A survey of Australian sonographer psychomotor teaching practices

Delwyn Nicholls[1,2], **Linda Sweet**[3,1], **Jon Hyett**[4,5] and **Amanda Müller**[1]

[1]College of Nursing and Health Sciences, Flinders University, Adelaide, South Australia, Australia
[2]Sydney Ultrasound for Women, Sydney, New South Wales, Australia
[3]School of Nursing and Midwifery, Deakin University and Western Health Partnership, Burwood, Victoria, Australia
[4]Sydney Institute for Women, Children and their Families, Royal Prince Alfred Hospital, Sydney, New South Wales, Australia
[5]Discipline of Obstetrics, Gynaecology and Neonatology, Faculty of Medicine, University of Sydney, Sydney, New South Wales, Australia

Abstract

Objective: To report on the findings of a survey of sonographer skill-teaching practices in Australia using the SonoSTePs tool.
Method: A cross-sectional survey of all qualified sonographers registered with the Australian Sonographer Accreditation Registry.
Results: The 528 responses showed the use of a two-step skill-teaching approach to teach scanning skills and the incorporation of additional instructional practices to support a learner's initial acquisition of scanning skills, which include: providing coaching and guidance as the skill is practised; performing physical guidance; providing immediate error correction; and providing end-task feedback. Based on our findings, sonographer skill-teaching practices fall short of best pedagogical approaches.
Conclusion: There is a pressing need to identify the optimal pedagogical approaches to teach complex psychomotor scanning skills. Research is required to ensure that the scanning skills are taught efficiently and that the pedagogical approaches to teach scanning skills foster the learner's long-term retention of the skill. There is also an accompanying need for sonographers involved in teaching scanning skills to have knowledge of the motor-learning theories and principles related to teaching a complex psychomotor skill.

Keywords: cognitive load, integrated task practice, psychomotor skill, teaching model, ultrasound.

Introduction

Complex psychomotor skills are required to perform an ultrasound examination[1] and there is very little theory or practice evidence about how these skills are taught in the workplace. There is a lack of research, in Australia or globally, about how the sonography profession teaches the psychomotor scanning skills required in clinical practice. Without this baseline knowledge about current teaching approaches being used, there can be no process of critical review and improvement. At the commencement of this research, there was educational literature about skill-teaching models for teaching psychomotor skills; however, none of these had examined the teaching and learning of ultrasound. In the two-step model (also known as the master-apprentice model), the educator provides a verbal description of the theory and skills steps as they demonstrate the skill, followed by the learner practising the skill and receiving feedback.[2] The three-stage motor skill acquisition model includes a cognitive stage where the learner develops a mental picture from demonstration, an associative stage where practice occurs, and an autonomous stage where consolidation occurs.[3] The four-step model is based on three demonstrations (one silent, one narrated by teacher, one narrated by learner) followed by performance session by learner.[4] The five-step model builds on the four-step model with the addition of the first step of motivating the learner by presenting them with concepts and goals of the skill.[5] Given these varied models, it was unclear which was being used in Australia to teach ultrasound. To address this deficit in knowledge, a survey tool was purposefully developed to collect data about sonographer skill-teaching practices, labelled SonoSTePs.[6,7] The aims of this research were to: (i) determine the approaches being used by sonographers to teach scanning skills, (ii) identify what pedagogical approaches described in the motor-learning literature are being used by sonographers to teach scanning skills and (iii) explore whether

Correspondence to email l.sweet@deakin.edu.au
doi: 10.1002/ajum.12223

heuristic instructional approaches were being used to teach psychomotor scanning skills.

Methods and Materials

A national cross-sectional survey was undertaken of qualified sonographers registered with the Australian Sonographer Accreditation Registry (ASAR). The SonoSTePs instrument comprised of 25 questions.[6] Three of the questions contained 12 or fewer rating scale items which explored the domains or scales related to teaching a complex psychomotor skill. The instrument was structured into four sections: (i) demographics and professional practice information, (ii) sonographer skill-teaching and feedback practices, (iii) sonographer training and education information and (iv) one question enquiring of the time taken to complete the survey.

