SONOGRAPHY

ORIGINAL ARTICLE

Skill development of beginner sonography students using high-fidelity simulators: Initial experiences

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Abstract

Background: The training of Australian sonographers is shared between accredited course providers and clinical training providers. Scanning skills are mostly developed in a real-life setting environment by the clinical training provider. Sonographer training is burdensome on clinical training providers due to increasing service delivery demands. Accredited course providers should therefore investigate innovative methods of skill training that can be undertaken outside of the clinical environment.
Aims: This report evaluates four sonographer skill development activities for novice students that used high fidelity ultrasound simulators.
Results: All students reported positive experiences and outcomes of simulator based learning activities and believed that simulated skills development sessions help them develop scanning skills. Students perceived their skills level after simulation sessions to be at levels where they could scan in a real clinical setting with supervision levels ranging from moderate to no assistance. Supervisor ratings ranged from students being able to scan with large amounts of assistance to being able to scan with minimal assistance. A self-directed learning package was introduced which was well received by students.
Conclusions: The results of the evaluations of the reported simulated learning activities are promising for a self-directed and student centered learning curriculum to be 'wrapped' around the use of high fidelity simulators to develop student skills in the early stages of training.

Introduction

In Australia, sonographer training is shared between accredited course providers and clinical training providers. Manual scanning skills and normal pattern recognition are underpinning skills for sonographers and need to be developed in the early learning period. These skills are mostly developed in real-life environments with the guidance of a clinical training provider. Increasing demands of service delivery on clinical training providers is making it challenging for them to dedicate time to quality sonographer training. It is therefore timely for accredited course providers to investigate practical training curricula using simulators that can prepare students for real-life scanning outside of the clinical training environment. New high-fidelity simulators are now available, which simulate real-time ultrasound scanning that have the potential to develop manual scanning skills and sonographic pattern recognition, particularly in the early learning period.

This report summarises the evaluations of four sonographer manual skill development activities using high-fidelity ultrasound simulators that were undertaken with students who were commencing their clinical training.

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Conflict of interest: None.

Methods

Setting

In our education institution, we deliver an accredited external sonography course to students from diverse geographical locations. Theoretical course components, including image interpretation, are delivered online and augmented with optional on-site workshops. We rely on clinical training providers to develop the student's practical scanning skills. In 2013, we acquired three high-fidelity Vimedix ® simulators (CAE Healthcare Inc, Montreal Canada), which we planned to use to for development of the manual scanning skills required by students for obstetric and abdominal examinations. The simulators consist of a mannequin, dedicated computer, high-definition monitor and a simulated transducer (Figure 1). The high-definition monitor has a dual display, which can simultaneously display 3-dimensional real time simulations of an anatomic model synchronous with a simulated ultrasound image. The Vimedix ® simulator has been shown to develop clinical sonography skills in medical doctors and students across a range of clinical scenarios.[1–3]

We collected evaluations from four discrete skills development activities that used the simulators: 1) faculty led interactive one day workshop; 2) clinical supervisor led focused skill development sessions; 3) self-directed online learning package; and a 4) faculty led one day focused skill development sessions. All skill development activities using the abdominal simulator were undertaken by students who were commencing sonography training, and activities using the obstetric simulator were undertaken by students commencing clinical training in obstetric sonography. All faculty and clinical supervisors involved in learning activities were accredited medical sonographers. All activities were evaluated using open and closed questions on standardised feedback forms. The activities in this report met the criteria of our institution for evaluation activities that did not require ethical approval.[4]

Skills development activity 1

A faculty led interactive one-day workshop focused on abdominal scanning for beginning sonography students. The workshop introduced basic ultrasound terminology and

Figure 1 Vimedix ® simulators (CAE Healthcare Inc, Montreal Canada).

and skills in image interpretation and manual scanning. An initial didactic presentation covered sonographic terminology, artefacts, image orientation, recognising normal and pathologic appearances and transducer manipulation. After the presentation, students were divided into two groups who rotated between an image interpretation learning station and a practical skills learning station. The practical skills learning station implemented the Vimedix® simulators, supplemented with some live scanning practice. Both learning stations were enabled with group discussion

Skills development activity 2

Focused skill development sessions were led by clinical supervisors in response to promotion by the faculty of the free availability of the simulators for both clinical supervisors and students to use. Four clinical supervisors provided non-standardised focused skill development sessions for students ($n = 7$) in the initial stages of obstetric sonography training at the supervisors workplaces. There was a maximum ratio of two students to one clinical supervisor in these sessions, with some student learning occurring without supervision. All clinical supervisors chose to use the sessions to develop the obstetric scanning skills of students. There was a lack of consistency between different sessions because clinical supervisors tailored the learning sessions to their own teaching styles and the learning needs of their students. The simulators were the primary learning tool, supplemented with discussion and image-interpretation activities.

