefore, training their assessment skills is of paramount importance.

The Nature of the Assessment for Suicide

In clinical work, a number of tools have been devised in an attempt to establish a scientific approach to sensitively screen suicide risk. One of the common suicide screening tool used in a clinical setting is the Sad Persons Scale, using a mnemonic ten-item scale of a “sad person” to guide suicide risk assessment. This is a ten-point scale with a score of 1 for each item. It is recommended that close monitoring is required for a person who scores 3 to 4; strong consideration of hospitalization for scores 5 and 6; and hospitalization for further assessment for scores 7 to 10 (Patterson, Dohn, Bird, & Patterson, 1983). Currently in Hong Kong, the psychiatric settings commonly adopt The Nurses’ Global Assessment of Suicide Risk (NGASR)’ as a major tool to assess the suicide risk of a person. The NGASR is a 15-item standardized assessment scale, comprising ten 1-mark items and five 3-mark items, with a maximum score of 25. For subsequent management, the NGASR proposes a low level of risk for scores of 5 or less; an intermediate level of risk for scores between 6 and 8; a high level of risk for scores between 9 and 11; and a score of 12 or more signifies a very high level of risk. However, no research evidence so far has validated the classification of the levels of suicidal risk (Cutcliffe & Barker, 2004). Some mental health experts also consider that categorizing people with different risk levels based on scores obtained may be too simplistic (Oquendo & Bernanke, 2017).

Although standardized suicide risk assessment tools can play a role in the assessment, they are subject to several limitations. All scales reduce the risk of suicide to a number representing a certain level of risk. As thinking about suicide is a multifaceted complex situation, it should not be interpreted only in terms of a number. The assessment tool can easily distract healthcare professionals from exploring the risk further and examining protective factors before formulating the whole clinical picture. Indeed, a standardized scale usually has a bias towards assessing those identified risk factors, without assessing protective factors.

Despite such limitations, the standardized assessment scale has the advantage of providing a set of standardized items for health care professionals to follow. Each assessment scale covers a number of items from different areas of suicide assessment, and health care professionals can easily follow the scales. The scoring system also has
several benefits. It not only provides a common language which informs all health care professionals of the classification of the suicide risk of the person under assessment, but also gives a set of subsequent management strategies to minimize the acts of suicide. A standardized assessment scale certainly can be helpful in ward situations where time constraints are a concern. However, suicide is a complicated event that involves dynamic risk and protective factors. The assessment of suicide, therefore, should be an ongoing process requiring attention to the ever-changing situation of the person more than to any pre-determined items in an assessment tool.

To achieve a sound and valid risk assessment for suicide, the American Psychiatric Association (APA) (2003) and the Registered Nurses’ Association of Ontario (2009) have highlighted guiding principles which are essential for this unique assessment process. The first principle is to establishing rapport through active listening and empathic communication skills; and the second is to obtain thorough and collateral information about the struggles of the person in distress. The third principle is about comprehensive documentation of the assessment regarding the overall level of risk in terms of immediate warning signs, risk factors, protective factors and specific protective measures to enhance the modifiable factors and secure the safety of the person. All these principles not only require a set of skilful and effective communication skills on the part of the assessor (Perlman, Neufeld, Martin, Goy, & Hirdes, 2011), but also a structured and systematic approach to assimilating all the essential skills.

**Chronological Assessment of Suicide Events (the CASE Approach)**

Specifically for suicide assessment, Shea (1998) developed an interviewing strategy known as *Chronological Assessment of Suicide Events, CASE*, which was designed to minimize the likelihood that essential pieces of information would be missing at the time of risk formulation. The CASE approach was firstly developed at the Diagnostic and Evaluation Center of the Western Psychiatric Institute and Clinic at the University of Pittsburgh in the 1980s. Later, it was refined at the Department of Psychiatry in the Dartmouth Medical School and used in front-line community mental health centre work during the 1990s. Subsequent refinements in the 2000s were implemented at the Training Institute for Suicide Assessment and Clinical Interviewing.

The CASE Approach is a flexible, practical, and easily learned interviewing strategy for eliciting suicidal ideation, planning, behaviour, desire, and intent. The goal is to create a practical interviewing strategy that can be used reliably to maximize the validity of the assessment of the suicidal intent of a person, even in a clinical situation where resource is limited.

**Two Techniques for Raising the Topic of Suicide**

The CASE approach provides a practical interviewing strategy using six useful interviewing skills to maximize the validity of the person’s information. The validity of the techniques being used is emphasized throughout the CASE approach. The emphasis
rests on how we ask a relevant question and the impact on the person who is intent on committing suicide. Before one can explore a patient’s suicidal ideation, the topic must first be addressed. While a person may not spontaneously talk about the topic of suicide, the skilful assessor must raise it in a fashion which is both engaging and likely to foster open sharing.

Two validity techniques – normalization and shame attenuation – may be relevant and useful here. They are considered useful skills for engaging the person in talking about the topic of suicide. Normalization is a method which unobtrusively normalizes the hidden suicidal ideation. The skill is that the assessor relates the pains and/or stresses of a person to another person undergoing a similar situation in which he/she has experienced suicidal thoughts.

Another slightly different but useful approach is that of ‘shame attenuation’. In contrast with normalization, the person’s own pain is used for opening the topic of suicide. Shame attenuation relies on the assessor engaging the person with empathy by expressing an understanding of his/her current painful situation and asking if the idea of committing suicide is already present.

**Four Other Key Techniques**

Although not specifically developed for suicide assessment, the following four techniques form the backbones of the CASE approach.

**Behavioural incident:** Behavioural incident questions are designed for soliciting specific facts, behavioural details, or trains of thought. They are, therefore, used for fact-finding.

**Gentle assumption:** This involves the assessor in discussing other taboo behaviours or ideas that may be present, but about which the person feels hesitant in talking about. The assessor asks his/her explorative questions in a gentle tone of voice and invites the person to talk about the initially unmentionable behaviour or idea.

**Symptom amplification:** This technique is designed to collect a rough number that may be helpful for clinical decisions. It might be related to certain behaviour or any substance or medications which has been taken by the person. Symptom amplification requires the assessor to ask the person a set of three to four numbers which are incremental in a series. The purpose is to get the person to downplay the amount to a level close to the actual. The number, however, must be large enough but able to reflect the reality.

**Denial of the specific:** This approach aims to increase the likelihood of gaining a valid response from the person on sensitive or offensive information. The skill involves setting specific individual questions that relate to the same issue of concern, such as different common ways of committing suicide. This technique is to refresh one’s memory by denying a specific instead of generic question.
Four Chronological Periods

The major benefit overall of the CASE approach is that it provides the assessor with a systematic, practical, and easy-to-remember framework for eliciting suicidal ideas, behaviour, desire, and intent. Through the CASE approach, the assessor sequentially explores the following four chronological periods according to the following order.

**Present Suicide Events**

The term “present suicide events” refers to any current attempt/idea/plan and is understood in the sense that the person is “currently” experiencing them. This includes the topic of suicide the person spontaneously raises; the topic of suicide uncovered with techniques such as normalization or shame attenuation; or the current suicide attempt. The assessor then explores the whole picture of the suicide attempt or ideation in a step-by-step fashion. During this stage, the assessor uses a string of behavioural incidents to build an accurate picture of presenting the suicide event.

**Recent Suicide Events (over the preceding 2 months)**

The information on recent suicide events is an information-rich area for exploring. The assessor may uncover the person’s real intent by exploring the ideation and planning which occurred in this time frame. It gives a longitudinal view of a person’s suicidal intent in terms of time. To start, the healthcare professional makes a bridging statement to make a transition to the recent suicide event after having examined the presenting suicide event. Usually, a gentle assumption question can serve the purpose of transition. Once it yields a negative response, a blanket denial of the specific questions is used to explore other unmentioned methods of suicide the person had in mind. If a second method is uncovered, then sequential behavioural incidents are used to explore the extent of actions taken with that method. After finishing the exploration of the second event, the gentle assumption question is used again. If another method is elicited, another set of behavioural incidents has to be developed. Otherwise, another set of questions for denial of specifics is launched to stimulate a response. After establishing a list of methods that have been considered and the extent of action taken on each method, it is time for the assessor to end this stage. The assessor can do this with a symptom amplification question to evaluate how much time the person had spent in the past several weeks thinking about suicide.

**Past Suicide Events (over 2 months ago)**

This is to explore the past history of suicide attempts. People with a complicated psychiatric history may have a lengthy past history of attempts at suicide. The assessor can stay focused on getting information on the most serious past suicide attempt, the rough number of attempts, and the usual triggers.
Immediate Suicide Events

The focus at this stage is on the “here and now”. The aim is to explore the person’s current level of hopelessness and to assess whether he/she is making productive plans for the future or any adaptive plans for dealing with current problems and stress. That is a critically important area of a suicide assessment. Here, the most subtle change of facial expression or hesitancy in speech may indicate that a suicide attempt is imminent.

The sequence of exploration is designed to maximize both engagement and the validity of the data obtained. Once the topic of suicide has been raised, it seems natural to talk first about the presenting ideation or attempt. Following the sequence, the assessor is generally able to improve the engagement with the person. When mutual trust has been maximized, this will increase the likelihood of the person sharing valid information.

From an educational point of view, teaching students to master the flow of all these four stages using the six essential questioning skills can be very challenging. Of course, lectures can help students to build up the concept of the structural systems in the CASE approach and the essential differences in the six questioning skills. My past teaching experience suggests that lectures combined with audio demonstrations and scripts can enable students to gain the whole picture of the approach from the beginning to the end. But the reality is that it still lacks opportunities for students to get a real experience of how to raise relevant questions appropriately and to control the flow of the CASE approach while reacting to the person’s responses.

The Use of a Virtual Reality Learning Environment

It is almost impossible to have a suicidal person for students to practise on. However, the use of a virtual reality learning environment opens up a new opportunity. The concept of virtual reality (VR) refers to a whole simulated reality, which builds an alternative reality powerful enough to create a realistic immersive experience by using VR helmets or dedicated glasses (Martín-Gutiérrez, Mora, Añorbe-Díaz, & González-Marrero, 2017). The VR learning environment can attract the attention of students to learn how to interact with the subject matter through practising in a new way (Freina & Ott, 2015; Martín-Gutiérrez et al., 2017). It allows students to be free from classical one-way passive learning in the classroom and become actively involved in experiential learning (Pantelidis, 1995). Mantovani (2001) also reminds us that VR could be an option for training learner in a context that is impossible or difficult to experience in real life. Guise, Chambers and Valimaki (2011) assert that, particularly in the mental health field, simulations through virtual patients is ideal for promoting essential nursing skills such as communication. Brown (2008) also argues that virtual patients (VPs) can be the best way for students to learn and practise core mental health care competencies. In brief, a VR learning environment is ideal for developing students’ clinical assessment skills for suicide risks before they enter clinical settings.
Implementation of the VR Learning Environment

Before practising in a VR environment, a two-hour lecture supported by an audio demonstration on the six questioning skills and the CASE approach was conducted with a class of 40 students in the Higher Diploma in Nursing Studies (Mental Health Care). The VR learning environment was arranged in two 1-hour tutorial sessions in the VR laboratory of the School of Nursing and Health Studies at The Open University of Hong Kong, with one tutorial session catering for 20 students.

The virtual patient (VP) was developed by the VR team of the School. The VP was designed as a lady whose son had died in a car accident a month ago. She was attempting suicide by burning charcoal and was admitted to a psychiatric ward for observation and suicide assessment. The setting was a virtual interview room. The students were asked to put on the VR goggle to enter into the VR environment. In the VR environment, the VP was sitting in front of the student, who had to conduct the assessment of suicide using the CASE approach. The responses of the VP were based on the scenarios provided in the literature describing the CASE approach. Hence, the responses of the VR were all pre-set.

During each tutorial session, a student volunteered to wear the VR goggle to be immersed in the VR learning environment for practising the CASE approach and questioning skills. The student was asked to initiate the assessment guided by the CASE approach, and the rest of the students viewed the VR environment on a large monitor. During practice, the response of the VP was controlled by the teacher. When the student had difficulty, the teacher gave advice to guide him/her in the VR environment; and when the student was unable to continue, another student replaced him/her and continued with the rest of the practice.

After each tutorial session, the students were asked to fill in an individual evaluation form, which was designed specifically to collect their feedbacks on the VR learning environment. The evaluation form had two parts. The first part involved eight items in the form of a 4-point Likert scale. A score of 1 meant ‘Strongly Disagree’, while a score of 4 was ‘Strongly agree’. The second part comprised two questions, which aimed to collect written feedback on how the students had benefitted and their comments on improvements.

Results

Students’ Feedback

In total, 38 students completed the evaluation forms and gave the following feedback and comments. There were 47% and 53% respectively who agreed and strongly agreed that the VR learning environment had provided them with a learning environment which was close to real. A similar percentage of students felt that the VR learning environment and classroom teaching were complementary (45% and 55%) and found it more useful than classical learning materials such as PowerPoint or lecture notes (47%
and 53%). More students (63%) strongly agreed that VR learning could help them to understand more about the topic and 61% felt strongly that VR learning could motivate them to learn. Overall, all the students felt that VR could help them to achieve the learning outcome and get them involved in learning.

