The role of Ultrasound simulators in education: an investigation into sonography student experiences and clinical mentor perceptions

Abstract

Introduction: Simulation as an effective pedagogy is gaining momentum at all levels of healthcare education (1). Limited research has been undertaken on the role of simulated learning in healthcare, and further evaluation is needed to explore the quality of learning opportunities offered, and their effectiveness in the preparation of students for clinical practice. This study was undertaken to explore ways of integrating simulation based learning into sonography training to enhance clinical preparation.
Research method: A qualitative study was undertaken, using interviews to investigate the experiences of a group of sonography students after interacting with an ultrasound simulator. The perceptions of their clinical mentors on the effectiveness of this equipment to support the education and development of sonographers, were also explored.
Findings: The findings confirm that ultrasound simulators provide learning opportunities in an unpressurised environment, which reduces stress for the student and potential harm to patients. Busy clinical departments acknowledge the advantages of opportunities for students to acquire basic psychomotor skills in a classroom setting, thereby avoiding the inevitable reduction in patient throughput which results from clinical training. The limitations of simulation equipment to support the development of the full range of clinical skills required by sonographers, were highlighted, and suggestions made for more effective integration of simulation into the teaching and learning process.
Conclusion: Ultrasound simulators have a role in sonography education, but continued research needs to be undertaken in order to develop appropriate strategies to support students, educators, and mentors to effectively integrate this methodology.

Introduction

Simulation is recognised as an innovative pedagogic approach that has gained much popularity in healthcare education in recent years. Simulation based learning takes many forms and spans a range of sophistication from simple reproduction of body parts through to the complex human interactions portrayed by high-fidelity simulators (1). The aviation industry first used simulation as a training method over 80 years ago (2) when, in 1929, Ed Link developed a simulator to train pilots. This approach to training and education is now not unique to the aviation industry, and is evident within many individual industries and disciplines.

Advances in technology have led to dramatic improvements in the sophistication and realism of simulators, and the role of simulation in healthcare education has developed rapidly over the past decade. It is a learning strategy requiring the learner to actively engage with the learning process, whilst the educator acts as a facilitator of learning (3), Students are able to use simulation to acquire essential skills through trial and error in a safe, non-threatening environment closely representing reality. (4) All forms of simulation allow students to develop skills whilst applying theoretical knowledge in a controlled setting away from the patient (5) and prepares students for real clinical situations.

Ultrasound simulators have evolved over recent years due to technological developments, and now offer students a realistic clinical learning experience. The student can often interact with the equipment using an interface in the form of an ultrasound transducer, whilst observing a computer generated display with in-built virtual examinations which mimic the view obtained during a scanning procedure. Haptic technology is able to recreate sensations of real-life scanning and enable the development of psychomotor skills (6). A range of cases of pathology can be made available, creating varying degrees of difficulty for the learner.

Background

A number of factors are impacting on the drive to incorporate simulation into healthcare education. Government initiatives associated with service efficiency and patient-centred care frequently highlight the need for the healthcare practitioner to be equipped with the appropriate knowledge and skills to partake in the delivery of a high quality service. In 2008, the Chief Medical Officer (7) highlighted the potential for simulation based education to reform the way clinical training is provided, citing examples of success in other industries. Many healthcare training programmes now include simulation equipment as part of the learning process, however, there is little guidance available on how best this can be utilised. In 2011 the NHS developed a *Framework for Technology Enhanced Learning* (8) which set out the aim for the use of technology across health and social care within the UK. This was centred around six key principles stating that technology should: be patient centred and service driven; be educationally coherent; deliver value for money; be innovative and evidence-based; deliver high quality educational outcomes; ensure equity of access and equity of provision. Whilst these principles provide general guidance for simulation, more specific strategies are required to ensure appropriate integration of this technology.