Skills development activity 3

The faculty developed a self-directed learning package that students could access through the online learning management system. Students accessed online modules prior to attendance on campus. The modules were lessons covering sonographic terminology, scanning planes, describing and interpreting images and transducer manipulation. The online lessons were image rich with explanatory text. A video demonstration was also provided for the transducer manipulation lesson. Students accessed the simulators on campus at their own convenience and used an iPad with internet connectivity to access a simulated abdominal scanning module. This module led the students through skills development activities on the simulators at a self-determined pace (Figure 2). The activities focused on asking students to replicate schematic anatomic images and simulated sonographic images that had been previously produced on the simulators. Faculty staff did not supervise these sessions but were available for assistance on request by the students. Evaluations were received from three students.

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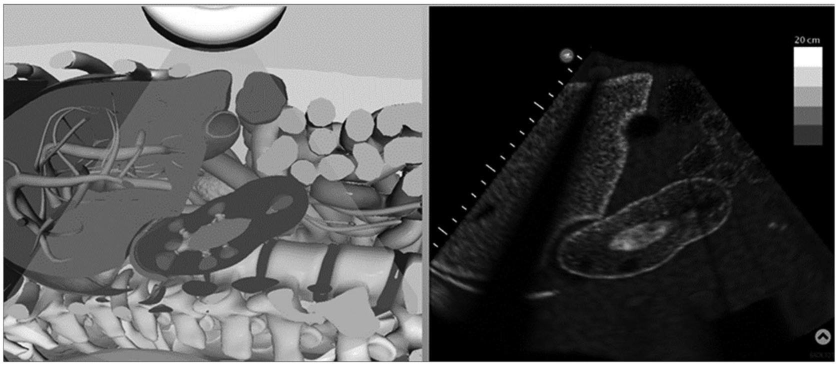

Figure 2 Example of image on online learning module. Students worked through a series of images, which they replicated on the simulator.

Skills development activity 4

A one-day faculty led skills development session was held with five students just prior to them starting their clinical training. Students prepared for the session by accessing modules from the self-directed online learning package prior to workshop attendance (described in Skills development activity 3). Learning activities focused on manual scanning skills to fully assess abdominal organs were led by faculty staff. Optimisation of equipment settings was not included in the workshop. During the first half of the workshop, the simulators were introduced to students, with demonstration of scanning manual scanning techniques to assess abdominal organs. Two simulators were made available for the five students to practice the skills. During the second half of the workshop, students were introduced to two ultrasound machines and used peer scanning to practice skills in a more authentic setting than what the simulators offered. Faculty staff were available to provide feedback and answer student questions throughout the workshop, and to assist with optimisation of images in the second half of the workshop.

Evaluations were sought from students and from clinical supervisors who assessed the student's ability in the clinical training setting up to 2 weeks after the workshop.

Results

Skills development activity 1

Eighteen students from across Australia participated in the workshop and provided feedback on a Likert scale questionnaire (Table 1). Nine students had no previous scanning experience, five students had been exposed to less than 6 months of clinical scanning and four students did not indicate their scanning experience.

Evaluation questions focused on student satisfaction. Students were satisfied with the quality of the workshop and their learning outcomes. They made suggestions for similar workshops on image optimisation, image recording and more real-life scanning activities. Neutral ratings were recorded for evaluation questions relating to the level of difficulty of the workshop.

Skills development activity 2

All sessions were directed on obstetric scanning. Two supervisors and five students provided feedback. Prior real-life clinical obstetric scanning experience of the students ranged from 10 to 24 hours. The simulator was used for manual skills training for 3–5 hours by four students and for 20 hours by one student. Evaluation questions focused on the potential of the simulators as a skill development tool.

Table 1 Evaluation results for Skills development activity 1 (faculty led interactive one day workshop)

Evaluation Question	Strongly agree (*n*)	Agree (*n*)	Neutral (*n*)	Disagree (*n*)	Strongly Disagree (*n*)
The material presented was appropriate to my level of training	13	3	2	—	—
The material presented was relevant to my learning needs	11	7	—	—	—
The difficulty level of this workshop was appropriate	12	4	2	—	—
I found the simulator activities useful	14	3	—	—	—
I found the image viewing activities useful	16	1	—	—	—
The workshop increased my confidence in my ability to scan	10	8	—	—	—
I accomplished the objectives of this workshop	8	9	1	—	—
I will be able to use what I learned in this workshop	9	9	—	—	—

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Responses to open-ended questions revealed that simulator training was valuable in assisting students to appreciate anatomy, pathology and orientation of scanning planes. Supervisors and students believed that the simulator could be used to develop and assess manual skills even though authenticity scores for the simulators attracted some responses of less than 'real' or 'very real'(Table 2).