Students’ Feedback on the Benefits

For the written feedbacks on the benefits, content analysis was conducted to isolate the essential themes the students reported as useful. There were four major themes, namely “Experienced the realness of the virtual world”, “Learned more from it”, “Applied the skills and enhanced self-understanding” and “Benefitted the future”.

Experienced the realness of the virtual world

The students’ feedback reflected that the VR learning environment could provide them with a close-to-real situation in which the virtual patient could give an immediate response after a student’s question. They appreciated this highly as the instant pressure motivated them to work out how to respond to the VP and pay attention to the flow of the assessment schedule. All these interactions, together with the atmosphere created in the VR environment, made them feel that it was very real – they felt as if they were confronted by a patient face-to-face. Another benefit of the VR learning environment reported by the students was that the situation could be paused, which gave them a chance to repeat again and again to get a right response and keep to the assessment schedule.

Learned more from it

The students felt that the created reality enhanced their impression of what they had learned, their involvement in learning, their understanding of the topic, and their memory. The impression they gained from such a “face-to-face” environment was remarkable. They felt that they could hardly forget the experience which had pushed them to practise the right questioning skills. By being immersed in this nearly-real situation, they felt actively involved in the learning environment by thinking about what to say in the process of assessment; and, in doing so, they found that they understood more about the questioning skills and grasped the flow of the CASE approach. They also knew how to make brief self-introductions, mentioning their roles and the purpose of the interview to the patient at the beginning of the suicide assessment. These experiences were so vivid that the students gained a deep memory of what they had learned in the VR learning environment.

Applied the skills and enhanced self-understanding

By applying the skills they had learned in the class, the students got other kinds of experiences. They found that their classroom learning was not something totally theoretical. They also discovered that the VR learning environment required them to bear in mind the theory behind the CASE approach when practising with the VP. In this
way, they found that they could obtain valuable clinical information through practising the questioning skills correctly at the right moment. Such experience was important for them as they felt they really had learned something practical and useful for their clinical practice.

Another remarkable learning experience the students reported was that they had more self-understanding. Through practice, some students found the manner in which they asked questions was rather rude. However, with guidance from the teacher, they learned how to correct their way of asking questions. The practice through the VR learning environment allowed them to reveal their weaknesses and strengths, which was a good start for them to develop themselves in a protected and conducive learning environment.

**Benefitted the future**

The students felt that practising through the VR learning environment could help them to prepare well for the future in the real clinical setting. They were perceived as having more confidence in handling different clinical situations, and so they found the skills they had learned via the VR learning environment could alleviate their worries about the coming practicum.

**Feedback on future improvements**

Most of the feedbacks referred to having more time to practise, creating more scenarios, and initiating more diversified responses. Such comments reflect that the VR learning environment had expanded the learning needs of the students. However, developing new clinical scenarios via a virtual environment as the learning and teaching platform requires time, expertise and resources.

**Conclusion**

This attempt to use the VR learning environment as a platform for training the assessment skills for suicide in nursing training is unprecedented. The feedback from the students illustrated the unique features of such an environment, which they found useful for practising such important mental health nursing skills for suicide assessment. The VR environment, the VP and the designed responses created a learning environment that classrooms can never achieve. Students treasured such remarkable learning experiences as they found themselves actively involved in learning practical skills which benefit their professional development.

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Technological Enhancement for Teaching Anatomy and Physiology in Nursing Education

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Abstract

Anatomy and physiology (A&P) is the fundamental knowledge for all health-related personnel training, including nursing students. However, learning A&P can be difficult for them. Various pedagogies have been used for teaching A&P courses in order to help nursing students to have a better understanding of the content. The application of technology in nursing education is common in today’s technological world. Using technology to enhance A&P teaching is one of the trends which helps nursing students to learn A&P. In this article, we share our experience in using three technologies – namely the Student Response System (SRS), 3D technology, and virtual reality technology – to enhance the teaching of the A&P curriculum in our nursing programme. Our study demonstrates that, by applying these technological tools in the A&P curriculum, students’ learning experiences are improved and they can better understand the teaching content in the course. Overall, applying technological education helps student learning on the A&P course, which is essential knowledge for their future careers.

Keywords: anatomy and physiology, technological education, Student Response System, 3D, virtual reality
Introduction

Anatomy and physiology (A&P) is essential in all medical or para-medical training. It is regarded as the fundamental knowledge for training all health-related personnel (McVicar, Clancy, & Mayes, 2010). In most cases, it is one of the required courses for the pre-clinical training of nurses and may even be the very first course in their training as nursing students. Although A&P is essential knowledge for all nurses, it is well understood that nursing students struggle to learn biological science subjects in their pre-clinical training stage (Bakon, Craft, Christensen, & Wirihana, 2016). Many studies have suggested various teaching pedagogies to help nursing students to overcome this problem and improve their learning experience and knowledge retention (Khot, Quinlan, Norman, & Wainman, 2013; Lewis, Burnett, Tunstall, & Abraham, 2014). These include improving interaction between the teacher and students by using the audience response system (Efstathiou & Bailey, 2012); introducing problem-based learning (Mayner, Gillham, & Sansoni, 2013); using videos (Guy, Byrne, & Dobos, 2018) and mobile apps (Chakraborty & Cooperstein, 2018); and introducing advance technological platforms. Our teaching team has incorporated several of these pedagogies into our Year 1 A&P curriculum. In this article, we discuss the use of such technologies in the A&P course and share our experience in using technological platforms in our curriculum.

Conventional Teaching Methods in Anatomy and Physiology in Nursing Education

As with other courses in the university, mass lectures remain the main teaching strategy for A&P courses for nursing students. In our case, we have about 350 to 400 students taught by one lecturer at a time during the mass lecture sessions. This remains the main teaching method because it is the most efficient way of teaching (Efstathiou & Bailey, 2012). However, there are several drawbacks in using mass lectures. Firstly, it neglects the variation in students’ backgrounds. Those who already have a strong background in biology and chemistry are more likely to have a better understanding of the biological content in the A&P course, especially the physiology content, which requires some basic knowledge of biochemistry to understand it. Secondly, interaction between the lecturer and students is very difficult with such large classes, and so the lecturer finds it very hard to track individual student’s understanding and progress during a lecture. Although we have tutorial sessions, which have a much smaller class size, due to time constraints, the interaction between the teacher and students is still very limited. This hinders the lecturer in identifying those students who need support.

Another issue is related to the content of the course. The human body has a very complex 3D anatomy involving difficult physiological concepts. Without seeing the dissection of a cadaver, students have difficulty in understand the 3D structure inside the human body by looking at figures from a textbook. Conventionally, a lecturer relies on textbooks, figures, and flowcharts to delineate the complex concepts to the students.
during a lecture. In the internet era, we are lucky to have some more resources, such as videos and animations from the web for explaining those difficult concepts. However, without some 3D images or videos, it’s hard for the students to understand how the 3D structural change in a particular organ changes the physiology of the human body. Understanding the human body in a 3D way is essential for learning human anatomy which is directly related to their understanding of concepts of human physiology. In view of these factors, due to technological advances, we can now incorporate various technologies into our curriculum. By using the Student Response System (SRS), the interaction between the lecturer and students can be improved slightly in a mass lecture. Instead of reading textbooks and looking at those figures, we can now use 3D animations or even virtual reality (VR) to understand the complex human anatomy, and hence the concepts of various physiological changes. The following sections explain how these technologies work and the advantages of using them compared with the conventional pedagogy.

**Technological Education in Anatomy and Physiology**

Technology can help to improve many aspects of our daily lives, including education. Nowadays, the application of technology in education is becoming more common, and various studies have demonstrated that it can promote active learning and improve students’ learning experience (Al-Modhefer & Roe, 2009; Koch, Andrew, Salamonson, Everett, & Davidson, 2010; Bakon, Craft, Christensen, & Wirihana, 2016). We are still using the mass lecture as the mainstay of our teaching method, but supplementing it with technological teaching tools can help to reduce its limitations and further enhance teaching and learning. Some technological teaching tools have been applied in our A&P curriculum for nursing students in the last few years. The details are discussed below.

**Student Response System**

As noted already, the major drawback of using mass lectures is the lack of interaction between the lecturer and students. It is difficult for a lecturer to assess students’ progress during a mass lecture, but the application of technological education tools can help to solve this problem. By using the Student Response System (SRS), an interactive learning system, students can give instant feedback to the lecturer who can then assess student learning. If the majority of the students have difficulty in understand a particular concept, the lecturer can explain it again during the lecture, which can significantly improve the interaction between the lecturer and the students. Our studies have suggested that students’ learning experience and knowledge acquisition can be improved by applying the SRS during a mass lecture (Yau, Lam, Tam, Ho, & Chong, 2016). Similar studies have also demonstrated that using an Audience Response System (another instant response system) can help to motivate student learning and help them to identify misconceptions during a lecture (Efstratiou & Bailey, 2012). All these results support the use of such instant response systems for minimizing the effects of lack of interaction in a mass lecture.
3D Technology in Nursing Education

Our School has started to adopted 3D technology in teaching A&P courses since 2015. We practise 3D teaching in both mass lectures, with a 3D projector, and in tutorial classes, with a 3D TV. We have purchased computer software with a built-in 3D model of various organs or systems in the human body for teaching. Although this can help our students to better understand the 3D structure of different human organs and systems, it is difficult for the 3D images to address some physiological concepts. Therefore, we developed some 3D videos to cover some of the systems so as to allow our students to both learn the structure of the organs and understand the structural and functional relationships to explain some key concepts in the A&P course.

Technological background of 3D technology

Our brain gives us 3D vision by processing slightly different images from our left and right eyes. The 3D technology makes use of this principle and produces two sets of fast-switching images to the left or right eye of the viewer to give the illusion of 3D images from a 2D screen (Woodford, 2018). With the help of 3D glasses, the left eye images can only be seen by the left eye of the viewer, while another set of images is seen only by the viewer’s right eye. There are two types of 3D technology, active and passive, to control the images entering the corresponding eyes in order to generate the 3D illusion. The active 3D technology uses glasses with a shutter to direct the images into the corresponding eyes, while the passive 3D technology is polarized to direct different images into the viewer’s left or right eye (Demers & Azzabi, 2017). As we are practising 3D teaching in both mass lectures and tutorials, we have chosen passive 3D as this is the easiest and most cost-effective way to practise 3D teaching with a large audiences at one time. Both 3D projectors and 3D TV have been installed in the lecture theatres and tutorial rooms for this purpose.

Advantages of using 3D technology for anatomy teaching

The human body is organized in a complex, three-dimensional manner. The traditional teaching aids – books, pictures and videos – cannot demonstrate the 3D structure of an organ or a system in the human body. It is difficult to explain the relationship between the 3D structural changes of an organ in relation to its physiological functions. In our experience, students have agreed that by introducing the 3D lecture, they could better understand the course content and it helps them to achieve the pre-set learning outcome during the lecture (So et al., 2017). These results demonstrated the importance and effectiveness of using 3D technology in teaching A&P courses.

Virtual Reality Technology in Nursing Education

Virtual reality (VR) is a relatively new computer technology which has been widely used in the military, aerospace, engineering, and video gaming. It has been used in the medical field training surgeons for simulating various surgical scenarios (Seymour et
al., 2002; Thomson et al., 2017). Our School also started using it for teaching anatomy and also simulating scenarios in different mental health situations. By applying the VR technology in our nursing curriculum, students’ learning experience was further improved (Lam et al., 2017).

**Technical background of virtual reality technology**

The name “virtual reality” seems contradictory as virtual and reality are always opposites. According to NASA, the definition of virtual reality is “the use of computer technology to create the effect of an interactive three dimensional world in which the objects have a sense of spatial presence” (Virtual Reality, n. d.). The most common type of VR technology currently used is immersive VR, using a head-mounted display to immerse the user in a virtual environment created by the computer software. The scenario can be tailored to serve specific purposes. In our case, some software has been purchased to allow our students to travel into the blood vessels of our body to understand the anatomy and physiology of the cardiovascular system. In that case, the anatomy and those physiological concepts are the reality parts, whereas the travelling experience by wearing the head-mounted display unit is virtual for our students, as they won’t have a chance to travel into the blood vessels in the real world. In addition to teaching the A&P course, we have also tailor-made several pieces of software for teaching our students to handle various mental health scenario. Students’ evaluation has been very positive on applying VR technology in our A&P curriculum. It can help to arouse student interest in studying human anatomy and motivate them to learn actively during the sessions (Lam et al., 2017). More importantly, the students’ learning experiences are further enhanced by using the VR technology when compared to the traditional learning routines.