The survey was administered electronically using SurveyMonkey™ software. A pre-test was performed prior to dispersing the SonoSTePs survey to ensure that there were no technical issues with accessing and completing the survey. In September 2014, the ASAR administration staff emailed a letter of introduction and a hyperlink to 3151 sonographers (three reminders sent), and the survey remained open for 11 weeks.

A census sampling approach was used to ensure that data was collected from a large and representative proportion of the population. As per the recommendation by Creswell,[8] a sample of at least 350 participants was required to ensure transferability and representativeness. Respondents from Queensland were excluded from this national survey analysis because they comprised the third and final pilot of the SonoSTePs instrument's calibration which has been reported elsewhere.[6] Ethical approval was obtained from Flinders University Research Ethics Committee (No. 5584). Participation was voluntary and anonymous.

All collected data were downloaded into Microsoft Excel, checked for completeness and then imported into SPSS (Statistics for Windows, version 25.0.) for descriptive and comparative statistical analysis. Frequency distributions and means were calculated for Likert-scale questions. Responses to open-ended questions were analysed using content analysis.[9,10]

Ethical Approval

The study was approved by the Social and Behavioural Research Ethics Committee at Flinders University, Adelaide, Australia (SBREC project number 5584). No trial registration required. Participants recruited September to December 2014. Consent was assumed by completion of the survey.

Results

A total of 595 participants commenced the survey; however, three responders did not complete any of the survey questions and were deleted from the dataset. Therefore, 592 (19%) participants completed the online survey. Sixty-four responses were excluded because a third, or more, of the rating scale questions were not answered. Therefore, 528 responses were included in this analysis. The number of participants who responded to each question varied, due to skip logic. For all Likert response tables, the seven-point rating scale frequency distribution has been condensed to three options. The category 'do' corresponds to the categories of 'often', 'nearly always', and 'always', while, the category 'do not' corresponds to the categories of 'never', 'rarely', and 'infrequently'. Values in **bold** indicate the most common responses.

Demographic information

The percentage of respondents reflected the distribution of the qualified workforce in 2014[11] (see Table 1).

The demographic and professional practice experience of the respondents is summarised in Table 2.

This shows the average respondent was approximately 46 years of age, female, worked full-time in private practice, worked in New South Wales, had a Graduate Diploma of Ultrasound and performed general ultrasound scans.

Qualifications in education theory and practice

Given the survey was about teaching practices, we explored participants' informal and formal teaching preparation in two separate questions. Most respondents (76%) reported that they had not undertaken any specific training (e.g. 'train the trainer course') in clinical education. Content analysis of open-text responses from those who had undertaken specific training (n = 97) shows the following distribution of courses: a clinical supervision course (n = 50); a 'train the trainer' course (n = 18); a level four certificate in workplace training and assessment (a vocational training certificate) (n = 5); and an assessors' course to examine students completing the Diploma of Medical Ultrasound (n = 3). The text responses specified that the education had been provided by private teaching companies or by professional organisations such as the Australasian Sonographers Association (ASA) or Australasian Society for Ultrasound in Medicine (ASUM) as masterclass courses, at annual national conferences, or dedicated weekend/day workshops. Regarding formal training, 38% had completed tertiary

Table 1: Number of qualified respondents of the four largest Australian states.

Australian state	Per cent of national workforce invited to complete the survey (*n*-3151, 2014)[7]	Per cent of respondents who participated in the survey
New South Wales	45%	43%
Victoria	28%	26%
Western Australia	11%	11.5%
South Australia	11%	9%

Table 2: The demographic and professional practice information of the participants.