Given the need to ensure healthcare practitioners are equipped with appropriate knowledge and skills, training should resonate with the mapping of core attributes that ensure effective patient services are being delivered. Experiential learning, where students are actively engaged in the learning process, is generally recognised as offering the most effective learning environment (9). However, it is often difficult to achieve the requisite clinical tuition when departments are under pressure for a rapid throughput of patients to control the ever-increasing waiting lists. Busy clinical departments struggle to allow students sufficient supervised clinical practice time. Patients are often reluctant to tolerate inexperienced operators, and the associated extended examination times, particularly where this may involve uncomfortable or invasive procedures. Simulation offers the potential to overcome the challenges associated with shortages of quality clinical placement experiences for students (9,10).

In addition to these pressures, in the current climate of global austerity, Higher Education Institutions (HEIs) are being challenged to identify more efficient and cost- effective methods of delivering education (11) .Universities have experienced severe reductions in budgets, and this puts additional emphasis on the need for more creative methods of education and assessment. There is a need to offer innovative and flexible training programmes that provide students with the necessary skills and opportunities to excel within their selected specialities (12,13). The further integration of technology such as simulators, into educational programmes for healthcare workers, offers a potential solution by enabling more cost-effective methods of delivering learning.

Most simulators however have limitations, and complete replication of the clinical scenario cannot be achieved. Whilst it is generally recognised that simulation based learning cannot replace clinical experience, concerns have been raised regarding widespread integration of technology-based education tools in healthcare education, and the drift towards technology rather than philosophically-based pedagogy is an area of particular concern for many (14, 15), The available literature indicates there is a lack of empirical research determining the efficacy and effectiveness of simulation (16), and in particular whether the knowledge and skills acquired through simulation are transferred as competence and proficiency in clinical practice . Prion (16) suggests that direct information about actual learning is difficult to obtain because it requires a demonstrated or observed change in the participant's behaviour. This suggests that simply including simulation based learning within a curriculum is not sufficient, and further evaluation of simulated learning across healthcare education is needed to explore the quality of learning opportunities that are offered, and their effectiveness in the preparation of students for clinical practice (17). Whilst the use of simulators is not new to healthcare education, care needs to be taken to ensure that a learning pedagogy appropriate to the required outcomes of the programme is introduced. Failure to do this has the potential to lead to student dissatisfaction, the introduction of irrelevant information and ultimately a lack of student engagement.

This project was undertaken as part of a process to help establish a pedagogic base for ultrasound simulation, in order to support the acquisition and development of the range of

complex clinical skills required by student sonographers. This will help to facilitate the development of educational resources that can impact positively into learning and teaching within ultrasound training.

Research Method

Following on from an earlier small project in 2013 (18), in September 2014 a larger study was undertaken to explore the experiences of a group of sonography students after interacting with a Medaphor ScanTrainer® ultrasound simulator. The perceptions of their clinical mentors on the effectiveness of this technology to support the education and development of student sonographers, were also explored in this study.

A qualitative approach was used, incorporating interviews with students who had interacted with the scanning simulator. All students on their first year of study on the Diagnostic Ultrasound programme, were invited to participate at the end of their clinical module via an information sheet. These students were undertaking a range of clinical practice modules incorporating both transabdominal and transvaginal approaches to scanning. Consent was obtained from twenty five students (this represented 47% of the cohort) who were willing to share their experiences. The interviews were conducted by a single member of the Programme team. Each interview was semi-structured, supported by a framework which acted as a guide for an informal conversation between researcher and participant, and also guided the analysis. This method of qualitative interviewing is recognised as an effective method of obtaining reliable views and information from participants (19). In addition sixteen clinical mentors were invited to participate in semi-structured telephone interviews, to explore their perceptions on the effectiveness of the simulation based learning in preparing their students for scanning patients in the real clinical environment. Fourteen mentors participated in the project and were each contacted individually. Institutional ethical approval was obtained for the study from the xxxxxx Ethics Committee in July 2014.

Findings
During the research, although discussions and responses were wide-ranging, several common themes began to emerge. A thematic analysis approach was taken in order to understand the findings. The broad range of comments from students and mentors that arose from the interviews, were reviewed by the project lead by defining subject content of the data, and then coded according to their content. As the codes were accumulated, they were then sorted into three themes. This resulted in a transfer of the descriptive data summarising the responses, into a more interpretative approach to help understand the data.