Respondents thought that manual skills could be developed to a level where students could undertake real-life scanning with minimal to moderate supervision, using a combination of supervised and unsupervised learning (Table 2). Students liked the low-pressure setting where questions could be freely asked without disruption to the care of a real patient.

All students and supervisors thought that simulated skills development sessions had potential to reduce clinical training time. Reductions were expressed in hours (5−15), or as a halving of training time or as a reduction in the time taken to scan a real patient (up to halving patient scan times).

Skills development activity 3

Two of the students who provided feedback had no scanning experience, and one student reported only 1 hour of scanning experience plus observation. Students engaged in on-campus self-directed simulator training for periods of 1–4 hours. All three students used the simulators with the aim to orientate themselves to real-time images and develop scanning techniques. All students reported the learning package was easy to use, it facilitated easy navigation of the simulator, and they thought that after the self-directed training that they could scan a patient with minimum assistance.

Skills development activity 4

All students thought that using the simulator was very effective or effective in preparing them for real-life scanning skills. Students self-rated their skills level after the workshop, informed by their perception of how much supervision they would need to scan a real patient. Similarly, clinical supervisors observed the students in the clinical setting and rated the students within 2 weeks after the workshop. Comparisons of the student self-ratings against the supervisor ratings are demonstrated in Table 3. Four students (students 1,3,4 and 5) received ratings from two supervisors, and no clinical supervisor ratings were available for one student (student 2).

Student self-ratings ranged from being able to scan with moderate assistance to being able to scan with no assistance. Supervisor ratings ranged from students being able to scan with large amounts of assistance to being able to scan with minimal assistance.

There were 70 comparisons of student and supervisor ratings available from assessments across nine skill areas. There was agreement between student and supervisor rating in 23 instances (32%). Where there were disagreements; a supervisor rated higher than the student in seven instances (10%), a supervisor rated one level lower than the student in 27 instances (39%), a supervisor rated two levels lower than the student in 11instances (16%) and a supervisor rated three levels lower than student in two instances (3%).

The supervisors rated the students as requiring no assistance in one instance (1%), moderate to minimum assistance in 57 (81%) instances and a large amount of assistance in 12 (17%) instances.

Table 2 Evaluation results for Skills development activity 2 (focused skill development sessions led by clinical supervisors)

Evaluation Question	Rating				
How effective is the simulator in preparing the student for real life scanning skills?	Not effective at all	Not very effective	neutral	Effective S (3/5), CS (1/1)	Very effective S (2/5) CS (1/1)
Is the scanning experience real on the simulator?	Not real at all	Somewhat real	Neutral S (2/5)	real S (3/5), CS (2/2)	Very real
What skill level can be achieved using the simulator?	No skills	Lots of assistance required	Moderate assistance required S (3/5), CS (1/2)	Minimum assistance required S (2/5), CS (1/2)	competent
Is supervision required if a self-directed learning approach is used?	Not at all	Yes (minimal supervision) S (4/5), CS (2/2)	Yes (half time supervised) S (1/5)	Yes (lot of supervision)	

KEY: Student responses; S (n), Clinical supervisor responses; CS (n)

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Table 3 Evaluation results for skills development activity 2 (student and clinical supervisor rating comparisons)

Skill	Student	Skills level				
		No skills	Scan with large amount assistance	Scan with moderate assistance	Scan with minimum assistance	Scan without assistance
Scout scan	1				x√√	
	2			x		
	3				√	x√
	4				√√	x
	5			√	x	
Scan Pancreas	1		√	x√		
	2			x		
	3			√	x√	
	4			√	x√	
	5			x√√		
Scan Aorta	1			x√	√	
	2				x	
	3				√√	x
	4			√	x√	
	5			x√	√	
Scan Gall bladder	1			x√	√	
	2				x	
	3				√√	x
	4			√	√	x
	5			x√√		
Scan CBD	1		√	x√		
	2			x		
	3		√	√	x	
	4			√√	x	
	5		√√	x		
Scan Portal vein	1		√	x	√	
	2				x	
	3		√	√	x	
	4			√√	x	
	5			x√		
Scan Liver	1		√	x√		
	2				x	
	3		√√			x
	4			√√		x
	5		√√	x		
Scan Kidneys	1			x√	√	
	2				x	
	3			√√		x
	4			√	√	x
	5			x√√		
Scan Spleen	1			x√	√	
	2				x	
	3			√	√	x
	4			√√		x
	5			x√√		

Key: green shaded cells represent where there was agreement in skills rating between student and supervisor, x; student self rating, √; clinical supervisor ratings.