Variable	Category	Number (*N*=)	Percentage (%)
Age (years)	21–75 years; mean 45.6 years		
Gender	Female	401	78
	Male	114	22
Type of practice	Public practice	165	32
	Private practice	302	58
	Hospital	17	3
	Equal public/private	21	4
	Other combinations	16	3
Hours of employment	Full-time	263	50.50
	Part-time	234	45
	Other combinations	24	4.50
Type of ultrasound scans performed	General	283	54
	Cardiac	111	21
	Obstetrical and gynaecological	65	12.50
	Vascular	33	6
	Paediatric	9	2
	Breast	8	1.50
	MSK	5	1.00
	Multiple areas	8	1.50
	Not employed in a clinical capacity	3	0.50
Ultrasound qualification	Graduate Diploma	266	50.50
	Diploma of Medical Ultrasound-ASUM	167	32
	Grandfathered	35	6.50
	TAFE certificate in ultrasound	5	1
	Master of Ultrasound	34	6.50
	Doctorate	6	1
	America Registry of Diagnostic Medical Sonography	7	1
	Others	12	1.50

Table 2. Continued

Variable	Category	Number (*N*=)	Percentage (%)
Location of employment	New South Wales	227	43
	Victoria	135	26
	Western Australia	59	11.50
	South Australia	48	9
	Tasmania	11	2
	Australian Capital Territory	11	2
	Northern Territory	8	1.50
	Multiple states	5	1.00
	Queensland	2	0.50
	New Zealand	15	3
	International location	3	0.50

TAFE refers to a College of Technical and Further Education.

qualifications in education. Those who completed a formal course had a Graduate Diploma in Health Education (23%), graduate certificate (5%), masters by coursework (4%), masters by research (2%), doctorate (2%), Bachelor of Education (0.2%) and 2% preferred not to answer.

The reported pedagogical approaches to teach a psychomotor scanning skill

The primary teaching practices used by respondents are shown in Table 3. Given the high prevalence of assessing learners' prior knowledge, demonstration with narration,

Table 3: The main reported skill-teaching practices.

Teaching practice	% Do	% Sometimes	% Do Not	Response count
Use a skill-teaching model	23	19	**58**	509
Assess prior knowledge	**86**	9	5	522
Provide silent real-time demonstration	38	16	**46**	517
Repeat demonstration-verbalising steps	**86**	8	6	520
Repeat demonstration: learner verbalises steps-educator demonstrates	35	21	**44**	517
Learner verbalises steps and performs skill	**48**	20	32	522
Immediate error correction	**79**	15	5	520
Guidance and coaching	**92**	7	1	519
Physical guidance	**65**	20	15	485
Short skill practice	**64**	21	15	514
Long skill practice	40	17	**43**	517

Table 4: In-task feedback practices while teaching a scanning skill.

Teaching practice	Do %	Sometimes	% Do Not %	Response Count
Guidance and coaching	**92**	7	1	519
Physical guidance	**65**	20	15	485
Provide feedback during skill performance	**51**	29	20	482
Limit feedback in the presence of the patient	**65**	26	9	481

Table 5: End-task feedback practice following teaching a scanning skill.

Answer options	Do %	Sometimes %	Do Not %	Response count
Provide feedback at the conclusion of a skill performance?	**83**	12	5	484
Deliver feedback using a model to guide delivery and content?	13	17	**70**	479
Ask for an overview of skill performance or how they felt they went?	**47**	27	26	483
Learner identifies what was done well and why?	**47**	27	26	483
Educator states what was done well and why?	**83**	12	5	483
Ask the learner to identify what could be improved and how?	**60**	21	19	481
Educator identifies what aspects of the skill performance could be improved and how?	**81**	14	5	481
Educator provides a summary of skill performance and identifies areas for learner to focus on?	**68**	17	15	479
End feedback session with positive comment(s)?	**93**	6	1	481

error correction with guidance and coaching, and skill practice, these results suggest that a two-step master–apprentice model was being used to teach psychomotor scanning skills. The duration of the supervised practice sessions varied. Content analysis of the open-text responses indicated that a dominant factor for use of longer practice sessions was the unpredictable nature of the clinical space and the ad hoc opportunities to teach and practice scanning skills. Long practice sessions were encouraged to compensate the learner for lost practice opportunities.

In-task and end-task feedback

There were varied ways in which participants provided in-task and end-task feedback when teaching psychomotor scanning

Table 6: Approaches used by sonographers when they first teach multi-part and complex scanning skills to learners.