**Future Direction for Technology Application in Anatomy for Nursing Education**

In view of the technological innovations and computer hardware capability, the application of technology in education is expected to increase dramatically in the coming years. The use of technology in nursing education can help nurses to train safely; and, by using various technologies, the students can have multiple training sessions before they go into a real clinical situation. Even in the A&P course, the better medical imaging technology and better performance in computer hardware make virtual cadaver dissection possible. Although cadaver dissection may not be essential for nursing students, such technology allows them to have hands-on experience in doing so, which gives them a better understand of the human anatomy and prepares them better for their future clinical work.

**Acknowledgement**

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References


Learning Feedback of University Nursing Students on Virtual Reality Exposure Therapy for Acrophobia in Hong Kong

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Abstract
Many people suffer from acrophobia, commonly known as “fear of heights.” However, the anxiety level of acrophobia can be gradually reduced by using proper treatment and therapy. Virtual reality (VR) has become one of the most significant technologies recently. Virtual reality exposure therapy (VRET) is known to be effective for the treatment of acrophobia. Thirty-four nursing students in Hong Kong were invited to experience and learn virtual reality exposure therapy by using a head-mounted display. Through this exposure, they could experience being placed on certain heights from a personal perspective and understand the psychological condition of clients with acrophobia. They could be trained to help relieving the symptoms of clients using VR technology. Feedback questionnaires were collected from the students after the training session. The questionnaire, using a 4-point Likert scale, was developed to see whether the VR technology could help the students to achieve a better learning experience for tackling patients with acrophobia when compared to traditional learning, such as using only books, PowerPoints and videos. As a result, the immersive experience of using VR technology did arouse students’ interest in learning the nursing knowledge and skills of caring for patients with acrophobia. Students also reported that the learning experience was better than using the traditional learning routine.

Keywords: virtual reality, acrophobia, exposure therapy
Introduction

Acrophobia is a psychological condition which makes people feel a fear of height (Suyanto, Angkasa, Turaga, & Sutoyo, 2017). It causes a logical barrier to being in high places and hinders people from activities such as parasailing. One in five people reported having a strong unreasonable fear of heights during their lifetime and one in 20 met the criteria for acrophobia (Freeman et al., 2018).

Virtual reality (VR) combines and integrates real-time computer graphics, body tracking devices, visual display, and some sensory inputs to immerse individuals in a computer-generated virtual environment (Emmelkamp et al., 2002). The use of VR can create environments to simulate the real world. Exposure can now be conducted through using VR technology. Suyanto et al. (2017) stated that a virtual environment helps people with acrophobia to reduce their fear of height in a secure and controllable environment. It mimics real heights and trains the clients to overcome their anxiety about high places. They are able to confront their fear gradually based on their level of progression in the virtual world; and they then have more experience in handling their fear and reducing their anxiety level.

Recently, VR technology has not only been applied in the medical treatment of patients, but also in training healthcare professionals. A Virtual Reality Learning Environment (VRLE) can provide healthcare students with ways to access and revisit learning materials in order to enhance their education. In this environment, there are some benefits for students. For example, they can practise in safe environments, rehearse without fear, have training at their own pace and in locations of their own choosing, and gain the confidence needed when faced with a real scenario. As a result, not only can the risk of errors be reduced but the safety of clients can also be increased (King et al., 2016). Through getting feedback from clients and students after completing VT trials, VR technology can continue to be improved.

Methods

Evaluation was done in the School of Nursing and Health Studies in The Open University of Hong Kong. Year 1 students who were studying Higher Diploma in Nursing Studies (Mental Health Care) were recruited. Beforehand, they had been taught nursing knowledge and skills related to acrophobia in the course’s lectures and tutorials by traditional learning strategies, including PowerPoints, lecture notes and videos. The students were invited to participate in the VR exposure training about acrophobia on a voluntary basis. There was no relation with their academic result of the course. They could withdraw from this project without any penalty. Students who were retaking this course were excluded.

During the VR training, the students were arranged to go into the training room (Virtual Reality Education Unit). By using a head-mounted display, they could experience a virtual world. They were required to wear the HTC VIVE VR headset to
learn virtual reality exposure therapy. Scenarios from walking across a virtual bridge in a high place at different levels of height were provided in the virtual world. The height level of the bridge could be adjusted according to the responses of the students. The students were monitored and guided by the trainers. Explanation of the details about the Virtual reality exposure therapy and caring skills of handling clients with acrophobia during the VR exposure were given to the students by the trainers.

After the completion of the training session, the students were asked to complete a self-administered questionnaire, which took about 10–15 minutes, for evaluating the efficiency of learning, with a comparison between VR learning and traditional learning. In the questionnaire, the students had to rate eight statements on a 4-point Likert scale, with 1 as “strongly disagree”; 2 as “disagree”, 3 as “agree”; and 4 as “strongly agree”. They also had to answer two open-ended questions. Confidentiality was ensured, with no personal identity given. All the completed questionnaires collected were locked away and kept confidential. The findings of this evaluation were used for academic purposes only, and all the data will be destroyed after the completion of this project.

Results

Evaluation was conducted in April 2018. Thirty-four students were invited to participate in this evaluation. Response rate was 100%. The questionnaire (Table 1) included two parts. The first part consisted of eight statements with a rating scale, and the other part had two open-ended questions.

In the first part of the questionnaire, the first statement was “The VR learning material is relevant to the course contents.” The result showed that 55.9% of the students strongly agreed and 41.2% agreed with this statement, with only 2.9% disagreeing with it. The second statement was “The VR learning material provides me with real-life experiences to interact with patients.” It was found that all students gave positive feedback on this statement: they all strongly agreed (58.8%) or agreed (41.2%) with it. The third statement was “The VR learning material is useful side by side with lecture notes.” In this case, 50.0% of students strongly agreed and 47.1% agreed, with only 2.9% disagreeing. The fourth statement was “The VR learning material is more useful when compared with traditional learning material such as PowerPoints, lecture notes and videos.” Most of the students (64.7%) strongly agreed with this statement and 32.4% agreed with, again, only 2.9% disagreeing with it.

The fifth statement was “VR learning can inspire my interest in learning.” In this case, the result was overwhelming. All the students strongly agreed (55.9%) or agreed (44.1%) with this statement. The sixth statement was “VR learning helps me concentrate more on my studies.” This result was also one-sided, with nearly half (47.1%) of the students strongly agreeing with the statement and another half (52.9%) agreeing with it. The seventh statement was “VR learning helps strengthen my understanding of the course contents.” The result showed that half (50.0%) of the students strongly agreed with this statement and 47.1% agreed with it. The final statement was “Conclusively
speaking, VR learning successfully helps me achieve my learning objectives”. In this case, 47.1% of the students strongly agreed and 50% agreed with it, with, as in Question 7, only 2.9% disagreeing.

In the second of the part of the questionnaire, there were two open-ended questions for the students to answer. The first open-ended question in this part was “What did you gain most from this VR learning experience?” The feedback from the students was quite positive. Some answered that it was their first experience of using VR technology for learning and the virtual environment was so real. Other comments included that they could: really try to overcome fear of height in this scenario; really feel and exposure to the fear of the clients with acrophobia through this experience; learn about the fear the clients experience; and understand more about the condition and feelings, including the clients’ fear and anxiety. Also, some students reported that: this experience would help them to counsel clients because it let them understand more about the feelings of the clients; they could practise relaxation techniques when feeling nervous during walking across the bridge in a high place in the virtual-world through encouragement, support and guidance from the trainers; and they were also convinced that it was a very good learning experience for them.

The second open-ended question was “Do you think this VR learning material requires improvement?” Some students suggested that each VR training session should be longer, so that they could have more time to experience it. The wind and speed effect could be added to the VR system in order to increase the level of reality. Some students were convinced that there was still room for improvement in the level of reality of the VR-scenarios. For example, that the images were not clear and real enough. Thus, more equipment should be input in order to enhance the effect of the virtual world and improve the quality of the training. Some students also recommended that more scenarios should be developed and added to this training.

**Discussion**

Clients with acrophobia can alleviate their symptoms by medication and standard cognitive behavioural therapy. The most effective therapy requires confronting the trauma itself. VR technology provides a platform for clients as treatment to do so (Cosma, Balan, Moldoveanu, Morar, & Moldoveanu, 2017). Besides applying VR technology to clients, based on the evaluation, it was shown that VR technology should be developed in nursing and more VR learning materials should be designed in nursing education for students to experience different situations, understand more about their clients and train their caring skills. It was found that the feedback from the students about the efficiency of VR learning material was positive. Students enjoyed the learning experiences through VR technology. Most of them were convinced that learning the virtual reality exposure therapy and nursing care for acrophobia by using VR learning material was useful and effective. VR learning material can provide students with a sense of the value of their learning as they agreed that their virtual experience would be significant benefit in their
nursing practice. VR learning materials would be an important element in teaching clinical skills in the future as they could practise their skills without causing harm to their clients. Not only can it offer nursing students a way of bridging the theory-practice gap, but it also allows them to experience “safe fails” that are vital in learning how to provide professional nursing care to clients. Students can keep on practising their skills by using the VR learning materials until their skills are up to standard before having their practicums in hospitals where they have to care for real clients.

Although there are many advantages in using virtual reality technology in education, the use of fully immersive virtual reality for health care education is still at an early stage of development (Kilmon, Brown, Ghosh, & Miktiuk, 2010). The development in this area has been relatively slow in progressing, especially in the field of nursing, because of multiple barriers, including technical complexity, difficulty in establishing a sense of identity in a collaborative virtual environment, and time and cost issues (Warbuton, 2009). Moreover, lack of support and skills among some academic staff may also be an obstacle. In Hong Kong, virtual reality learning material is still a new application in nursing education. Based on the nursing students’ feedback in this study, if more resources can be provided to develop more different virtual learning materials and improve their quality, more nursing students can benefit in their learning.

In this evaluation, only 34 students were recruited for providing feedback. Research projects with larger sample sizes which focus on nursing students’ satisfaction in using VR learning material should be conducted in future. Experimental research on the learning outcomes of nursing students by comparing pre- and post-VR training should also be considered.

**Conclusion**

Virtual reality technology can help nursing educators to bridge the gap between knowledge and application. Virtual reality learning materials enhance the learning of nursing students through various scenarios and exposures. By using different VR learning materials, students can practise their nursing skills and even nursing procedures. Students will be likely to become more confident and competent when they face real clients in a healthcare setting. It is hoped that, in future, a greater variety of virtual learning materials can be developed for nursing students and there can be a bright future for using VR in nursing education.

**Acknowledgement**

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References


## Table 1. Questionnaire for evaluation

### 第一部分：調查問卷（請圈上最符合你意見的選項）

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<tbody>
<tr>
<td></td>
<td>非常不同意</td>
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<tr>
<td>1. 虛擬實境學習資料與課程內容相關。</td>
<td>1</td>
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<tr>
<td>2. 虛擬實境學習資料為我回應病者提供了一個更為真實的環境。</td>
<td>1</td>
</tr>
<tr>
<td>3. 虛擬實境學習能與講義相輔相成。</td>
<td>1</td>
</tr>
<tr>
<td>4. 虛擬實境學習資料比傳統的學習材料（例如PowerPoint，講義和視頻）更有用。</td>
<td>1</td>
</tr>
<tr>
<td>5. 虛擬實境學習可以激發我對學習的興趣。</td>
<td>1</td>
</tr>
<tr>
<td>6. 虛擬實境學習可以讓我更投入學習。</td>
<td>1</td>
</tr>
<tr>
<td>7. 虛擬實境學習可以增強我對課程內容的理解。</td>
<td>1</td>
</tr>
<tr>
<td>8. 總的來說，虛擬實境學習可以幫助我達成學習成果。</td>
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### 第二部分：自由發揮的問題

1. 您認為虛擬實境最能令你得益的是什麼？

   ____________________________________________________________

   ____________________________________________________________

   ____________________________________________________________

2. 您認為今次虛擬實境學習有什麼改善之處？

   ____________________________________________________________

   ____________________________________________________________

   ____________________________________________________________

再次非常感謝您的時間和意見！
Evaluation of Nursing Students’ Experience on the Implementation of 3D-based Learning in Anatomy and Physiology in Hong Kong

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Abstract

Anatomy and physiology courses are the most fundamental and important courses in the nursing and healthcare professions (Andrew, McVicar, Zanganeh, & Henderson, 2015). The number of students has continuously increased in recent years, and we have limited resources for teaching these courses. According to Hilbelink (2009), students of anatomy need to use three-dimensional (3D) technology to learn more easily than with the traditional two-dimensional model of teaching. Our School has used 3D-based learning for teaching the courses on anatomy and physiology since 2015. This study is based on the feedback of nursing students in using 3D-based learning. Seven areas have been examined to evaluate students’ experience in implementing 3D-based learning in anatomy and physiology, viz. the correspondence between the 3D-based learning materials and the course; the attractiveness of using the 3D-based learning materials; the quality of the 3D-based learning materials; the comparison between the 3D-based learning materials and traditional learning materials; the arrangement of the 3D-based learning sessions; the usefulness of using the 3D-based learning materials to teach; and the nursing students’ comments on the 3D-based learning experience. We collected 331 valid questionnaires; and the feedback was promising and positive, with most students being satisfied with 3D-based learning.

