Nurse Education Today 40 (2016) 198–203

Contents lists available at ScienceDirect

Nurse Education Today

journal homepage: www.elsevier.com/nedt

Online intravenous pump emulator: As effective as face-to-face simulation for training nursing students

Victoria R. Terry *, Clint Moloney, Leslie Bowtell, Peter C. Terry

Faculty of Health, Engineering and Sciences, University of Southern Queensland, Toowoomba, Australia

ARTICLE INFO

Article history:
Received 22 September 2015
Received in revised form 21 February 2016
Accepted 7 March 2016

Keywords:
Nursing students
Clinical
Simulation
Emulation
Technology
Intravenous
Blended learning

ABSTRACT

Background: The expansion of online education for nursing students has created the challenge of finding innovative ways to teach clinical skills. An online intravenous pump emulator (IVPE) modelled on actual IV pumps used in clinical healthcare settings was developed to facilitate online education delivery.
Objectives: The objectives of the study were to implement the online IVPE and evaluate student learning outcomes and perceptions of device use.
Design: A mixed method, quasi-experimental design was used.
Setting: The study was conducted in the School of Nursing and Midwifery at a regional university in Queensland, Australia.
Participants: Participants were 179 first year nursing students enrolled in a medications course, ranging in age from 18 to 44 years, of whom 150 were female.
Methods: Participants were assigned to one of three groups and trained in the use of IV infusion pumps. Group 1 ($n = 57$) were trained online using the IVPE (ONL); Group 2 ($n = 73$) were trained on-campus using an actual IV pump (ONC); Group 3 ($n = 49$) were trained both on-campus using the actual IV pump and online using the IVPE (ONL + ONC). Competence in using the actual IV pump was assessed for all participants at the conclusion of the training period.
Results: No significant differences in learning outcomes, measured by assessment scores out of 80 points, were found between the ONL ($M = 65.5 \pm 9.2$) and ONC ($M = 62.0 \pm 14.8$; $p > .05$) groups. Significantly better learning outcomes were evident for the ONL + ONC group ($M = 68.7 \pm 4.9$) compared to the ONC group ($p < .01$).
Conclusions: This study highlights that the nursing students became more competent in the skill of preparing and administrating IV infusions when face-to-face and online learning were combined.

1. Introduction

The education of nursing students at universities has involved a "hands-on" process delivered in on-campus simulated hospital wards using manikins as patients, as well as a range of clinical equipment. Online education is advancing rapidly in universities globally, particularly in North America, the United Kingdom, Australasia, and parts of Asia (McCutcheon et al., 2014). In hands-on practical disciplines, such as nursing, traditional teaching techniques and styles are evolving to meet the challenge of providing contemporary educational resources online. This shift has prompted healthcare educators to explore innovative teaching resources and methods of delivery to students (Oermann, 2015). As a precursor to the present study, a multidisciplinary team of engineers and nurses collaborated to develop an online intravenous pump emulator (IVPE) (Bowtell et al., 2012, 2013). Fig. 1 shows the actual IV pump used for training purposes in the simulated nursing laboratories and Fig. 2 shows the online IVPE.

2. Literature Review

IV infusion pumps are used in healthcare facilities throughout the world, primarily for IV fluid administration and also for delivering IV medication infusions, whereby a nurse will programme a dose or rate and a specific volume to be infused (Taxis and Barber, 2003). Clinical errors in IV medications have been showed to be commonplace (Anderson and Townsend, 2010). One study reported that 70% of all infusions were incorrectly administered, of which 92% involved incorrect solutions, incorrect rate and volumes, and/or incompatibilities with other IV fluid solutions and medications (Pang et al., 2011).

A range of strategies to avoid IV infusion errors have been proposed, with multifaceted programmes combining numeracy education, computer-assisted programmes, online activities, and practical simulations yielding the best results (see Harris et al., 2014; McMullan et al., 2011; Sears et al., 2010; Sherriff et al., 2011; Stolic, 2014).

The teaching of clinical skills, previously confined to a simulated laboratory, is now often enhanced using computer-based resources, videos and other interactive material (Billings and Halstead, 2013). A systematic review of the relative effectiveness of online, face-to-face, and

* Corresponding author.
E-mail address: Victoria.terry@usq.edu.au (V.R. Terry).

http://dx.doi.org/10.1016/j.nedt.2016.03.004
0260-6917/

Fig. 1. Actual IV pump.

blended learning models of teaching clinical skills to nursing students, concluded that online teaching is no less effective than classroom teaching (McCutcheon et al., 2014). Further, a review of student learning in medical, dentistry, nursing, physical therapy, and pharmacology degrees, reported better skill acquisition in the online and computer-assisted environment than by face-to-face methods (George et al., 2014). Additionally, a recent health workforce review commissioned by the World Health Organization concluded that students studying via e-teaching methods learn equally well, or better than, via traditional training (Al-Shorbaji et al., 2015).