Teaching practice	Do %	Sometimes %	Do Not %	Response count
Teach whole skill in one session	25	30	**45**	488
Break a task down before teaching it	**66**	21	13	485
Teach a sub-part of the task	**61**	26	13	484
Progressively practices sub-tasks until whole-task practice is achieved	**65**	21	14	480

skills. In-task feedback practices are shown in Table 4. The most prevalent approach is guidance and coaching.

End-task feedback practices are shown in Table 5. Most respondents (94%) reported that they do or sometimes provide verbal feedback to their learners. The majority of the respondents (70%) reported that they did not use a feedback model to deliver end-task verbal feedback.

Limiting cognitive load

Approximately two-thirds of the respondents reported that they used three instructional approaches that were intended to limit the effects of cognitive load when teaching and learning complex psychomotor skills and 45% reported using one approach also to limit cognitive overload (see Table 6).

Simulation to teach psychomotor scanning skills

Again, there were some discrepancies in reporting the use of simulation. Overall 18% of respondents stated in response to one question that they used simulation (defined as plastic manikins, animal models, simulated, or standardised patients) when teaching students and/or colleagues. However, when asked a different question on the same topic, 5% of respondents stated they sometimes and 4% do used phantoms, and 30% sometimes and 42% do use staff members as models to teach scanning skills.

Respondents were asked to explain why they did or did not use simulation to teach scanning skills. Content analysis of 31 open-text responses showed the benefits of simulation including: (i) communication is uninhibited and does not require censorship; (ii) it enables scanning skills to be isolated and purposefully practised; and (iii) there is a limited role for commercial simulators to teach scanning skills. Some respondents stated that the venue in which they worked had no access to phantoms, that they found them too unrealistic, or created poor practices. The majority of comments related to teaching with human beings.

Discussion

The demographics and work practices of the respondents closely matched the workforce data and are therefore representative of the age, gender, imaging streams, professional practice, place of work and the educational preparation. These results suggest that the cohort of sonographers who responded to this survey were representative of the larger population of Australian sonographers. Despite all respondents recognising their teaching role and practices, only 24% had undertaken informal education and 38% formal education in how to be an educator. Understanding best pedagogical approaches is important for clinical educators.[12] Learning how to teach is a different skill set to being an expert clinician, and without training in education practices, it is common for clinicians to teach in the manner they were taught,[12] often without critique or contemporary best practice. In this study, we surveyed Australian sonographers to try and elicit what pedagogical approaches were used to teach psychomotor scanning skills. As shown in Table 7, there are differing instructional approaches for each of the three stages related to teaching a complex psychomotor skill[13] and the performance of these by the majority of respondents is shown.

Stage one

This study showed that the majority of respondents considered cognitive task analysis and established the learner's prior knowledge and skills. It is well known in the education literature that educators who have progressed to a master or expert level become automated; therefore, they may no longer need to pay attention and think about the skill sub-parts and steps needed to perform the task.[41] Consequently, when expert educators teach a psychomotor skill they may inadvertently and unknowingly omit some of the steps needed to perform the task. Sullivan et al.[18] found that expert gastrointestinal specialists left out 50% of the steps needed to execute the skill if they did not identify beforehand the steps used to perform a colonoscopy examination or perform cognitive task analysis. Clark et al.[14] concluded that cognitive task analysis improved the completeness and accuracy of the surgeon's recollection and description of the task steps when they taught a surgical skill. Therefore, the limited literature on this area of skill education suggests that there are tangible teaching and learning benefits from the educator identifying the skill sub-parts and steps

Table 7: Comparison of findings with the published skill-teaching models.