Keywords: anatomy, physiology, 3D-based learning, 2D-based learning, stereo 3D
Introduction

Anatomy and physiology are the most fundamental and important courses in the nursing and healthcare professions (Andrew, McVicar, Zanganeh, & Henderson, 2015). The knowledge of anatomy and physiology is concerned with human structures and functioning, an area which involves a lot of the daily work in nursing care. For example, when assessing a patient’s pulse, nurses need to know where human arteries are; and when a patient suffers from low back pain, they have to know which parts of the human body are involved (Registered Nurse RN, 2018, March 5). However, many nursing students fail in anatomy and physiology courses because of poor understanding due to the traditional teaching strategies.

We have found that the traditional ways of teaching anatomy and physiology, which use two-dimensional (2D) materials – such as text, images and videos – are not good enough to support nursing students’ clear understanding of the subject. For this purpose, Hilbelink (2009) argues that three-dimensional-based (3D-based) learning needs to be employed. As many of the details of the relationships inside a human body are complicated, nursing students find them difficult to understand without dissection sessions.

However, because of limited resources, most educational institutions in Hong Kong are unable to set up a dissecting laboratory easily, so many nursing students cannot experience dissection sessions. Because investment on dissection training is very expensive, it is mainly used to train the medical profession. In this situation, nursing students need to imagine the relationships and concerns of the course by using 2D-based materials, which make it difficult for them to imagine and understand topics such as blood flow to the heart, the work of skeletal muscles, and the hearing of sounds. We need to find another way to handle such issues.

As technology advanced, we realized that 3D-based learning can provide a cheaper and efficient way to make up for the inadequacies of traditional (2D) learning, so we have used 3D technology in teaching anatomy and physiology nursing courses since 2015. This study focuses on feedback on using passive 3D TV to show 3D human organs and system models in anatomy and physiology nursing courses in Hong Kong.

Methods

In the 2017–18 spring term, we invited Year 1 undergraduate nursing students, all of whom were studying the course Human Anatomy and Physiology, to participate in this study. We divided them into 12 groups, each with 25 to 30 students, and held a 3D-based learning session lasting for 30 minutes. Each of them got passive 3D glasses, which were distributed at the start of the lesson, to watch 3D human organs at different angles and a 3D video about how viruses infect humans. None of the 3D contents had sound, and a lecturer was responsible for explaining the related topics in the 3D-based learning session.
We used a questionnaire to collect the students’ feedback. Each student got the questionnaire before the start of a session and, after the session, they could choose whether or not to submit it. We collected 331 valid questionnaires.

**Hardware and Software**

The equipment in this study consisted of an LG 79-inch 3D 4K UHD TV, passive 3D glasses, and a laptop. The reason for choosing LG 3D 4K UHD TV was that it uses passive 3D technology, which provides a cheaper and more comfortable form of 3D experience than active 3D technology.

**LG 79-inch 3D 4K UHD TV and passive 3D glasses**

**How 3D /stereoscopic technology works**

The effect of 3D /stereoscopic technology is that it shows images at different angles to different eyes at the one time. When we see an object, the placing of the two eyes affects the images; and those which have been received in the left eye and right eye have slightly different angles, and our brain can calculate the object’s depth, distance, height, and width (Speck, 2003). According to Figure 1, the goal of 3D stereoscopic technology is that it projects 2D images at two slightly different angles to your left and right eyes to ‘cheat’ your brain into thinking that it is a 3D image.

**A brief explanation of active 3D technology**

This 3D technology uses 3D glasses to switch eyes to project the right image and left image to your right and left eyes. As Figure 2 shows, the 3D glasses block the left eye when the TV projects the right-side image. The 3D TV and 3D glasses need to communicate with each other by using an infrared (IR) emitter (PC Magazine Encyclopedia, n.d.).

**A brief explanation of passive 3D technology**

In Figure 3, the 3D TV projects an image which combine the left image and the right image. The left image only passes through the left side of the passive 3D glasses to the left eye; and the right image only passes through the right side of the passive 3D glasses to the right eye. With the 3D technology, 3D TV and 3D glasses do not need to communicate with each other (Demers & Azzabi, 2017).

**The reason for choosing a passive 3D TV**

Passive 3D glasses are cheaper, lighter and more comfortable than active 3D glasses because they don’t have a communication component [the infrared (IR) emitter] as they do not need to communicate with the 3D TV (Morrison, n.d.). Also, the passive 3D glasses do not have to be charged, and so are better than active 3D TV for use with a large class.
**Laptop**

The laptop used in this study installed Intel i7 CPU, 32GB RAM, 512GB SSD and a NVIDIA GEFORCE 1080-ti Display Card to make sure that it could work with the LG 79-inch 3D 4K UHD TV to provide a smooth 3D experience.

**Questionnaire**

The questionnaire used in this study had 15 questions, as can be seen in Table 1, to collect the comments of the nursing students who joined the 3D-based learning session. As noted above, at the end of the last 3D-based learning session, we collected 331 questionnaires.

Of the 15 questions in the questionnaire, Questions 1 to 13 were Likert-type rating scales questions and Questions 14 to 15 were open-ended questions. All the Likert-type rating scales questions used a scale of 1 to 4 – where 1 meant “strongly disagree”, 2 “disagree”, 3 “agree”, and 4 “strongly agree” – to let the nursing students rate the statements in the questions.

The questions represented seven different areas related to 3D-based learning as follows.

1. Questions 1 and 6 were concerned with the correspondence between the 3D-based learning materials and the anatomy and physiology course. Question 1 asked whether the 3D-based learning materials were relevant to the course content; and Question 6 asked whether the 3D-based learning materials complemented the lecture notes well.

2. Question 2 was about the attractiveness of using the 3D-based learning materials. It asked directly whether the 3D-based learning materials were attractive to the nursing students.

3. Questions 3 and 4 represented the quality of the 3D-based learning materials. They asked whether the labels and the 3D models were shown clearly or not.

4. Questions 5 and 9 were about the comparison between the 3D-based learning materials and traditional learning materials, such as images and texts. Question 5 asked whether the 3D-based learning materials were more realistic than the traditional learning materials; and Question 9 asked whether the 3D-based learning process was more enjoyable than the traditional learning process.

5. Questions 7 and 8 were concerned with the arrangement of the 3D-based learning sessions. Question 7 asked whether the arrangement of the sessions was well organized; and Question 8 asked whether the nursing student found it easy to get the 3D glasses from the teaching staff.

6. Questions 10 to 13 represented the usefulness of using the 3D-based learning materials for teaching. Question 10 asked whether 3D-based learning aroused the
nursing students’ interest in learning; Question 11 asked whether 3D-based learning could engage the nursing student more in learning; Question 12 asked whether 3D-based learning could enhance the nursing students’ understanding of the course content; and Question 13 asked whether 3D-based learning could help the nursing students to achieve the learning outcomes overall.

(7) Finally Questions 14 and 15 were related to the nursing students’ comments on the 3D-based learning experience. Question 14 asked what the most interesting part of the 3D-based learning experience was; and Question 15 asked for comments on further improvements.

Results

As can be seen in Table 2, the means of Questions 1 to 13 were all above 3, and their standard deviations were quite small. The data show that the tendency of the nursing students’ comments was concentrated, with the means on all questions falling between 3.20 and 3.44.

Table 3 shows the results of the percentages as follows.

For the correspondence between the 3D-based learning materials and the anatomy and physiology course, on Question 1, 98.8% of the students agreed that the 3D-based learning materials were relevant to the course content; and on Question 6, 95.2% agreed that the 3D-based learning materials complemented the lecture notes well.

About the attractiveness of using the 3D-based learning materials, 95.5% of the students agreed on Question 2 that the 3D-based learning materials were attractive.

On the quality of the 3D-based learning materials, 96.4% of the students agreed on Question 3 that the 3D-based learning materials allowed a clear visualization of human body structures; and for Question 4, 94.9% agreed that the 3D-based learning materials showed clear labelling of the structures of the human body.

On the comparison between the 3D-based learning materials and traditional learning materials, on Question 5, 97% of the students agreed that the 3D-based learning materials showed more realistic images than the traditional approach; and on Question 9, 93.1% agreed that the 3D-based learning process was more enjoyable than traditional learning.

For the arrangement of the 3D-based learning sessions, on Question 7, 94.6% of the students agreed that the 3D-based learning sessions were well organized; and 97.6% agreed on Question 8 that it was easy to get the 3D glasses from the teaching staff.

About the usefulness of the 3D-based learning materials for teaching, on Question 10, 92.4% of the students agreed that 3D-based learning can arouse their interest in learning; on Question 11, 90% agreed that 3D-based learning can engage them more in learning; on Question 12, 96.1% agreed that 3D-based learning can enhance understanding of the course content; and, on Question 13, 97.3% agreed that, overall,
3D-based learning can help in achieving the learning outcomes.

On Question 14, many of the students commented that they liked the 3D human structure models, the passive 3D effect, and the control of the 3D models – which included zoom in, zoom out, and rotation, showing the inside of the organs.

Finally, in the nursing students’ comments on Question 15, most of them wanted bigger and clearer labels on the 3D models, a longer time experiencing the 3D models, and more 3D effects. A few students complained about feeling dizzy.

**Discussion**

As the number of nursing students is rising year by year, and there are limited resource for teaching the anatomy and physiology course, it is essential to find a new approach for teaching the subject which is easier and more efficient than before (Collins, 2008). Nowadays, nursing students do not have dissection lessons; and 2D materials, such as texts, images, and videos, are not adequate for giving students a clear understand of the subject. 3D-based teaching seems to be a good way forward.

This study gathered the nursing students’ feedbacks on using 3D-based learning. This was a preliminary study to help us to find out whether it was suitable for teaching courses in anatomy and physiology. The results provide a promising outcome, with the students’ comments being very positive. The nursing students enjoyed the 3D-based learning sessions and recommended that the time for them should be extended.

**Conclusion**

To conclude, 3D-based learning stimulated and facilitated the nursing students’ learning of the content of the course Human Anatomy and Physiology, and problems related to 2D materials for teaching this subject can be resolved. As this study showed, insight can be gained by using 3D-based learning. In general, its academic and research relevance was confirmed. Therefore, we intend to extend the 3D-based learning to other nursing courses.

**Acknowledgement**

The work described in this paper was fully supported by a grant from the Institutional Development Scheme (IDS16/16)

We thank our colleagues from the Virtual Reality Team and the Anatomy and Physiology Team who provided expertise that greatly assisted the study. We would also like to show our gratitude to all the participants in this study for sharing their precious opinions.
References


# Table 1. Evaluation questions

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<td>Q1</td>
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Table 3. Percentage distribution of students’ rating on whether they strongly disagreed, disagreed, agreed or strongly agreed with each question

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<th>Question Number</th>
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<th>Disagree</th>
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<td>0.3%</td>
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<td>0.3%</td>
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<td>62.6%</td>
<td>34.7%</td>
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</table>
Figure 1. How 3-D PC glasses work (Speck, 2003)

Figure 2. Active 3D definition from the *PC Magazine Encyclopedia* (n.d.)
Figure 3. Active 3D vs passive 3D: What’s better? (Morrison, n.d.)

Figure 4. The 3D-based learning lesson
Using Three-Dimensional Technology to Enhance the Teaching of Anatomy and Physiology in Nursing Education

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Abstract

The purpose of this paper is to compare the advantages and disadvantages of traditional teaching methods with three-dimensional (3D) technology in teaching Anatomy and Physiology (A&P). This paper also introduces the use of the visual learning tool Sensavis for teaching A & P in our University. At present, as there are limited studies on the efficacy of Sensavis, further research should be carried out in order to establish its contribution conclusively.

Keywords: anatomy and physiology, three-dimensional technology, nursing
Introduction

Anatomy and Physiology (A & P) is a fundamental subject in undergraduate nursing programmes. However, many nursing students regard it as a great challenge. Proficiency in A & P knowledge ensures patient safety and achieves better patient outcomes. Nurses are responsible for having appropriate A & P knowledge before they perform any nursing procedure on patients. Since 2015, 3D technology has been applied in A & P education in Hong Kong. The impact of using the tool Sensavis in teaching A &P is illustrated in this paper.

Anatomy and Physiology in Nursing

Anatomy and Physiology (A & P) is one of the core modules in nursing education at the undergraduate level. As a bioscience subject, A & P includes knowledge areas in pathophysiology, microbiology and pharmacology. A & P is the foundation subject in nursing education. According to Christensen, Craft, Wirihana & Gordon (2015), nurses are required to have in-depth knowledge of bioscience so that they are competent in utilizing the knowledge for patient care and have a positive impact on patient outcomes.