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Discussion

Our vision has been to use high-fidelity simulators to provide opportunities for sonography students to develop foundation manual transducer manipulation and image interpretation sonography skills in a safe and non-threatening environment prior to their first clinical experience. High-fidelity ultrasound simulators have potential to reduce clinical training times and the costly supervisory burden on clinical training sites. Simulated training also has potential to reduce patient examination times for examinations performed by students or trainees and limit the use of human models in ultrasound skills training.[5] However, there is not a large or reliable evidence base to justify the use of high-fidelity simulation in sonography education. According to Sidhu *et al*.,[6] a body of evidence is most likely to build where simulation education is developed concurrently with existing curriculum and robust evaluation. This paper reports on evaluations on learning activities that have been in tandem with existing curriculum and provided preliminary information to guide the design of future curriculum and associated rigorous evaluation.

All students who participated in the simulation skills development activities were in the beginning stages of skill development and were developing the manual skills and pattern recognition skills required to sonographically assess anatomic structures. Acceptance and satisfaction was high, with no negative responses. Neutral comments relating to the level of difficulty were received for the faculty led interactive one-day workshop. This activity included students from the widest range of student experience level (0–6 months) and most likely represents a mismatch between the assumed prior knowledge of the workshop and the learners' conceptions. It is important therefore in future curriculum to set learning objectives appropriate to the student level, which should be standardised as much as possible across the group. Neutral scores were also reported for authenticity of the obstetric simulator and were probably due to the simulator not replicating a mobile fetus. All students believed that learning on the simulators would result in a reduction of their clinical training time and would decrease the time it would take them to scan a patient.

Students perceived their skills level after partaking in simulation sessions to be at levels where they could scan in a real clinical setting with supervision levels ranging from moderate to minimum assistance. There were also responses where students who had undertaken the faculty led one-day interactive workshop who believed they could scan with no supervision. These results imply good confidence levels of students. As there is no correlation between confidence and clinical performance,[7,8] we sought feedback from the clinical supervisors after observing and supervising the students in the clinical setting. Supervisors rated the students for their ability to assess specific body regions (organs) in real patients. The majority of these assessments rated the student as being able to scan the specific body organ with moderate to minimum assistance. The comparisons between student and supervisor evaluations were mostly in agreement or disagreed only by one skills rating level. Where there was disagreement, the supervisors mostly gave lower ratings than the student. This could be explained by the students rating themselves after a simulated experience, whereas the supervisors rated the students after real clinical experiences. This highlights the step up in level of difficulty from simulated learning to the clinical learning setting and the importance of the role of clinical training.

We introduced a self-directed learning package that was well accepted by students. This learning package consisted of an online series of tutorials focusing on basic image interpretation concepts, which could be accessed off campus. This approach has been successful with medical students who developed image-interpretation skills using self-directed electronic modules.[9] Students then accessed the simulators on campus and used an online tutorial on an iPad, which directed them through exercises in image acquisition. This approach was informed by feedback by supervisors and students that supervisor led sessions was not required for all of the learning. It was also founded on the supposition that simulators could be used by students to develop their skills at their own pace without time pressures and without risk and inconvenience to a patient. We also thought it to be a cost sustainable model as supervision requirements are minimal.

The evaluations in this report do not provide strong evidence that high-fidelity ultrasound simulated learning is more effective or efficient than clinical training because of limited responses and lack of a rigourous research design. However, the findings are encouraging, particularly as training times on the simulators were not very long. Further development of a scaffolded curriculum integrated with clinical training is likely to improve student satisfaction and the achievable level of skills.

The evaluations give us confidence to develop a standardised curriculum using high-fidelity simulators, delivered external to the clinical environment, and which could develop the manual scanning and image-interpretation skills to a level where students could scan in a clinical setting with moderate to minimum supervision. This approach could relieve some training burden from clinical sites and offer less risk and inconvenience to patients. A standardised and focused curriculum can be more effective than clinical training,[3] which relies on an opportunistic case mix that is often not congruent with student ability. In clinical training, students may spend

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valuable learning time on activities that are not suited to their knowledge and skill level.

We propose that a self directed learning curriculum that is scalable and student centred can be 'wrapped' around the simulators. A similar approach has also recently been reported in echocardiography training.[10] Scanning of live models could also be used to overcome deficits in simulator authenticity. Another approach would have students working in pairs for practical sessions to provide peer support, which can translate into positive outcomes for student confidence and improved clinical skills.[11,12] Self-directed learning would be augmented with supervised sessions allowing trainers to demonstrate skills, provide guidance in self-directed learning activities, assess skills and to provide debriefing and feedback according to the good practice principles of simulated learning.[13] While our evaluations were limited to development of manual scanning skills and normal pattern recognition, high-fidelity simulators could be integrated in learning activities addressing pathology recognition, image optimisation, systematic examination, examination documentation, communication and interprofessional learning. Simulated learning can be structured using approaches that are less resource intensive than the early stages of clinical training where there is one to one supervision.

The success of future simulated curriculum for beginning sonography students will depend on rigorous evaluations from clinical supervisors who can validate that these students are at a skills level where they can practice within a clinical environment with moderate to minimum supervision.

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