Stages to teach and learn a psychomotor skill	Instructional steps to teach a psychomotor skill proposed by authors from the motor-learning domain	Step included in two-step or traditional approach	Step included in four-step- authored by Walker and Peyton[4]	Step included in 11 step model by Nicholls et al.[13]	Skill-teaching steps reported by the respondents with a frequency of >51% of the time
Stage one: Prior to teaching the skill	Educator performs task analysis[14-19]	✗	✗	✓	✓
	Establish learner's prior knowledge and skill level[12,20]	✗	✗	✓	✓
	Pre skill conceptualisation of what the skill execution involves, looks, sounds, and feels like. Contra-indications of when not to perform the task are taught.	✗	✗	✓	Question not asked in the SonoSTePs instrument
Stage two: The steps required to teach a psychomotor skill	Silent demonstration - learner observes[3,4,21,22]	✗	✓	✓	✗
	Demonstration - verbalisation of skill steps by the educator[2,4]	✓	✓	✓	✓
	Learner verbalises the skill steps- prior to the educator executing the skill step(s)[4]	✗	✓	✓	✗
	Learner verbalises the skill steps prior to executing the step[4]	✗	✓	✓	✗
	Immediate error correction of learner's verbalised or executed skill steps[23-26]	✗	✗	✓	✓
	Educator provides guidance and coaching[27-29]	✗	✗	✓ limit	✓ Provide
	Educator provides physical guidance[30-32]	✗	✗	✓ limit	✓ Provide
Stage three: Skill practice and feedback	Learner intentionally practices the skill[2,4,22,33-37]	✓	✓	✓	✓
	Educator provides post-skill execution feedback[22,34,38-40]	✗	✗	✓	✓

before it is taught. This aspect was reported as being reasonably well done.

The type and amount of information that is taught to a learner in any one session should be limited.[42,43] Nearly two-thirds (66%) of the respondents reported that they broke a scanning skill down into discrete sub-parts before they taught it and this reported behaviour aligns with the pedagogical approaches used to reduce a learner's cognitive load. Nearly two-thirds of the respondents (61%) reported that they taught each sub-part before progressing to the next skill part. Approximately two-thirds of the respondents (65%) identified that they encouraged learners to progressively practice skill sub-parts together until whole-task practice was achieved. However, other survey results contradict these reported practice behaviours, since a large majority of the respondents (55%) reported they teach the whole scanning skill in one teaching session. It is unclear if this occurs all the time or just some of the time. Nevertheless, teaching a whole scan in one teaching session, when the skill is novel and the learner has limited prior learning of the skill, should be avoided. This is because the quantity and the density of the information that is required to be processed by the learner's working memory may exceed its capacity.[27,42,44] This places the learner into cognitive overload, and when this occurs, the learner's skill acquisition progress becomes impeded.[27] Chunking information enables the learner to grasp the cognitive and procedural knowledge to perform the task, and helps retain motivation and promote confidence.[45]

Stage two

Stage two of teaching a psychomotor scanning skill involves demonstration of the steps performed by the sonographer to teach the skill and to provide immediate error correction (while also limiting guidance and coaching) when the learner is first acquiring and performing the psychomotor scanning skill.[13] The purpose of performing the skill demonstration is to illustrate the standard for performance of the task and to convey the motor movements that are required to perform the skill.[3,21,22] While 86% of respondents reported that they used demonstration and narration, less than half perform a silent skill demonstration, or asked the learner to describe the skill steps prior to demonstration by the educator or themselves. The benefits of providing multiple demonstrations, both silent and narrated, are as follows: to enable the learner's visual neural tract to focus on the motor movements linked to the skill[13]; to provide a mental model or schema of the skill in real time, so the learner is able to identify when the skill looks, feels, or sounds right[13]; and to narrate the components in the correct order for performance.[13] Published skill-teaching models specifically point out that the first skill demonstration should be performed silently,[4,5,13] to allow the learner to observe the skill steps without dividing their attention between viewing the task performance and listening to the verbal narration of the learner.[26,27] It is well accepted that a minimum of four demonstrations is preferable when learning a new skill.[4,13]

The provision of error correction feedback involves making the learner immediately aware of their verbalised or executed mistakes while the skill is being rehearsed and/or practised.[23,24] During the early stages of skill acquisition, the creation of an error-free mental schema to execute the skill is reliant upon the learner encrypting the motor map in their brain without mistakes.[25,42,46] Most respondents (79%) provided immediate error correction when teaching. The provision of error-correcting feedback is essential as the learner does not yet have the ability to detect and/or fix their skill errors.[25,26] The corrective feedback may be in the form of verbal instruction to the learner[28] or through the educator physically adjusting the transducer or the machine controls.