There is no doubt that nurses need to link their A & P knowledge with clinical practice every day, as it is clear that the daily practices of clinical ward nurses are closely related to A & P knowledge and, indeed, proficiency in A & P knowledge has an affirmative impact on nursing care. It is the cornerstone of building up nursing skills which promote higher levels of critical thinking in clinical practice (Johnston et al., 2015). For example, it involves invasive procedures such as the insertion of nasogastric tubes, urinary catheters, intravenous access, and intramuscular injections. Patient safety can be enhanced if nurses show familiarity with knowledge of A & P (Logan & Angel, 2011) – otherwise, patients’ lives will be put at risk. Furthermore, A & P knowledge is also important in the interpretation of laboratory results, for example in cases of hyperkalaemia (elevated serum potassium level). Nurses without sufficient understanding of the effects of potassium on body functions do not realize its serious consequences and the need to provide prompt and appropriate treatment.

Equipping nurses with knowledge of A & P is crucial in daily practice, particularly for understanding and comprehending examination reports. Communicating with and updating patients and their families on patients’ progress is another key duty for nurses. While the application of technologically advanced investigations – such as computed tomography, magnetic resonance imaging and ultrasonography – are common in the course of diagnosing diseases and monitoring patients, nurses with a good knowledge of A & P are able to understand patients’ condition more thoroughly, and hence are able to explain their condition confidently and in greater detail.

With the expanding roles of nurses in clinical practice, the importance of their understanding A & P becomes even more prominent (Johnston, 2010). One obvious example of nurses’ expanding role is the establishment of nurse clinics in recent
years (Lee, 2017). The clinics include specialty areas such as cardiology, breast care, respiratory problems, clinical oncology, and wound care. Detailed physical assessments by nurses are required in every consultation. Therefore, nurses need a more robust level of anatomical knowledge than ever before (Finn, Connolly, Gillingwater, & Smith, 2018).

In spite of its importance in nursing practice, nursing students find it challenging when studying A & P (Johnston, 2010). During the lectures/tutorials, different human systems and anatomical structures are taught. Nursing students have expressed their difficulty in utilizing the information together with different systems (Estai & Bunt, 2016) and they find it hard to correlate and conceptualize the subject in clinical practices (Brown, Bowmar, White, & Power, 2017; Christensen et al., 2015). McLachlan, Bligh and Searle (2004) stated that it is of substantial importance to employ the anatomy knowledge learned and apply it appropriately in clinical settings.

With the factors mentioned above and the rapidly evolving health care system, there are higher expectations for the knowledge and competence of nurses. Nursing students need to be well equipped before proceeding through their careers. There is no single method that has proved to be most effective for learning A&P (Estai & Bunt, 2016). However, various teaching strategies in A&P should be scrutinized by nurse academics (Johnston, 2010) and the curriculum should be constantly reviewed.

**Traditional A & P Teaching for Undergraduate Nursing Students**

Didactic lecture, textbook, two-dimensional (2D) diagrams and atlases are some common traditional strategies for teaching anatomy to undergraduate nursing students (Preim & Saalfeld, 2018). Estai and Bunt (2016) pointed out that cadaver dissection has been one of the essential anatomy teaching methods for medical students for many years. However, it may not be the best and most suitable method for anatomy teaching for nursing students, especially in Hong Kong. Considerable resources are required in operating cadaver dissection (Deng et al., 2018). The colour and texture of a deceased body are also different from a living body (Preim & Saalfeld, 2018). The space, facilities and human resource requirements for running a cadaver dissection system are high, but the resources available for medical education are generally more abundant than for nursing education. The feasibility of nursing education running cadaver dissection as in medical education are remote. It has also been suggested that training using cadaver dissection is best placed in a postgraduate curriculum (McLachlan et al., 2004). Also, the A&P syllabus for teaching nursing students may be different from that for medical students; nurse students may not need to memorize the very in-depth structure to meet the required learning outcome.

Indeed, didactic lectures are the most convenient way to disseminate knowledge to a mass student groups in a limited time and cost-effectively. Although lectures are considered to be an inactive learning method which lacks interaction between the lecturer and students, some students still prefer them. The didactic lecture enables the
lecturer to illustrate complicated concepts and summarize the information from various sources (Brown et al., 2017). It also provides a chance for students to ask questions and clarify misunderstanding. However, by its nature, A & P involves understanding 3D images and content on in-depth structures, but 3D anatomical structures of the organs are difficult to present by using lectures (Brenton et al., 2007). By using 2D anatomical diagrams, textbooks and atlases, one cannot present a spatial relationship among and between organs (Hilbelink, 2009). It is crucial for students to understand spatial relationships and interpret deviations from the normal clinical situation. Failure to recognize spatial relationships will alter the overall understanding of the functional anatomy of the organs (Yammine & Violato, 2015). In the long run, nursing students will only get the idea of surface anatomy by using lectures and the 2D diagrams for learning (Johnston, 2010). Therefore, it is imperative to explore further methods along with the traditional ones.

**Use of Three-Dimensional Teaching in A & P**

“Visualization has been recognized as a key component in learning and understanding anatomy” (Tam, 2010). Using picture, diagrams and 3D presentations may help learners to understand the abstract and complicated contents. Kuyatt and Baker (2014) suggested that new knowledge and lifelong memory are built up by text and pictures. Numerous studies have suggested that students will easily remember the content by using pictures or images, although the findings are not very conclusive (Cui, Wilson, Rockhold, Lehman, Lynch, 2017). Nowadays, with the advances in technology, there is an increasing use of multimedia as a supplementary pedagogy in teaching anatomy (Yammine & Violato, 2015). Learning is no longer restricted to textbooks, PowerPoint or computers. Some of the software can even be downloaded to smartphones and tablets. Among all the multimedia methods, three-dimensional visualization technology (3DVT) has been used frequently in recent years (Yammine & Violato, 2015).

According to Yammine and Violato (2015), 3DVT consists of using 3D images, animations, interactive programs and virtual reality. The ability to view the spatial relationship between structures is one of the major advantage of using 3DVT in teaching A & P. It is necessary to fully understand and integrate the knowledge of the structures, and surrounding structures or organs (Stull, Hegarty, & Mayer, 2009). Familiarity with the spatial relationships enhances the assimilation of knowledge and functional anatomy in particular regions and systems (Preim & Saalfeld, 2018). Moreover, 3D visualization enables students to view or imagine the hidden parts of the structure that cannot be represent by 2D diagrams.

The dynamics and direction of the body can also be illustrated – for example, the blood flow in the arteries and muscle contraction and relaxation mechanisms while in movement. These advantages facilitate students’ understanding of abnormal conditions in complicated situations (Silén, Wirell, Kvist, Nylander, & Smedby, 2008). If students
do not understand the spatial relationship of structure, they will be unable to identify the structures in real patients (Brenton et al., 2007).

Secondly, 2D images are drawn by different personnel with different styles, and an individual’s personal style of drawing may hinder students from knowing the accuracy of the structure. However, 3D images can be incorporated from datasets of real human images and show the most accurate anatomical structure (Tam, 2010).

The ability to manipulate the 3D images in order to view them from different viewpoint and angles is another benefit of using 3DVT (Yammine & Violato, 2015). Some of the 3DVT interactive programs allow students to ‘remove’ the layers of structure one by one so that they can see inside the inner structure. Students are able to explore the contents and have interaction at the same time (Estai & Bunt, 2016). They recognize that active participation and interaction in learning anatomy is a precious experience. Students can move, flip and turn the 3D images at their own pace. The extensiveness of coverage can also be varied according to the unique needs and required learning outcomes. Compared to traditional teaching methods, using 3D images in teaching A&P involves more active learning. Green et al. (2006) stated that students found it more amusing, satisfying and self-motivating to learn when using technology as a supplementary method for learning A&P. The study by Luursema, Verwey, Kommers, Geelkerken, & Vos (2008) showed that the students performed better in identifying structural landmarks and abdomen organs if they were able to rotate the images. Meanwhile, students in another group, without manipulating the images, showed no clear significant results. Bonwell and Eison (1991), as cited in Brown et al. (2017), suggested that active learning may help students to attain a higher order of thinking, such as analytic and evaluative performance.

Using 3D images to teach anatomy also has its disadvantages. First, it is time-consuming and requires high technology to develop 3D images which are anatomically correct (Brenton et al., 2007; Yammine & Violato, 2015). The expenses for professional personnel and equipment to maintain the system can be high. Also, not everyone is capable of understanding the 3D images as it requires learning and practice (Yammine & Violato, 2015). Vandeberg and Kuse, as cited in Azer & Azer (2016), pointed out that visual-spatial ability – the ability to manipulate object mentally – is extremely useful for understanding anatomical structures. The acquisition of this ability requires repeated practice and revision, so it is not surprising that students may face difficulty when they first encounter 3D images and feel their learning is not being enhanced.

**Learning A&P with the aid of Sensavis**

Sensavis visual learning tool is software developed by a Swedish educational technology company – Sensavis. This software was launched in 2013 and is currently used in 36 countries (Sensavis, 2017). Middle schools have adopted Sensavis as a supplementary aid in teaching the STEM (Science, Technology, Engineering and Mathematics) programme which is currently popular in teaching science subjects.
This visual learning tool contains three-dimensional visualization and interactive components which benefit both teachers and students in six areas – Biology, Geography, Physics, Chemistry, Mathematics and Engineering. There are different categories in each area. Sensavis provides 3D images or animation without any sound or labelling, which provides great flexibility for teachers to make their own teaching materials. Teachers may tailor the diagrams according to the level of their students and the required learning outcomes. As Sensavis can be downloaded to personal computers or other electronic devices, students are able to use it out of school to continue their studies. In addition, students can also move and rotate the object by the cursor which enables interactivity while learning.

Through this 3D interactive visual learning tool, students are expected to understand abstract areas and complicated concepts more easily. Nursing students always regard the A & P subject as demanding due to its extensive content and the difficulty in memorizing the key points (Johnston et al., 2015). Students have also found the A&P contents hard to remember because they could not link them up with the clinical situation. Brown et al. (2017) suggested that the students would get a better performance if the contents of A&P were closely related to clinical practice. The 3D images or animation in Sensavis enables students to understand the spatial relationships of the structure, which allows them to integrate functional anatomy and enhances the linkage with the clinical situation (Yammine & Violato, 2015). In addition, the students are able to view the structure with different planes by flipping the image. Overall, students may have more engagement and accountability in their studies (Brown et al., 2017). The underpinning of good A & P knowledge is necessary for nursing students in order to provide better patient outcomes.

**Conclusion**

It has been shown that 3DVT has advantages in teaching the factual and spatial anatomy knowledge (Yammine & Violato, 2015). However, there is no conclusive result showing that 3DVT can replace the traditional methods in the teaching of A & P. At this moment, it is still a supplementary teaching pedagogy. Further significant research should be performed to investigate the efficacy of 3DVT.

**Acknowledgement**

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We thank our colleagues from the Virtual Reality Team who provided expertise that greatly assisted the study.
References


VR-based Anatomy Learning: Feedback Evaluation of University Nursing Students in Hong Kong

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Abstract

Anatomy is an essential foundation subject for nursing students. As the number of nursing student has risen greatly, it is difficult to allocate time for each student to have his/her own anatomy dissection session. Also, students always have difficulty in transforming 2D pictures in books to 3D images. They have been found to have little interest in studying 2D images (Hamza-Lup et al., 2009). This learning process and experience are not efficient and effective (O’day, 2007). New learning methods and having dissection lessons should be introduced. Two VR anatomy learning software applications have been introduced to the University’s Year 1 nursing students who are studying anatomy. We wish to know whether VR technology can help them to achieve a better learning experience in studying the subject when compared with traditional learning (i.e. books and PowerPoints). The aim of using VR software is to facilitate the learning efficiency. Students wear HTC VIVE headsets and learn anatomy by using virtual reality software. The software applications provide various 3D human body models, and also show labels and tags on the body parts. Hand controllers are used to control the movements and interactions between the students and 3D models. Inside the Virtual Anatomy Centre, students can observe and manipulate different body systems from 360 degrees. A 4-point Likert scale survey, with a comparison between VR learning materials and traditional learning materials, was used to evaluate the efficiency of learning. The recently introduced VR-based learning experience aroused students’ interest in studying human body structures. The interactions provided by the applications can attract students to learn anatomy actively; and they also reported that the learning experience was better than using the traditional learning routine.

Keywords: virtual reality, nursing education, anatomy
Introduction

Hong Kong always needs nurses to alleviate the burden of medical services. Nurses are required to have various skills and knowledge to assist healthcare practitioners and professionals to maintain human health. Anatomy is one of the essential subjects for nurses, as it provides the foundation that helps nursing students to understand human organs, and interrelationships among systems. The real objective of learning anatomy is to integrate an understanding of normal structures, which provides the basis for helping students to develop the logic, inferences, and problem-solving needed to diagnose and manage patients (Collins, 2008).

Every university and nursing school provides an anatomy course(s) for undergraduate nursing students. However, confronted with a greatly increasing number of nursing students, less time and space can be allocated for each of them to dissect organs. Students cannot have their own dissection sessions.