All the points raised by individuals were finally identified as fitting into one of three themes. These were: *Advantages of simulation; Limitations of simulation; Suggestions for improvement.*

The comments have been synthesised and outlined in Table 1

Discussion

Although it is recognised that simulation based learning cannot replace clinical experience (17), the findings from this study indicate that simulators do have an important role in the training of sonographers, Several students commented on the pressures placed on them when trying to master scanning techniques in a busy clinical environment. Trying to get protected one-to-one quality tuition time with a mentor is always challenging when rapid throughput of patients is often the chief objective of a department. In addition, if patients are delayed whilst waiting for scans they are often not receptive to agreeing to be scanned by a student. Students commented that they particularly benefited from time spent on the simulator where they could repeat tasks without the clinical pressures arising when working in a busy department. Simulation offers the potential to overcome challenges associated with shortages of quality clinical placements for students. Time spent working with a simulator in a classroom can help alleviate the pressures on students, mentors and patients. In their study

of nursing students, Baillie & Curzo (20) concluded that replacing some clinical hours with simulation was undoubtedly advantageous for students as an alternative to busy clinical environments.

To become an effective sonographer demands expertise in several areas, and a holistic approach to practice requires these to be integrated. Bloom's taxonomy of learning objectives is widely used within healthcare education and its three categories of knowledge, skills and attitudes are frequently quoted (21). *Knowledge* is gained by assimilation of information. *Skills* require the development of psychomotor competencies and require regular practise complemented by expert feedback. *Attitudes* relate to how knowledge and skills are combined in the care of patients, and include areas such as clinical decision-making and professional behaviour. Arguably, whilst ultrasound simulators may be helpful in the acquisition of knowledge and psychomotor skills, opportunities for integrating the formulation of attitudes into this method of learning are currently limited, and remain the preserve of the clinical departments.

One criticism of simulated learning is that it may only reproduce procedural training (22) and therefore not include all the skills required by a competent practitioner. This is supported by comments in this study from sonography mentors regarding the lack of patient interaction, clinical decision-making and report-writing skills involved in using current simulation equipment. This is an area that could potentially be developed further by the manufacturers, or by the course tutors, by interfacing report-writing skills and patient communication skills with the simulated scans and case studies.

Another criticism that was made on several occasions by both students and mentors in this study, was that the simulator did not provide a complete replication of reality. McKenna *et al* (23) in their study concluded that simulation offers educational opportunities to support the development of competent students, but the potential for further use is limited by lack of realism in available simulation models. As the technology improves, so does the potential for more complex and realistic simulation. However such authentic replication cannot always be achieved and should not be aimed for at the expense of the development of student confidence and competence (24). The primary aim should be to prepare the student for practice in the real clinical setting, in a context where time and repeat practice can be manipulated to meet the needs of the student (25). Rather than spending resources on advanced simulation technologies that mimic real-life, it is more important to develop systems which put the student at the centre of the learning experience to enable them to have time for reflective learning in a non-pressurised environment (23). Those developing simulation equipment need to work closely with clinical practitioners and educationalists to ensure that the field will not be dominated by technology, but rather driven by needs of the students. Neary (24) in her research supports this claim that skill laboratories can facilitate the development of 'real practice' in clinical placements without trying to replace it. She observes that the emphasis rather needs to move away from focusing on the technology and towards a more integrated learning framework where knowledge can be acquired alongside technical skills and not in isolation from them. Work on 'situated learning' emphasises the potential for simulation to enhance clinical practice (25) rather than trying to replace it, otherwise there is a danger that skills learnt in the simulator environment and skills applied in real-life clinical practice may exist separately.