Guidance and coaching provide verbal or nonverbal[28] sensory information to the learner about the motor movements needed to execute the skill. The purpose of this in-task feedback is to convey to the learner an understanding of the magnitude and combination of the motor movements used. The majority of the participants (92%) used guidance and coaching to support a learner's skill acquisition. Furthermore, 65% used physical guidance, or hand-on-hand scanning. Brown et al.[47] explain that transducer manipulation was one of the most difficult scanning skills to teach novices. Most educators had difficulty describing the large and small motor movements that were required to guide the transducer to obtain specific images of cardiac structures[47]. Sonaggera[32] found that sonography students valued having hand-on-hand scanning to direct them to the correct acoustic window or to convey the transducer movements that were needed to image the organ. It is known that motor skills with three or more dimensions are difficult to explain and describe verbally or visually.[13] This may explain why many sonographers use guidance, and coaching with physical guidance, to support a learner's skill acquisition. Physical guidance can provide the learner with kinaesthetic understanding of the type, timing and magnitude of the motor movements required to execute the skill.[28]

Verbal coaching and physical guidance are forms of in-task feedback.[27,29,48] When asked about providing in-task feedback, only 49% thought they did this, suggesting some confusion about the pedagogical impact of different feedback practices or misinterpretation of the question. When simple skills are being taught, in-task feedback should be limited to only error-correcting feedback, which limits reliance upon the coaching while executing the skill.[5] Prolonged provision of in-task feedback and support enhances the learner's skill performance in the short-term, but degrades their long-term learning and recall of the skill.[49,50] The in-task feedback for complex skill development can be provided in the early stages of skill acquisition but this should be faded over time.[37,48] The optimal timing of this fading is unknown and warrants research.

While respondents declared teaching occurred mostly in authentic clinical practice, the majority of respondents (83%) reported that they did not use simulation or simulative aides to teach scanning skills. Until recently, many of the available phantoms lack the ability to accurately represent the challenges associated with scanning in a real-world context. However, 42% said they asked learners to practice on staff members – the latter being a form of simulated learning. Teaching psychomotor scanning skills using simulation provides the opportunity for uninhibited and uncensored communication between teacher and learner. In front of a patient, educators must exercise discretion and caution about what and how much information they share about practise performance with the learner. Pedagogical approaches on how best to do this have been described.[51] The use of staff members enables practice on an authentic human body without the need for censored communication (but can lead to conflict if pathology is identified) and should be used with caution. Simulation offers the learner the ability to learn sub-parts of the larger skill, with increasing complexity, also referred to as scaffolding.[13]

Stage three

Stage three relates to intentional practice[34] of a skill, and end-task or terminal feedback.[22,40] Deliberate skill practice is essential to learn psychomotor scanning skills.[33,36,37] The skill practice format used will either advance or hinder the learner's acquisition of the psychomotor skill. This study found that up to 64% of the respondents use short sessions of skill practice of less than 60 min duration, while 42% used long sessions of more than 60 min duration. There is a small body of literature which suggests psychomotor skill acquisition is fostered through the use of more frequent and spaced practice sessions[22,35,37] of shorter than 60 min in duration[37,45,46,52]; however, this work is not specific to ultrasound.

A learner's psychomotor skill acquisition is facilitated by the provision of end-task, or terminal, verbal feedback.[22,34,39,40] Verbal feedback should be based on the direct observation of the practice performance and involve a two-way exchange of information between the learner and the educator.[38,53-55] The survey results showed that the majority of the participants provide unidirectional information about the practice performance, with only 47% asking the learner how they thought the skill practice went, and 47% asking the learner to identify aspects of performance that they did well and why. These practice steps are essential to the learner's continuing skill development and advancement as help to build capacity of self-evaluation. There are many models which can be used to guide end-task feedback; however, 70% of the respondents reported that they do not use a feedback model. The practices performed by the respondents reflect two of the four steps that Pendleton et al.[54] recommend: stating what was done well and what could be improved. Molloy[56] found physiotherapist educators similarly had a one-way 'conversation' with their learners which did not foster the learner to reflect on their skill practice.

