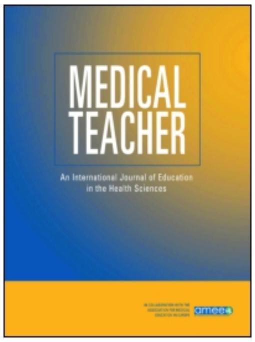

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Teaching psychomotor skills in the twenty-first century: Revisiting and reviewing instructional approaches through the lens of contemporary literature

Delwyn Nicholls[a,b], Linda Sweet[a], Amanda Muller[a] and Jon Hyett[c,d]

[a]Faculty of Medicine, Nursing and Health Science, Flinders University, Adelaide, Australia; [b]Sydney Ultrasound for Women, Sydney, Australia; [c]RPA Women and Babies, Royal Prince Alfred Hospital, Sydney, Australia; [d]Discipline of Obstetrics, Gynaecology and Neonatology, Faculty of Medicine, University of Sydney, Sydney, Australia

ABSTRACT
A diverse range of health professionals use psychomotor skills as part of their professional practice roles. Most health disciplines use large or complex psychomotor skills. These skills are first taught by the educator then acquired, performed, and lastly learned. Psychomotor skills may be taught using a variety of widely-accepted and published teaching models. The number of teaching steps used in these models varies from two to seven. However, the utility of these models to teach skill acquisition and skill retention are disputable when teaching complex skills, in contrast to simple skills. Contemporary motor learning and cognition literature frames instructional practices which may assist the teaching and learning of complex task-based skills. This paper reports 11 steps to be considered when teaching psychomotor skills.

Introduction

Teaching health practitioners the core psychomotor skills required for clinical practice remains an ongoing challenge in the twenty-first century. Most psychomotor skills are unique to each discipline and are required to perform specific clinical practice roles to deliver competent patient care. These skills are first taught using a stepped instructional approach and then acquired, performed, and learned by the student. A learned skill is retained beyond the practice period; it can be recalled and executed competently in a variety of clinical settings (Kantak & Winstein 2012). In the twentieth century, motor learning theorists posited the steps to teach and learn a manual task or psychomotor skill (Fitts 1962; Simpson 1966; Fitts & Posner 1967; Gentile 1972; Harrow 1972). Subsequently, several authors have published models which are permutations of these enduring theoretical principles (Payton 1986; Walker & Peyton 1998; George & Doto 2001). The primary tenet of the skill-teaching literature asserts that skills are best learnt using a sequenced and stepped teaching approach. This dogma guides the method used to teach either a simple or complex manual task. However, the majority of skills used by health professionals are complex. For the purposes of this paper, we suggest a complex task comprises more than seven skill elements. Multi-part tasks are difficult to teach, learn, and be retained by the student. A retained skill can be recalled and executed by the learner beyond the practice period (Kantak & Winstein 2012). The published models continue to be used to teach both simple and complex skills in the health disciplines, despite the dearth of evidence ascertaining their effectiveness.

The efficacy of using a stepped instructional model to teach psychomotor skills continues to be debated. When using the five-step George and Doto (2001) model to teach a simple dental skill, Virdi and Sood (2011) reported that after one skill attempt, novices were able to perform the task. Furthermore, Wang et al. (2004) found that the Walker and Peyton (1998) four-step model enhanced simple skill acquisition by the fourth year medical students, to learn a simple interrupted stitch. In contrast, some studies have been unable to report improved learning outcomes, such as skill acquisition and retention, when using a skill teaching model to teach a moderately complex or complex skill. Archer et al. (2015) compared skill teaching models involving two steps, four steps, and a modified five step approach to perform manual defibrillation of a manikin with ventricular fibrillation, and identified no significant differences in skill acquisition and retention after two months. These findings corroborate studies which similarly explored the use of the four-step skill teaching model to teach complex skills such as: laryngeal mask airway insertion (Orde et al. 2010), needle cricothyroidotomy (Greif et al. 2010), and gastric tube insertion on a manikin (Krautter et al. 2011). A paucity of evidence, however, on skill teaching and learning outcomes limits meaningful analysis and interpretation of the data. Nevertheless, there is a suggestion the four-step and

> **Practice points**
>
> - Five points to teach a complex psychomotor skill.
> - Don't teach a whole complex skill in a single session.
> - Task analysis involves breaking down a skill into knowledge and skill sub-parts.
> - Limit verbal input throughout skill practice.
> - Correct all skill errors immediately as they occur.
> - Use multiple short practice sessions to develop a skill.

CONTACT Delwyn Nicholls dnicholls@sufw.com.au Sydney Ultrasound for Women, 321 Kent St, Sydney, NSW, Australia

five-step models have limited utility to assist skill acquisition and retention when teaching large and complex tasks.