Comments from some students demonstrated that they were under the misapprehension that use of the simulator in their final viva assessment meant they would be tested on their use of the simulator, whereas what they were actually tested on was their knowledge of clinical scanning, using the simulator merely to demonstrate specific aspects. This resulted in some students spending time on the simulator towards the end of their training period, simply to familiarise themselves with the simulator; this was time which they perceived as not beneficial to their clinical scanning. This will need to be made more explicit to future cohorts to provide greater clarification. Another area that received criticism from students was the perceived onerous requirement to successfully complete alt least 75% simulator formative assessments. This requirement was introduced to ensure appropriate levels of engagement by all students, and for the tutors to track which areas a student may be struggling with. However, this may

need to be reviewed for future cohorts to ensure students' interactions are beneficial, rather than perceived as merely additional tasks to complete.

Many positive responses were received from students and mentors about the advantages of using the simulator to gain an understanding of orientation and improve hand-eye co-ordination. This is an area where many students struggle to master the skills required of a competent sonographer. Skill acquisition occurs at different rates in individuals, and simulators allow students to work at their own speed, and perform repetitions as many times as required without being observed (26). The incremental approach around which the simulator is structured allows the students to work at a pace to suit the individual. Some students find the technical aspects of scanning a particular problem to overcome, and may decide to abandon their training without a sympathetic department where they can be given the additional time needed to become proficient (27). Tutors, whilst working with these students on the simulator, have observed the benefits for students when they are able to engage with the simulator in a classroom setting. Comments from mentors also noted observable improvements in students' psychomotor skills after time spent interacting with the simulator. The opportunity to halt the learning in order to reflect on the experience is advantageous for students, particularly as the clinical setting offers limited opportunities for this. Enabling the student opportunities to repeat the simulation activities guided by feedback, undoubtedly increases confidence, which is important as low levels of confidence are recognised as a barrier to learning (28).

Several comments from students in this study indicated that the simulator helped to reinforce theoretical concepts relating to ultrasound which were difficult to assimilate in the classroom. The simulator enabled the blending of theory with practical contextualised application, which served to ensure the learning had more impact. Much of the literature reinforces this observation that simulation can provide more focused and deeper learning experiences (29).

The development of simulators has made standardised training possible, and students commented that they found it useful to have a package they could work through, knowing that everyone else was learning the same information. Students are often concerned that there may be areas of their learning which have not been covered during their often unstructured training period, leading to unknown holes in their knowledge. This is always a potential problem when students rely on a number of different individuals in clinical practice and educational instituitions to teach them, and there is often not one person guiding them systematically through the learning process. The requirement for alll students to work through the same training package on the simulator, provides a certain amount of reassurance that they have all covered the same areas and reduced the possibility of 'unknown unknowns' in their knowledge. Students particularly appreciated the opportunity to scan a number of different pathologies on the simulator that may not have been encountered during their clinical training period. Ectopic pregnancies or unusual pelvic masses could be scanned, for example, giving the students the opportunity to visualise and identify these images.This helps to prepare students for clinical situations that they may not otherwise encounter during training, thereby providing a response to the challenge of ensuring consistent learning for all students in clinical practice (30). However, several students commented that there needed to be more case studies available to enable interaction with an even greater range of pathologies.

Some students did not manage to engage with the simulator until after they had already spent time in clinical practice mastering the basic skills of scanning. In some cases this was due to clinical departments being reluctant to let their students spend time out of the clinical department; in others the students viewed the simulator as another hurdle to master in their learning process, rather than a facility which would enhance their clinical practice learning. There was a tendency for these students to wait until much later in their course to use the simulator and to then interact with the simulator just to fulfil the requirements stated by the tutors, without retaining an awareness of how this would enhance their clinical practice. Students and their clinical departments need to be encouraged to realise the benefits of time spent using the simulator in the early stages of their training. This would help to ensure they book time on the simulator at the beginning of their training and realise that, rather than being an additional burden during their training, it is more beneficial for students if used early in the training period. This is an area where maybe tutors need to be more insistent with students to

ensure they do book time on the simulator, as often it is not until the end of their training periods that students realise the benefits that could have been obtained.