Apart from the limitations of time and space, students also have difficulty in memorizing the numerous body parts and systems. Without the aid of dissection sessions, they take a great deal of time to understand and visualize 2D pictures in books. Students have been found to have little interest in studying 2D images. The learning process is lengthened, and the experience is not pleasant. New teaching methods and technologies should be developed for effective and efficient teaching.

In 2017, 3D-based learning using animations was introduced in the Open University of Hong Kong to replace part of the 2D images and videos for anatomy teaching. The outcome was satisfactory. Most of the students (~75%) were satisfied with the overall 3D-based learning materials (So, 2017).

To further enhance students’ learning efficiency, VR-based learning software was introduced for learning anatomy in 2018. The 3D virtual world facilitates the visualization of difficult content and offers tools for learning challenging concepts (Barab et al., 2000). A 3D virtual world was generated by the VR-based learning software, with the software allowing students to learn anatomy. We hoped that the software could provide an alternative method to help students to overcome their difficulty in visualizing 2D images. It was expected that positive feedback would be received – that is, that students could achieve a better learning experience by using VR-based learning than with the traditional approach.

Methods

Nursing students who were studying anatomy and physiology in the 2018 spring term were invited to join the experience session in April 2018. Each session lasted for 30 minutes, and had fewer than 18 students. Three or four students volunteered to try the VR experience in each session, while the remaining students observed, watching the VR learning materials on a TV monitor. Detailed explanations of the anatomy were given verbally by a lecturer.
Questionnaires were distributed at the end of each session. A total of 281 questionnaires were received. Fifty-five students tried the VR headset, and the remaining 226 students watched the VR learning materials on a TV monitor and observed how the students wearing the headsets used the software.

**Hardware and Software**

An HTC VIVE headset, a laptop, two base stations (sensors), two hand controllers and a TV were used in this learning experience. Figure 1 shows the hardware and software used in VR-based learning. The hardware worked with the software to provide accurate real-time position tracking in the virtual world.

The two base stations were placed diagonally at two opposite corners of the laboratory, and a walking area was set up between the two stations. Figure 2 shows the floor plan of the setup. The positions of the headset and the two hand controllers were detected by the stations. The stations transferred the actual position to the software, and the software then converted the data to a virtual position in the virtual world.

The HTC VIVE headset is a device that a student could wear to be immersed in the virtual world. The headset displayed graphics of the virtual learning centre and 3D anatomy models. It was equipped with two screens with a resolution of 1080 x 1200 pixels per eye. The headset had three strips which could be tightly secured to a student’s head to prevent it from sliding down during the VR experience.

Hand controllers were used to control the interactions between the students and the 3D models. The students could freely view organs, vessels, etc. from various angles. Labelling, tags and information were shown in the software for enhancing students’ knowledge.

**Walking Area**

A 2.6 x 2 metre walking area was set in the laboratory. The area was cleared to prevent accidents, such as tripping over. Students who wore the headset could walk around the laboratory within the walking area. The data on the size of the actual walking area were pre-defined in the software so that the movement of student could be synchronized with the virtual world simultaneously.

**Questionnaire**

We distributed questionnaires to students to collect their opinions. Fifteen questions (Table 1) were asked about what they thought of the VR anatomy software; how they felt about having VR tutorials; and any improvement which could be made. The questionnaire was divided into two parts. Question 1 to 13 were rating questions and Question 14 and 15 were open-ended questions. The 13 questions required students to rate whether they “strongly disagreed”, “disagreed”, “agreed” or “strongly agreed” with the statements. The 15 questions were grouped into seven categories: “Do the VR learning materials match the course content?”; “The attractiveness of VR learning
materials”; “The quality of VR learning materials”; “Are VR learning material better than traditional learning materials?”; “Are the arrangements for the VR experience session satisfactory?”; “The helpfulness of VR learning materials in studying anatomy”; and “Comments on the VR learning experience”.

The question numbers were as follows.

- Questions 1 and 6 asked if students thought the VR learning materials matched their course notes and content.
- Question 2 asked if students thought the VR learning materials were attractive.
- Questions 3 and 4 asked what students thought about the quality of the VR learning materials.
- Questions 5 and 9 asked if students thought the VR learning materials were better than the traditional learning materials.
- Questions 7 and 8 asked the students about whether they were satisfied with the arrangements for the VR learning session.
- Questions 10 to 13 asked if VR learning materials helped them in studying anatomy.
- Question 14 and 15 asked for students’ opinions about the most interesting part of the VR learning experience and suggestions for improvements.

Results

Rating Questions (1 to 13)

Table 2 shows the percentage distribution of students’ ratings on whether they strongly disagreed, disagreed, agreed or strongly agreed for each question. The questions were grouped into six categories. Table 3 records the mean and standard deviation for each question. The mean score on each question ranged from 3.27 to 3.54.

VR learning materials matching the course content

The percentage of students who chose “agree” or above for Questions 1 and 6 were 99.3% and 95.4% respectively. Question 6 – “The 3D-based learning materials complement the lecture notes well” – had the lowest mean (3.27). Although the VR materials provided relevant 3D models, labelling and explanation, some information might not have been as thorough as in our lecture notes, so verbal explanation was still needed. This might have confusion some students and caused a lower mean score. The data revealed that, although the students agreed that the VR learning materials was relevant to their course notes and content, a more detailed explanation is still needed.

Attractiveness of VR learning materials

Almost 98% of the students chose “agree” or “strongly agree” for Question 2. Clearly, the vast majority of them agreed that the VR-based learning materials were attractive.
Quality of VR learning materials

We asked students whether they thought the VR learning materials gave a clear visualization and labelling of the human body structures in Questions 3 and 4, and 97.9% and 96.5% of the students agreed or strongly agreed.

VR learning materials outperforming traditional learning materials

Questions 5 and 9 asked students if they agreed that VR learning materials showed more realistic images and whether they thought that the learning process was more enjoyable than the traditional learning materials. For the former question, 98.6% of the students chose “agree” or above; and 98.2% did so for the latter question. These two questions gave the highest and the second highest mean score, 3.54 and 3.52 respectively. The VR materials generated realistic 3D models which traditional learning materials cannot provide. The models could be viewed from 360 degrees and manipulated by students. This might have given students a profound experience and caused higher mean scores.

Satisfaction with the arrangement of the VR experience session

We asked students if they were satisfied with the arrangement for the VR learning session in Question 7, and if they thought the VR head-mounted display was easy to wear with assistance from the teaching staff in Question 8. On Question 7, 95% of students agreed or strongly agreed, and 92.2% chose “agree” or above for Question 8. Questions 7 had a relatively low mean (3.27) as students thought the session was not long enough for everyone to try wearing the VR headset, and 16 students did not answer Question 8 as they did not know whether the headset was difficult to wear or not.

Helpfulness of the VR learning materials in studying anatomy

The percentage of students who chose “agree” or above for Questions 10, 11, 12 and 13 were 97.2%, 95.1%, 98.5% and 97.9% respectively. We asked the students whether they agreed that VR learning materials could help them in studying anatomy in these four questions.

Open-ended Questions (14 to 15)

Questions 14 and 15 were open-ended questions that asked students to write down their comments and suggestions on the VR experience.

Among the 213 students who replied to Question 14, 181 of them thought that the interactive 3D models with clear, realistic and detailed visualization was their favourite part of the VR-based learning experience.

Among the 145 students who replied to Question 15, 42 of them suggested the experience session should be lengthened so that more students could try it.
Overall Result

The overall result was satisfying. Over 97% of the students were satisfied with the VR-based learning method (Figure 3).

Discussion

This study helped the team to find out whether the application of virtual reality learning software could help nursing students to achieve a better learning experience in studying anatomy when compared with the traditional learning approach. The feedback was very positive: the students enjoyed studying anatomy using VR and hoped that the sessions would be extended. The questionnaire responses reflected that VR software aroused students’ interest in studying anatomy; and some feedback also showed that they were willing to learn anatomy using the VR software by themselves at home or at the University. However, this study had some limitations. The equipment and time were limited, so that not all the students could have their own session. Therefore, no attempt was made to check whether the students showed an improvement in their studies after using the VR software. We hope that more students can be involved in VR-based learning. A CAVE system will be applied in the future, which allows more than 10 students to be immersed in virtual reality at the same time. The CAVE system provides more interaction between students and the virtual 3D models and, as noted above, it allows more students to enjoy the VR experience at the same time.

Conclusion

Comparing the learning efficiency of VR-based and traditional learning routines is a long-term assessment. Although it will take time to observe the outcome, the feedback from the students in this study showed that most of them agreed that VR-based learning is more attractive than the traditional learning approach. Students showed great interest in using VR and preferred studying with VR-based learning than following the traditional learning methods. Students would be more proactive in learning by using VR.

Acknowledgement

The work described in this paper was fully supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (UGC/IDS16/16).

We thank our colleagues from the Virtual Reality Team and Anatomy and Physiology Team who provided expertise that greatly assisted the study. We would also like to show our gratitude to all the participants in this study for sharing their precious opinions.
References


So, L. H. (2017). Evaluation of nursing students’ learning feedback on the implementation of 3D-based learning in anatomy and physiology in Hong Kong. Hong Kong: The Open University of Hong Kong
<table>
<thead>
<tr>
<th>Question Number</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The VR-based learning materials are relevant to the course content.</td>
</tr>
<tr>
<td>2</td>
<td>The VR-based learning materials are attractive.</td>
</tr>
<tr>
<td>3</td>
<td>The VR-based learning materials give a clearer visualization of human body structures.</td>
</tr>
<tr>
<td>4</td>
<td>The VR-based learning materials show clear labelling of human body structures.</td>
</tr>
<tr>
<td>5</td>
<td>The VR-based learning materials show more realistic images than the traditional learning materials (e.g. PowerPoint and video) on the same body structure.</td>
</tr>
<tr>
<td>6</td>
<td>The VR-based learning materials are well complemented with the lecture notes.</td>
</tr>
<tr>
<td>7</td>
<td>The arrangement of the VR-based learning sessions is well organized.</td>
</tr>
<tr>
<td>8</td>
<td>It is easy to wear the VR head-mounted display with the assistance from teaching staff.</td>
</tr>
<tr>
<td>9</td>
<td>The VR-based learning process is more enjoyable than the traditional learning process (e.g. learning through PowerPoint and video).</td>
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<tr>
<td>10</td>
<td>VR-based learning can arouse my interest in learning.</td>
</tr>
<tr>
<td>11</td>
<td>VR-based learning can engage me more in learning.</td>
</tr>
<tr>
<td>12</td>
<td>VR-based learning can enhance my understanding of course content.</td>
</tr>
<tr>
<td>13</td>
<td>Overall speaking, VR-based learning helps me to achieve the learning outcomes.</td>
</tr>
<tr>
<td>14</td>
<td>Which area(s) do you like most in your VR-based learning experience?</td>
</tr>
<tr>
<td>15</td>
<td>What is/are the area(s) for further improvement?</td>
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Table 2. Percentage distribution of students’ ratings on whether they strongly disagreed, disagreed, agreed or strongly agreed for each question.

<table>
<thead>
<tr>
<th>Question Number</th>
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<th>Disagree (%)</th>
<th>Agree (%)</th>
<th>Strongly agree (%)</th>
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<td>3</td>
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<td>1.4</td>
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<td>4</td>
<td>0.7</td>
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Table 3. Means and standard error of Question 1 to 13

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Figure 1. Hardware and software used in VR-based learning
Figure 2. Floor plan of the setup for base stations and walking area

Percentage of Students' Satisfaction towards VR-based Learning

Figure 3. Percentage of student who were satisfied with VR-based learning
Position-based Dynamics for Deformation, Cutting and Suturing Simulation in Virtual Surgery

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Abstract
Surgical simulation based on virtual reality is of great significance for modern surgical training education. In this paper, we present a unified framework with position-based dynamics for developing a stable, efficient and realistic virtual surgery simulator, including the modelling of soft tissue deformation, cutting and suturing. We constructed the volumetric particle model of soft tissue via segmented medical images and employed position-based dynamics to model the movement of the volumetric particles to achieve simulation of soft tissue deformation. To simulate soft tissue cutting, we modified the positional constraints after detecting collision between the scalpel and soft tissue, and reconstructed the soft tissue surface with marching cube algorithm. By simulating the suture line with position-based dynamics and setting constraints between collision particles and the suture line, we were able to develop a realistic virtual suturing simulation. The experimental results demonstrated efficient and stable virtual surgery simulation with highly visual plausible effects.

Keywords: virtual surgery, position-based dynamics, deformation, cutting, suturing
Introduction

Traditional surgical training education is now facing severe challenges from legal and ethical concerns for patient safety, the high cost of operations, limited learning opportunities, and long learning curves. With the rapid development of modern information technology in recent years, surgical simulation based on virtual reality (VR) provides a promising alternative to traditional training in surgical education. By constructing a highly immersive surgical environment, the VR-based surgical simulation enables the trainees to learn the surgical skills in a safe and low-cost way, with plenty of opportunities and greatly accelerated learning curves, which could bring a significant breakthrough and shape the future of surgical training education.