Online simulation represents a new chapter in nursing education delivery and appears likely to secure a prominent place in nurse training curricula in the coming years (Cant and Cooper, 2014). An emerging principle is that emulation technology (i.e., where a computer imitates a machine) can help to create an individualised learning environment, given that gaining access to emulated equipment makes learning a relatively autonomous and self-directed experience (Bowtell et al., 2013).

Gagnon et al. (2013) emphasised the benefits of self-directed learning for nursing students, providing them with increased autonomy, accountability, and confidence as they prepare for the challenges of the workforce, whereas others recognise that students often benefit from a more guided and teacher-centred traditional style of instructional learning (Levett-Jones, 2005). Self-directed learning of clinical skills, using computer-assisted simulation rather than instructor-led hands-on simulation, has been shown to be more beneficial in terms of skill retention (Brydges et al., 2012) and developing confidence for clinical practice (Samawi et al., 2014) and that a combination of both may provide the most effective approach.

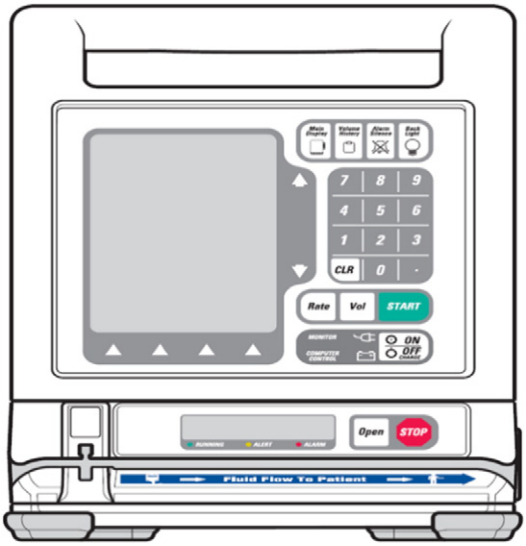

Fig. 2. IV pump emulator (IVPE).

3. Methods

A mixed-method research design was used to evaluate the nursing students' learning outcomes and user perceptions for using online technology compared to a physical piece of medical equipment. This combination of quasi-experimental and survey methodology is considered to be both pragmatic and appropriate to clinical practice in nursing (Roberts and Burke, 1989).

3.1. Participants

A first year medication course was selected for the research. This particular cohort of nursing students entering the programme had no recognised prior learning (RPL) or prior experience or exposure to the features and functions of an actual IV pump. A total of 199 nursing students were recruited to the study, of whom 179 participants (female = 150) completed all activities, a retention rate of 90%. Participants were allocated to groups; Group 1: online only (ONL, $n = 57$), Group 2: on-campus only (ONC, $n = 73$), Group 3: online and on-campus (ONL + ONC, $n = 49$). The sample included 60 international and 119 domestic students, with participants being categorised into three age groups; 18–24 years ($n = 97$), 25–34 years ($n = 59$), and 35–44 years ($n = 23$). International students originated from 10 countries (India = 18, Nepal = 14, Saudi Arabia = 7, Philippines = 7, Congo = 4, China = 3, Chad = 2, Rwanda = 2, Sudan = 2, Nigeria = 1).

Group 2 received on-campus face-to-face training on an actual IV pump; Group 1 and Group 3 received training on the online IVPE, with Group 3 also receiving on-campus, face-to-face training. A video demonstration of the functions and instructions for using an actual IV pump was produced and made available for all participants to view. Distance students were allocated randomly to Groups 2 and 3, reducing the probability of initial group differences in competence.

3.2. Measures

Competence in using the actual IV pump was assessed using a clinical assessment protocol, referred to as the Activity Assessment Tool (AAT), which was developed in a pilot study (Bowtell et al., 2013). The AAT included a series of activities designed to guide participants through the general functions and features of an actual IV pump. Included activities were informed by expert opinion of experienced nurse educators and after consulting the clinical textbook for the course of study (Tollefson, 2012). Reflection on the experience of the pilot project prompted refinements to methodological and procedural aspects resulting in a Revised Activity Assessment Tool (RAAT).

Activity 1 of the RAAT followed a chronological sequence as if preparing an IV infusion for a patient: (a) Select 1000 mL sodium chloride and check the order provided, (b) Turn on the IV pump, (c) Load the IV giving set into the IV pump, (d) Set the rate at 83 mL, (e) Set the volume to be infused (VTBI), and (f) Start the infusion. Activity 2 required participants to list the six rights (National Prescribing Service, 2008). Activities 3 and 4 required participants to programme into the actual IV pump a variety of rates and volumes from problem-based medication calculations, using the formula they had been taught. Activity 5 was simply to switch off the IV pump. Competency was scored on a 5-point Likert scale, anchored by 0 = "could not or did not perform