A review of contemporary motor learning literature shows that there are silos of knowledge and research which serve to inform and modify the mechanistic steps used to teach psychomotor skills in the twenty-first century. These instructional processes are relevant when teaching large and complex skills and they include: cognitive task analysis or breaking down a large or complex skill into component knowledge and skill parts well in advance of the teaching session (Phipps et al. 2008; Jabbour et al. 2011); restricting the number of skills taught in any one teaching session to limit the effects of cognitive overload when learning a *new* skill (van Merriënboer & Sweller 2010; Young et al. 2014; Leppink & Heuvel 2015); dissuading educator guidance and coaching to a learner during skill practice and rehearsal (Walsh et al. 2009; Leppink & Heuvel 2015); providing immediate error correction when a skill is declared (verbalized) or practiced incorrectly (Kovacs 1997; Kantak & Winstein 2012); providing multiple short skill practice opportunities to ultimately learn the skill components (Foy & Evans 2009; Wise & Willingham 2009; DeBourgh 2011); and lastly ensuring that the learner receives skill practice feedback or knowledge of results at the conclusion of an observed skill performance (Ende 1983; Poole 1991; Walsh et al. 2009). An integrated instructional model to teach multi-part psychomotor skills, one which results from weaving contemporary teaching principles into the theoretical principles, may prove in the longer term more effective, than current approaches, to teach the complex psychomotor skills required for clinical health practice.

This paper reviews the historical steps which underpin psychomotor skill acquisition and learning, and evaluates these in the context of more contemporary literature, with the aim of re-defining the rationale and instructional approach used to teach complex psychomotor skills for clinical practice.

Teaching a psychomotor skill

The skill teaching models currently used in clinical practice are based on long-standing and widely accepted motor learning theory originally posited by Fitts (1962) and thereafter Simpson (1966), closely followed by Fitts and Posner (1967). These authors and others concur that psychomotor skills are acquired in stages using a sequenced skill teaching approach. Over the years, disciplines such as surgery (Kneebone 1999; Hamdorf & Hall 2000; Kneebone et al. 2002; Lake & Hamdorf 2004; Reznick & MacRae 2006), anesthetics (Castanelli 2009), gynecology (Hammond & Karthigasu 2006), nursing (Cornford 1999; Jamison et al. 2006), dentistry (Virdi & Sood 2011), physiotherapy (Payton 1986 cited in Rose & Best 2005), colonoscopy (Raman & Donnon 2008), internal medicine (Ramani 2008), and emergency medicine (Greif et al. 2010) have used teaching models premised on this long standing literature that outlines the tenets of psychomotor acquisition or the motor learning domain. These disciplines use skill teaching models with a variable number of skill steps to teach manual tasks. The salience of these models in supporting the instructional steps to teach simple psychomotor skills is acknowledged, but so too is the value of the contemporary literature which describes new knowledge that is relevant to teaching a complex psychomotor skill. The process of integrating this literature has resulted in a series of instructional approaches which, we suggest, are applicable when teaching and learning complex psychomotor skills. The steps to teach a complex psychomotor skill (Table 1) are presented through a contemporary lens to explain the rationale for adopting this method of teaching a complex skill. The next section will explore each of these skill steps in more detail.

Task analysis and cognitive load awareness

When developing a process to teach a new skill, it is important to remember that cognitive load theory emphasizes the limitation of the working memory when learning complex tasks (Sweller 1993). The instructional approaches an educator can use to limit cognitive overload include: undertaking task analysis (Phipps et al. 2008; Jabbour et al. 2011), limiting the number of skills taught in any one teaching session to a range of five to nine (van Merriënboer & Sweller 2010; Young et al. 2014), and limit dividing the learner's attention between two concurrent information sources (Leppink & Heuvel 2015).

Unlike long-term memory, working memory is finite and limited in capacity (van Merriënboer & Sweller 2010; Young et al. 2014). This limitation has ramifications when teaching large or complex skills because the working memory quickly becomes overloaded when the volume of information being taught in one session is large or the duration of attention required to learn the task is lengthy (Leppink & Heuvel 2015). While teaching a complex skill, working memory can become overloaded when: the task is novel and therefore the brain must concurrently process multiple sources of information (theoretical, visual, auditory and tactile elements); the learner's attention is divided between learning the skill and processing extraneous information provided by the educator, or the task is multi-part and they are taught in one session (Young et al. 2014; Leppink & Heuvel 2015).

Task analysis—also referred to as cognitive task analysis (Jabbour et al. 2011)—is one instructional approach the educator can perform, to limit cognitive overload (Leppink & Heuvel 2015) to improve the performance of technical skills and equipment handling for complex tasks (Sullivan et al. 2007; Jabbour et al. 2011). This strategy involves breaking a large or complex skill into sub-parts (Phipps et al. 2008; Jabbour et al. 2011) and then further dissecting each sub-part into a range of five to nine discrete items (van Merriënboer & Sweller 2010; Leppink & Heuvel 2015). As a guide, van Merriënboer and Sweller (2010) subscribe to teaching no more than seven skill steps in any one teaching session and when there are more than this for a sub-component the task should be taught in two parts. This step occurs *prior* to the commencement of the skill teaching session (Sullivan et al. 2007; Phipps et al. 2008; Jabbour et al. 2011). The benefit of performing task analysis is that the information is placed into manageable learning chunks and this has the effect of minimizing the steep learning curve and cognitive demands placed on working memory (Leppink & Heuvel 2015), especially when learning a new and complex psychomotor skill (Hamdorf & Hall 2000; Sullivan et al. 2007; Lammers et al. 2008; Castanelli 2009; Razavi et al. 2010). Leppink and Heuvel (2015) argue that

Table 1. The educational steps required to teach a complex psychomotor skill.