The suggestions from the participants for improving the ways in which the simulator experience can be enhanced, provided useful insights. Several students and mentors commented on the logistical problems associated with booking time on the simulator when competing with numerous other students also requiring access. This was a particular problem for students travelling from further afield when trying to organise their simulator sessions to coincide with lecture days at the university, in order to reduce travel time. Whilst every effort was made to give these students priority, it was not always logistically possible to accommodate all requests. This is unfortunate, as most students would have appreciated the ability to book usage of the simulator at more convenient times, and is a problem that will need reviewing to avoid ongoing issues. In addition, ergonomic aspects of using the simulator need to be addressed. With some students spending a whole day working on the simulator, height adjustable stools and benches are needed to avoid the development of musculoskeletal disorders. Ideas for technical developments for the simulator have been forwarded to the manufacturers.

As in the previous study undertaken in 2013 (18) this project confirmed that students in the early stages of their training found the opportunity to practise scanning without having to consider potential patient discomfort, particularly advantageous. Students reported that being able to separate tasks was beneficial so that, for example, they could concentrate on scanning technique and locating anatomical structures, without having to simultaneously consider activities such as communicating with the patient. Most felt that on reflection, they needed to have used the simulator more extensively before interacting with real patients.

Comments from many of the experienced clinical mentors in this study suggested that student performance was enhanced by interacting with the simulator. The speed of acquisition of skills appeared to be increased, and this was of particular benefit to busy departments and training staff. Those mentors whose students had spent time on the simulator prior to scanning patients noted a marked improvement in their initial performance with patients, compared with experiences with previous students who had not been given the opportunity.

Simulation has the capacity to offer sonography students opportunities to practise skills in a controlled, safe environment (31), and to improve patient safety whilst helping to achieve fitness to practise (32, 33). The primary aim of simulated learning should be to prepare the student for practice in the real clinical setting and there is therefore a need to understand to what extent the learning can be transferred to practice settings. Whilst further research is needed to assess the effectiveness of ultrasound simulation in achieving clinical learning objectives and competence, this study demonstrated several useful insights from students and their mentors in determining some of the benefits and limitations of this learning technique. Simulation provides an opportunity for learning where students can be supported to consider the integration of theory into practice, without the pressures that inevitably occur in a clinical department. Additionally, simulation can potentially offer a range of opportunities not always available in clinical practice. Limitations of this study include potential interviewer bias, however, acknowledging this at the beginning of the study enabled this to be kept to a minimum by the interviewer (19).The results from this study demonstrated that there does appear to be validity in teaching psychomotor skills using a designated simulator, in a context where time and repeat practise can be manipulated to meet the needs of the student, but there are questions as to its value in terms of the overall clinical experience.

Conclusion
Simulation as an effective pedagogy is gaining momentum at all levels of healthcare education. The literature however, shows diverging views on the role of simulated based learning in healthcare, and further evaluation is needed to explore the quality of learning opportunities offered, and their effectiveness in the preparation of students for clinical practice. This study was undertaken to explore ways of effectively integrating simulation into sonography training to enhance clinical preparation.

Simulation was positively evaluated by the majority of the students and mentors in this study. The findings confirm that ultrasound simulators provide positive learning opportunities in a risk- free environment, which reduces stress for the student, and potential harm to patients. Confidence levels were increased, thereby improving future clinical scanning experiences for both the student and their patients. Busy clinical departments acknowledge the advantages of opportunities for students to acquire basic psychomotor skills in a classroom setting, thereby avoiding the inevitable reduction in patient throughput which results from clinical practice training. The limitations of simulation equipment to support the development of the full range of clinical skills required by sonographers, were highlighted, and suggestions made for more effective integration of simulation into the teaching and learning process. Simulation should therefore remain as one component in a larger picture of education, and there is a need to ensure effective integration of technology with clinical practice, and professionalism. The primary aim of incorporating simulation into sonography education should always be to improve patient safety whilst helping to achieve fitness to practise.

Ultrasound simulators have the potential to enhance and transform sonography education. However, continued research needs to be undertaken in order to develop appropriate strategies to support students, educators, and mentors in order to effectively integrate this methodology, and maximise the advantages of the simulation experience.

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