To develop a practical VR-based surgical simulator, it is necessary to efficiently and realistically simulate the phenomena during the surgeons’ key surgical operations – including soft tissue deformation, cutting and suturing – which involve complicated geometrical representation and dynamic physical modelling of the soft tissue. Traditionally, researchers have employed the Finite Element Method (FEM) (Freutel, Schmidt, Dürselen, Ignatius, & Galbusera, 2014), with discretization of the continuum-mechanics formulations on mesh elements to model the geometric modification and mechanics response of the soft tissue. The FEM enables highly accurate computation of soft tissue behaviour, the accuracy of which depends highly on the mesh elements. High resolution complicated meshes are often employed to represent the anatomical details of complex human organs. However, very large amounts of mesh elements decrease the computational efficiency which makes it difficult to apply in practical virtual surgical simulation. To balance the computational efficiency and accuracy, the geometric discretization is decoupled from that of the physical simulation, which aims to achieve an interactive frame rate for practical applications (Jeřábková & Kuhlen, 2009; Jeřábková, Bousquet, Barbier, Faure, & Allard, 2010; Wu, Dick, & Westermann, 2011; Koschier, Bender, & Thuerey, 2017). However, the cutting procedure is usually accompanied by frequent geometric modifications with FEM methods which still leads to the heavy computational burden of assembling the global stiffness matrix of FEM at each step. In addition, the quality of the mesh element cannot be guaranteed due to mesh deformation, distortion and degeneration, which result in numerical instability during the computation of the soft tissue behaviour.

The numerical instability and inefficiency of FEM due to the complicated geometric modification and computation of the finite elements inspired us to find a possible way to solve these difficulties. Position-based dynamics (PBD) (Müller, Heidelberger, Hennix, & Ratcliff, 2007) is a robust, effective and efficient particle-based method for computing the dynamics of the object’s physical movement, which is suitable for interactive simulation of the behaviour of the soft tissue. It can directly and effectively manipulate the positions of particles and parts of the objects during the simulation and gives control over explicit integration which removes the typical problems of numerical instability. PBD discretizes the soft tissue with a set of particles that interact with each
other according to the position-based constraints, which has greater flexibility and higher efficiency in handling the computation of soft tissue and achieves a more stable geometric modification. In this paper, we present a unified framework based on position-based dynamics for the deformation, cutting and suturing simulations in virtual surgery. By using the PBD-based unified framework in modelling the behaviour of the soft tissue, we were able to develop a VR-based simulator for lobectomy, which can perform realistic and real-time simulation for surgical skills training.

**Methods**

In this section, we present the details of the PBD-based unified framework in the interactive modelling of soft tissue deformation, cutting and suturing with surgical instruments.

**PBD-based Soft Tissue Deformation**

We employed position-based dynamics to model the interactive soft tissue deformation with surgical instruments. To realistically simulate the soft tissue behaviour, it is necessary to model both its surface and internal structure. Therefore, we discretized the soft tissue with volumetric particles and constantly corrected the particles’ positions by constraints during the deformation procedure.

As shown in Figure 1, we directly constructed the volumetric particle model of soft tissue via segmented medical images, such as MRI, CT or slices from the virtual human projects. We stacked up all the segmented slices of medical images, each of which defines the isosurface, and then applied the marching cube (MC) algorithm to reconstruct the triangular mesh of the soft tissue. During the reconstruction, the particles that are inside or outside the soft tissue can be determined by the isosurface, and the vertices of the spatial grids generated by the MC algorithm are utilized to sample the volumetric particles of the soft tissue.

We employed position-based dynamics (Müller, Heidelberger, Hennix, & Ratcliff, 2007) to calculate the deformation of soft tissue. For a deformable object with \( N \) volumetric particles, the movement of these particles is controlled by \( M \) constraints. Suppose \( C \) is the constraint function and \( p \) is the position of the volumetric particles, given \( p \) we want to find a correction \( \Delta p \) such that \( C(p + \Delta p) = 0 \). This equation can be approximated by the following:

\[
C(p + \Delta p) \approx C(p) + \nabla_p C(p) \Delta p = 0
\]

By restricting \( \Delta p \) to be along \( \nabla_p C(p) \), we have \( \Delta p = \lambda \cdot \nabla_p C(p) \), where \( \lambda \) is a scalar, which implicitly conserves the linear and angular momenta by position projection and achieves stable simulation computation. The scalar \( \lambda \) is calculated by:

\[
\lambda = -\frac{C(p)}{\left|\nabla_p C(p)\right|^2}
\]
During the deformation, the sampled volumetric particles are controlled by the stretch constraint to simulate the elastic force between two particles, as well as volume constraint to conserve the soft tissue volume by dividing each cube into five tetrahedra in position-based dynamics, and the positions of the volumetric particles are constantly corrected to ensure visual plausibility. The intersection of the isosurface and MC spatial grids can be computed and recorded, which enabled us to efficiently reconstruct and render the soft tissue after computing the updated positions of the volumetric particles.

Meanwhile, to support accurate efficient collision detection during the simulation procedures, we applied the axis-aligned bounding box (AABB) to compute real-time collisions between soft tissue and surgical instruments. By employing position-based dynamics in soft tissue deformation modelling, we achieved real-time interaction with the surgical instrument. When the simulator detects a collision event and the surgical instrument continues to move into the soft tissue, the volumetric particles near the surface of the soft tissue follow the instrument to move inwards, resulting in a pressing deformation effect. If the instrument grasps the detected volumetric particles, the localized PBD particles will follow the surgical instrument to move outwards, resulting in a clamping deformation effect.

**PBD-based Soft Tissue Cutting**

During the soft tissue cutting procedure, the scalpel dramatically changes the topology of the soft tissue. To tackle this issue and achieve stable and efficient cutting results, we used the PBD-based cutting method which directly modifies the positional constraints and reconstructs the soft tissue surface with marching cube algorithm after cutting.

Figure 2 demonstrates the procedure of the PBD-based cutting of the soft tissue. First, we defined the cutting plane and detected the accurate cutting position on the volumetric particles of the soft tissue. We modelled the scalpel as a line and recorded its position at each frame, and every two sequential positions of the scalpel could form a cutting plane. By calculating the intersection between the cutting plane and the edges between volumetric particles, we could find the accurate cutting position during the cutting procedure. For every edge that intersected with the cutting plane, we removed the constraint between the two volumetric particles, and set them as the outside vertices. Then we reconstructed and rendered the soft tissue triangular mesh with marching cube algorithm and new surface triangles were reconstructed at the cutting position. Finally, we recorded the local PBD particles at two sides of the cutting plane at each time-step and exerted two opposite external forces that were perpendicular to the cutting plane on the particles.

**PBD-based Soft Tissue Suturing**

In real surgery, the surgeons utilize a surgical clip to clamp the suture needle to perform the suturing operation. By fixing one end of the suture line, the surgeons need to tighten the suture line and then cut it to accomplish the whole suturing performance. During
the suturing procedure, the suture needle and line affect the PBD particles’ positions on the soft tissue, resulting in deformation of the soft tissue. In addition, by tightening the suture line, the two sides of the incisions will approach each other. To simulate the suturing operation, we should realistically model the suture line and the accompanying mechanical response of the soft tissue during the suturing procedure. In this paper, we present the PBD-based soft tissue suturing method. We employed position-based dynamics to model the suture line as the elastic rod (Zuo, Qian, Liao, & Heng, 2018), which mainly has edge-length, bending and twisting constraints to control the particles’ positions on the suture line and achieve realistic simulation of the mechanical response. The suture needle was modelled as a rigid body with several vertices on its central line.

The soft tissue suturing procedure is as shown in Figure 3. We employed a surgical clip to clamp the suture needle, and moved the needle along with the clip. When we stuck the suture needle into the soft tissue or pulled it out of the soft tissue, collision detection was performed between the suture needle and the surface mesh of the soft body, and we could find the collision particles and record their positions. During the stick procedure, the collision particles are constrained on the suture needle. When the suture needle continues to move out of the soft tissue, the suture line then follows the movement of the suture needle and slides via the collision particles with the same speed as the suture needle. When tightening the suture line, we utilized a clamp to fix one end of it and tightened the other side, which gradually closed the incision. During this procedure, the collision particles and the suture line are constrained by each other, which forces the soft tissue to generate accompanying deformation.

Results

The experimental platform was Windows 7, 64bit, Intel Xeon E5-2640 v4 CPU, NVIDIA GeForce GTX 1080 Ti, Unity 3D and Geomagic Touch X. The interactive virtual lobectomy simulation was developed by our unified framework with position-based dynamics on Unity 3D with C# programming and two Geomagic Touch X. In the experiments, we demonstrated the soft tissue deformation, cutting and suturing performance of the virtual lobectomy simulation.

To achieve real-time performance of surgical simulation, we also implemented the GPU version of our method by transferring the position of the PBD particles to the GPU and updating the particles’ position on it, which can accelerate the computation of the surgical simulation. We have sampled 9216 PBD particles for the human lung model. The comparison of the average frame rate at different simulation stages between the CPU version and the GPU version of virtual lobectomy simulation is illustrated in Table 1. The virtual lobectomy simulation was divided into three stages, viz. the pre-operation, cutting and suturing stages, respectively. The pre-operation stage indicates that the simulator runs without any operation; and the cutting stage involves the soft tissue deformation and cutting procedure. As shown in Table 1, the average frame rates of the CPU version for the three stages of the virtual lobectomy simulation were all less
than 4 fps. After GPU acceleration, the average frame rates for the three stages of the surgical simulation were more than 25 fps, which achieves real-time interactive surgical simulation.

Figure 4 and Figure 5 illustrate the soft tissue pressing and clamping deformation effects with our PBD-based unified framework, respectively. We utilized a surgical clip to interact with the virtual lung model. When the surgical clip approached the soft tissue, accurate and real-time collision detection was performed, and the soft tissue deformed when the surgical clip grasped the collision PBD particles and moved inwards or outwards, resulting in the pressing or clamping deformation effects. The experimental results in Figure 4 and Figure 5 demonstrate that we achieved visual plausible soft tissue deformation effects in virtual lobectomy simulation.

As shown in Figure 6, we employed a scalpel to perform the cutting operation. The scalpel was modelled as a line and the cutting plane was constructed by two sequential positions of the scalpel. By performing accurate collision detection and calculating the intersection between the cutting plane and the edges between volumetric particles, we were able to remove the constraint between the two volumetric particles that forms the intersection edges. After MC reconstruction of the surface triangles of the human lung, the final cutting effects were achieved with high visual plausible effects. Also, as shown in Table 1, the average frame rate for the cutting procedure was 26.72 fps by GPU acceleration. The experimental results in Figure 6 demonstrate the effectiveness and high efficiency of our method in modelling the soft tissue cutting procedure.

Figure 7 illustrates the whole procedure of the soft tissue suturing simulation. The suture needle was clamped by the surgical clip and was utilized to stick into or out of the soft tissue to finish the suturing procedure. The collision particles were found by accurate collision detection and, during the stick procedure, the collision particles were constrained on the suture needle, resulting in the soft tissue deformation during this procedure. When the suture needle moved out of the soft tissue, the suture line followed its movement via the collision particles (red points), as shown in the three-time suturing in Figure 7(a) – Figure 7(c). The fix and tightening of the suture line are shown in Figure 7(d) – Figure 7(e), and both sides of the incision approached each other with the enforcement of the tightening of the suture line. As shown in Table 1, the average frame rate of suturing was 30.11 fps by GPU acceleration. The experimental results in Figure 7 demonstrate the realistic and real-time soft tissue suturing effects.

**Discussion**

In this paper, we have presented the PBD-based unified framework for the soft tissue deformation, cutting and suturing in virtual surgery. The mechanical responses of the soft tissue, as well as the suture line, were all modelled by position-based dynamics. The experimental results demonstrate the high efficiency of the virtual lobectomy simulation with visual plausible effects on the GPU. Compared with the FEM, our method avoids
the complicated re-meshing of the finite elements and has greater flexibility in handling the computation of soft tissue and achieving more stable geometric modification.

However, the computation efficiency of our method was greatly influenced by the number of the sampled volumetric PBD particles, so we should balance the computation efficiency with the realism of the visual effects. In addition, the real lobectomy surgery usually involves the bleeding phenomenon during the cutting procedure. To realize more realistic virtual lobectomy simulation, the accompanying bleeding simulation should be investigated in the PBD-based unified framework.

**Conclusion**

This paper has presented a unified framework with position-based dynamics for the soft tissue deformation, cutting and suturing simulation. By employing our method, we developed a realistic and real-time interactive virtual lobectomy surgery simulator, which has the potential to facilitate lobectomy surgical skill training in the healthcare industry. In future work, we will carry out research on incorporating the accompanying bleeding simulation into our PBD-based unified framework to achieve a more realistic virtual lobectomy simulation.