Strengths and limitations

The survey instrument was purposively designed and extensively validated. While we had a 19% response rate, the total sample included over 500 sonographers whose demographic profile reflected national workforce statistics, and this makes the findings generalisable. While there were variable response numbers to each question, none went below 480. The use of an anonymous online survey eliminated any interview bias and no time-limits enabled unpressured responses. The use of Queensland data in the validation process, and as a result the need to subsequently exclude this state in the final survey, limits this from being a national survey. This paper has presented the primary quantitative data. A second paper will present the qualitative responses. Lack of shared understanding between educational language in the survey and sonographers' knowledge of these may have influenced the findings. It is, however, acknowledged that the survey was based on self-reported information. The limitations of self-reported data are well known and have been previously described.[8,56]

Conclusion

Based on our findings, sonographer skill-teaching practices fall short of best pedagogical approach. While research into best practice is ongoing, there are published recommendations which would foster learners' long-term skill retention. This research has shown that the main instructional approaches being used by the participants to support a learner's initial acquisition of scanning skills are the use of stage one activities, in addition to the master/apprentice model where the educator provides a verbal description of the theory and skills steps as they demonstrate the skill, followed by the learner practising the skill and receiving feedback. Using the two-step model may not be the optimal instructional approach to teach a complex scanning skill.

There are three reasons why this approach may be suboptimal. First, using one skill demonstration may not visually communicate all the motor movements that are needed to perform the skill. Several skill demonstrations may be required by the learner to understand the sequence and magnitude of the large and small motor movements needed to perform the skill. Therefore, when only one skill demonstration is used by the educator, other pedagogical approaches maybe needed to ensure this procedural knowledge is known and understood by the learner. Second, the amount of information that is concurrently taught when the skill steps are described and demonstrated may exceed the finite capacity of the learner's working memory and place them in cognitive overload. Third, the use of a narrated skill demonstration requires the learner to split their attention between two visual sources of information and the auditory information being simultaneously communicated and conveyed to the learner. This practice, when the skill is large and complex, may cause the learner to experience cognitive overload. Most respondents reported that they provided unidirectional end-task feedback to the learner, rather than a two-way exchange of information with the learner. There was also a high number of respondents who taught a whole task at once or had long practice sessions, both of which are unlikely to produce optimal outcomes for learners. These findings do not fit with the 11-step model that has been proposed to address these educational concerns[13] and warrant further research.

There is a pressing need to identify the optimal pedagogical approaches to use to teach complex psychomotor scanning skills. Research is required to ensure that the scanning skills are taught efficiently and that the pedagogical approaches used to teach scanning skills foster the learner's long-term retention of the skill. There is also an accompanying need for sonographers involved in teaching scanning skills to have the knowledge of the motor-learning theories, principles and pedagogical practices related to teaching a complex psychomotor skill. These two outcomes are relevant and important for all users of ultrasound imaging in Australia and across the globe.

Acknowledgements

This work was unfunded. We would like to thank the Australian Sonographer Accreditation Registry for their support in this research.

Authorship Statement

We acknowledge that (i) the authorship listing conforms to the journal's authorship policy, and (ii) that all authors are in agreement with the content of the submitted manuscript.

Please note: the first author, Ms Delwyn Nicholls wrote the first draft of this manuscript in the form of a thesis chapter in her PhD. She has since passed away, and the manuscript is being submitted posthumously. We acknowledge this is primarily her work with the support and supervision of the co-authors. The final manuscript was prepared by Prof Linda Sweet from Ms Nicholls' PhD thesis.

Funding

No funding information is provided.

Disclosure Statement

No disclosure.

Author Contributions

Delwyn Nicholls: Conceptualization (lead); Data curation (lead); Formal analysis (lead); Investigation (lead); Methodology (lead); Project administration (lead); Writing-original draft (lead). **Linda Sweet:** Conceptualization (supporting); Data curation (supporting); Formal analysis (supporting); Supervision (lead); Writing-review & editing (lead). **Jon Hyett:** Conceptualization (supporting); Formal analysis (supporting); Supervision (supporting); Writing-review & editing (supporting). **Amanda Müller:** Formal analysis (supporting); Methodology (supporting); Supervision (supporting); Validation (supporting); Writing-review & editing (supporting).

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