**References**


Table 1. Average frame rate at different simulation stages

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<th>Stage</th>
<th>CPU (fps)</th>
<th>GPU (fps)</th>
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Figure 1. Reconstruction of the soft tissue and sampling of the volumetric particles

Figure 2. The procedure of the PBD-based soft tissue cutting
Figure 3. The procedure for PBD-based soft tissue suturing

Figure 4. Soft tissue pressing deformation effect

Figure 5. Soft tissue clamping deformation effect

Figure 6. Soft tissue cutting simulation
Figure 7. Soft tissue suturing simulation
Development and Promotion of Hand Hygiene Using Virtual Reality (VR) Technology

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School of Nursing and Health Studies, The Open University of Hong Kong

Abstract

Hand hygiene is the most important issue for infection control in both clinical and non-clinical settings. Performing proper hand hygiene is becoming essential for preventing the spread of infectious disease. The overall compliance with hand hygiene has a very wide range – from 8.1% to 83.5% (Kingston, O’Connell, & Dunne, 2016; Sundal et al., 2017; Zivich, Gancz, & Aiello, 2018). Although some of the compliance rates were high, inappropriate hand hygiene procedures were common (Kim et al., 2013). More effort should be made to promote proper and standardized hand hygiene procedures.

The objectives of this study are to develop a VR software program to demonstrate this procedure, and to evaluate its outcome in training on hand hygiene. A cross-sectional survey and self-administered questionnaires were used for data collection. Proper and standardized hand hygiene procedures were demonstrated to the participants by the VR software program; and, after that, they performed the procedure by using it. Questionnaires were then given to participants for evaluation. All 44 participants performed the hand hygiene procedures correctly. The results were as follows: on two out of the seven items, over 90% of the participants agreed or strongly agreed with the statements in the questionnaire; and on the other five items, 100% agreed or strongly agreed with the statements. More positive than negative comments were received on the last two open questions. In brief, by using the VR technology, participants can use the VR program to learn proper and standardized hand hygiene procedures.

Keywords: hand hygiene, virtual reality, technology
Introduction

Hand hygiene is the most important issue for infection control in clinical and non-clinical settings, as well as in the community. In clinical settings, such as hospitals and elderly care centres, healthcare-associated infections have major consequences for patient outcomes, including an increased length of stay in hospital, morbidity and mortality, and the financial burden in society (WHO, 2011). In non-clinical settings, such as schools and office workplaces, the prevention of infectious disease is also vital as such settings include healthy and ill individuals in close contact. Performing proper hand hygiene is becoming essential to prevent infectious disease spreading in this context. In the community, the shared public areas are also a high-risk place for spreading communicable diseases. To promote hand hygiene, the World Health Organization (WHO) initiated its global campaign “Clean Care is Safer Care” in 2005 (WHO, 2009). In addition, the WHO set up a gold standard, “My five moments for hand hygiene” and “The seven steps of hand hygiene”, which allowed hand hygiene compliance to be quantified and evaluated.

Many studies have assessed hand hygiene compliance in various target groups, such as healthcare professionals – including physicians, medical students, nurses, nursing students, healthcare assistants, patients and visitors in hospitals, as well as individuals in schools and office workplaces. The overall hand hygiene compliance results range widely from 8.1% to 83.5% (Kingston et al., 2016; Sundal et al., 2017; Zivich et al., 2018). Although some of the hand hygiene compliance rates were high, inappropriate hand hygiene procedures were common (Kim et al., 2013). More effort should be made to promote proper and standardized hand hygiene procedures.

Hand Hygiene Promotion in Hong Kong

In 2005, Hong Kong pledged support for the World Health Organization’s First Global Patient Safety Challenge – “Clean Care is Safer Care” – by actively promoting hand hygiene (Centre for Health Protection, 2014). Since then, a series of hand hygiene campaigns have been launched. From 2010 onwards, in Hong Kong, 5thMay has been the Hand Hygiene Awareness Day, which aims to raise the awareness of good hand hygiene (Centre for Health Protection, 2014). There are numerous programmes targeted on hand hygiene promotion and education in community settings. The main message the government wishes to convey is about when and how to perform hand hygiene, which can be generally encapsulated in the World Health Organization’s “Five moments for hand hygiene” (Centre for Health Protection, 2011). There are advertisement on the importance of hand hygiene on the mass media, and facilities and venues of the Leisure and Cultural Services Department. In general, factsheets and posters are the most effective and traditional way to disseminate the message of hand hygiene to the public. A 24-hour health education hotline and websites are other routes for promoting hand hygiene. In addition, promotional materials on Facebook and Youtube pages and the use of the QR code have become a popular way to educate citizen on hand hygiene due to the increasing use of social media and the internet (Centre for Health Protection, 2015).
Every year, the Centre for Health Protection emphasizes specific aspects of this issue, and in recent years it has developed a series of promotional materials. These are five moments for hand hygiene (Centre for Health Protection, 2011) and seven steps for hand-rubbing (Centre for Health Protection, 2013). In 2016, the Department of Health called for healthcare workers and the public to pay attention to hand hygiene by a series of events and promotional materials (Centre for Health Protection, 2016). A hand hygiene education campaign was implemented by hand hygiene ambassador (Cheng et al., 2016).

Good hand hygiene is of prime importance for preventing infections. For this purpose, The Department of Health, Centre for Health Protection and the Hospital Authority have also actively promoted hand hygiene in the community and healthcare facilities. In order to minimize the cross-infection rate, the Infection Control Team from each hospital has inspected and performed an audit on hand hygiene compliance through healthcare workers on a regular basis. After review, reports and analysis on healthcare workers’ performance from different parties were generated and relayed by the team head to the staff concerned.

All these programmes aim to promote proper hand hygiene in clinical settings or the community.

**Virtual Reality Technology for Education in Health Care**

VR technology has been developed in the last decade and has been used in different fields including medical education. It can cater for whole new learning styles that cannot be matched by traditional teaching, which facilitate self-directed learning; allow trainees to develop skills at their own pace; and provide a safe environment for unlimited repetition of specific scenarios for skills practices (Ruthenbeck & Reynolds, 2015). VR technology has been widely used in medical education for training health-care professionals (Ellaway, 2010). It has been employed for physicians and nurses in training for surgery and critical situations such as dental and bone surgery (Buchanan, 2004), intubation (Rodrigues, Gillies, & Charters, 2001), and cardiopulmonary resuscitation (Kilmon, Brown, Ghosh, & Mikitiuk, 2010). However, few studies have reported the use of VR technology in health education for the general public. A study was conducted in America on using VR technology for hand hygiene in teaching the World Health Organization’s five moments, which had a positive result, showing that using VR technology was better than convention methods (Bertrand, Babu, Gupta, Segre, & Polgreen, 2011). However, a similar study with a VR program was not found in Hong Kong or other Asian countries. In view of this, it would be beneficial to develop a VR program and use it for promoting proper hand hygiene among medical and health care personnel as well as the general public in Hong Kong. The program developed could be used to promote proper hand hygiene procedures for patients, medical and health care personnel, and the public in order to minimize the risk of disease transmission.
Aims and Objectives

This project aims to develop a VR program for promoting a proper and standardized procedure for performing hand hygiene. The objectives are: (1) to develop a VR software program to teach proper and standardized hand hygiene procedures; and (2) to evaluate the outcome of the VR software program for training in hand hygiene procedures.

Participating in a VR program can have various benefits for patients, health care personnel, students, and the general public. By using VR technology, proper and standardized hand hygiene procedures can be learned in interactive ways instead of reading instructions or watching videos.

Methods

This study was designed as a cross-sectional survey. A VR software program was developed and used for demonstrating and evaluating hand hygiene procedures. Self-administered questionnaires were given to participants after they had finished experiencing the VR software program.

Participants and Setting

A convenience sample of 44 participants was recruited during a health promotion event organized by the School of Nursing and Health Studies at The Open University of Hong Kong (OUHK). The participants were invited to experience the VR software program in a hand hygiene booth setting. The VR software program for training on the hand hygiene procedures was developed by the VR team of the OUHK’s School of Nursing and Health Studies. There were two sets of VR hardware, which included the VR head-set with a tracking system (the HTC Vive and the Leap motion) and a high-performance portable computer to run the VR program.

Procedures

Participants were asked to wear a VR head-set which demonstrated proper and standardized hand hygiene procedures. When they were familiar with the procedures, they proceeded to the evaluation stage. By using VR technology, germs on both hands appeared on the screen of the VR head-set. With two controls in their hands, participants performed the hand hygiene procedures without guidelines on the VR head-set. If they could perform the procedures correctly, the germs on their hands were washed away. The VR software program showed them a checklist on which actions they had performed well, and which ones needed further improvement.

Data Collection

After experiencing the VR software program, the participants were asked to complete self-administered questionnaires.
The questionnaire contained Parts I and II with a total of nine items, with Part I containing seven items and Part II two items. In Part I, they were asked to rate the statement in the questionnaire on a rating scale of 1 “strongly disagree”; 2 “disagree”; 3 “agree”, and 4 “strongly agree”. In Part II, there were two open-questions about the most beneficial aspects of the VR software program; and improvements on the hand hygiene VR software program. Thus, participants were able to give their feedback on their VR experience.

Data Analysis

The data were analysed by the Statistical Package for Social Science (SPSS) version 22. Descriptive statistics were calculated to show the frequencies and percentages of the variables on their VR experiences. The statistical significance for this study was set at the p<0.05 level.

Ethical Considerations

Before the use of the VR program, an introduction to the study was given. An information sheet which included its aims and the procedures, and the names and contact phone numbers of the researchers, was given to participants. All the participants were volunteers and they were informed that they had the right to withdraw from the study at any time without any penalty. Also, they needed to sign a consent form before the study commenced. Sufficient time was given (15 to 20 minutes) to fill in the questionnaire; and all the completed questionnaires collected were locked and kept confidential and anonymous. The findings were used for research and academic purpose only. All the data will be destroyed after the completion of the study. Ethical approval was obtained from the Research Ethics Committee of the University before the data collection commenced.

Results

The total number of participants was 44. All the data were valid and no data were missing. All the participants could finish the hand hygiene procedure correctly after watching the proper and standardized hand hygiene procedures via the VR head-set. Two of the seven items resulted in over 90% agreeing or strongly agreeing with the statements in the questionnaire. These items were: “The VR hand hygiene program is relevant for the promotion of hygiene” and “The VR program provides a realistic environment”. The other 5 items resulted in 100% agreement or strong agreement with the statements. These five items were: “The VR hand hygiene program is more useful that conventional learning methods (such as PowerPoint, lectures and videos)”; “The VR program allows me to understand the importance of hand hygiene”; “The VR program makes me concentrate on hand hygiene”; “The VR program arouses my health awareness”; and “Overall, the VR program helps me to pay attention to hygiene”. More positive than negative comments were received on the two open questions: “What benefit do you get from the VR experience?” and “What improvements could be made for VR hand hygiene”. These included “got familiar with the 7 steps of hand hygiene”;
“can know more about personal hygiene”; “can increase infection control knowledge”; “know how to wash away all the bacteria”; “know how long [I] should be washing”; “It is practical and interactive”; “know how to perform hand hygiene”; and “impressive and new”.

**Discussion**

As VR technology has developed and become widely used in various fields, it has great potential for becoming an interactive way to arouse awareness of the importance of hand hygiene and the appropriate hand hygiene procedures. While there are numerous programmes on the promotion of, and education about, hand hygiene in clinical settings, for non-clinical and community settings, most of the programmes use one-way information – such as advertisements on the importance of hand hygiene on the mass media; factsheets and posters; 24-hour health education hotlines and websites; promotional materials on Facebook and Youtube pages; and the use of the QR code (Centre for Health Protection, 2015). However, interactivity is an important component in promotion and education.

There are also other uses of technology to promote hand hygiene compliance in different settings, such as olfactory and visual prime near hand-washing facilities and hand gel dispensers (King et al., 2016); audio-visual reminders on electronic devices that tell people to comply with hand hygiene after restroom visits (Knighton et al., 2018; Moller-Sorensen, Korshin, Mogensen, & Hoiby, 2016); and simulation education in nursing education (Jansson et al., 2016). VR technology can be a leading light in the development of such roles in all the settings.

In this study, positive comments were received from the participants. The idea of using VR in the development of health promotion is welcomed by the general public. More VR programs could be developed. The use of new technology arouses the interest of individuals, as well as giving them strong impressions, so that they can easily remember the messages they received. Other than the conventional ways of promotion which have been mentioned, the government should support the development of new technology in health promotion.

**Limitations**

The study has several limitations. Due to the small number of participants, the results cannot be generalized. Also, the questionnaires were returned immediately after watching the proper hand hygiene procedures, which did not reveal whether or not the participants would remember all the steps after some time. In addition, the number of VR head-sets used was small, as they are expensive within a limited budget.
Conclusion
The results suggest that hand hygiene promotion and education can be done effectively in an interactive way using VR technology.

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