Skill step	Educator behavior
Task analysis and cognitive load awareness	Prior to the skill teaching session, the task or knowledge required to perform the task is broken down into chunks. The steps to teach each skill chunk are itemized and should contain no more than nine sequenced steps (preferably seven) in any one teaching session (refer to diagram 1).
Identifying learner skill level and learning needs	Ascertain learners' needs and prior knowledge and skill level to focus the skill teaching session.
Pre-skill conceptualization (sensory norms)	Describe when and when not to perform the skill. Review *all* key information linked to competent skill execution (including equipment handling) and what the task should look, sound and feel like.
Demonstration—visualization (visual standard of performance)	Educator silently demonstrates the skill with the correct sequence and timing. A silent video clip of the skill may also serve as a synchronous or asynchronous learning tool.
Demonstration—verbalization	Educator repeats the skill demonstration whilst describing the demonstrated skill steps to the learner.
Immediate error correction	Correct all narrated or executed skill errors immediately as they occur.
Limit guidance and coaching	Minimize verbal guidance and coaching. Withhold feedback until the conclusion of the task.
Verbalization–execution	The learner describes the skill steps with the correct skill sequence and timing in advance to the *educator* executing the skill. Corrects incorrectly rehearsed skill step(s) as they occur.
Verbalization–performance	The learner describes the skill steps prior to executing the task steps. Educator withholds feedback.
Skill practice	Skills are developed using multiple, short practice sessions of less than 60 minutes in duration.
Post skill-execution feedback	Educator provides feedback at the conclusion (terminal) of the skill performance.

overloading a learner's working memory results in cognitive overload and the negative effects are compelling. The consequences of not using a teaching approach which limits the effects of cognitive overload are persuasive and include: asynchronous and erratic skill performance, a protracted skill learning time-line, and erosion of a learner's confidence (Blissett et al. 2012; Young et al. 2014).

Performing an early first trimester pregnancy dating scan is one example of a complex psychomotor skill. The task can be broken down into six knowledge and skill sub-parts, as seen in Figure 1. Each sub-component is further deconstructed into discrete task or information elements. The skill steps to each sub-component are taught and learned separately (Aggarwal et al. 2006,2007; Masters et al. 2008a,2008b; Razavi et al. 2010). Over time the skill-parts are practised with increasing order of task complexity and reconstructed together until integrated and whole-task practice is achieved (van Merriënboer & Sweller 2010; Spruit et al. 2014). Therefore, we assert that cognitive task analysis is an important contemporary approach to use when teaching complex skills.

Identifying learner skill level and learning needs

Assessing the learner's prior skill knowledge and experience *before* teaching a clinical skill is an important instructional approach when preparing to teach a complex skill because it avoids repetition and potential disengagement of the learner (Rose & Best 2005; Dent & Harden 2009; Spruit et al. 2014). Raman and Donnon (2008) suggest that adopting this practice benefited both the learner and the educator because it brought clarity to the teaching/learning start point for both parties. Furthermore, Foy and Evans (2009) assert that this practice enables the maximal use of skill-teaching time and avoids over- or under-estimating a learner's ability which can impact upon educational outcomes. Importantly, Faarvang and Ringstead (2006) point out that identifying learners who have been taught a skill incorrectly is another tangible benefit of ascertaining a learner's prior skill practice, knowledge, and experience. The use of open questions to elicit cognitive and task-based knowledge, as well as reviewing log books and asking the learner to perform a simulated skill demonstration, are tools the educator may use to establish prior to skill teaching. We suggest that this is an important precept of contemporary skill teaching model.

Pre-skill conceptualization (sensory norms)

This step occurs prior to the skill teaching session and relies on the learner being taught the information and skill practice norms relevant to performing the task. The unique elements relevant to the skill are reviewed and described by the educator and as an example include: skill protocols, diagnostic criteria, and patient safety; sensory (visual, tactile, and auditory) norms associated with executing the task; equipment handling, care, and safety; and anatomy, physiology, and pathophysiology linked to competent execution of the task. The instructional approach used by the educator to teach the theory linked to understanding and performing a complex skill is also important. Deconstructing the theory into manageable portions (cognitive task analysis), before the task is taught, has two important benefits to the learner: (1) this approach minimizes the cognitive load required to process large volumes of core knowledge which are central to a learner being able to perform the task and (2) avoids the skill steps and information elements being taught concurrently. Teaching a learner how to perform a task whilst overlaying the task with information on how to operate the equipment, for example, is detrimental to the learner. This is because the learner's attention is divided (Leppink & Heuvel 2015) between performing the task and simultaneously processing the incoming verbal information provided by the educator, which results in overloading the working memory and cognitive overload. Leppink and Heuvel (2015) point out that teaching practices which divide a learner's attention should be avoided when teaching a skill.

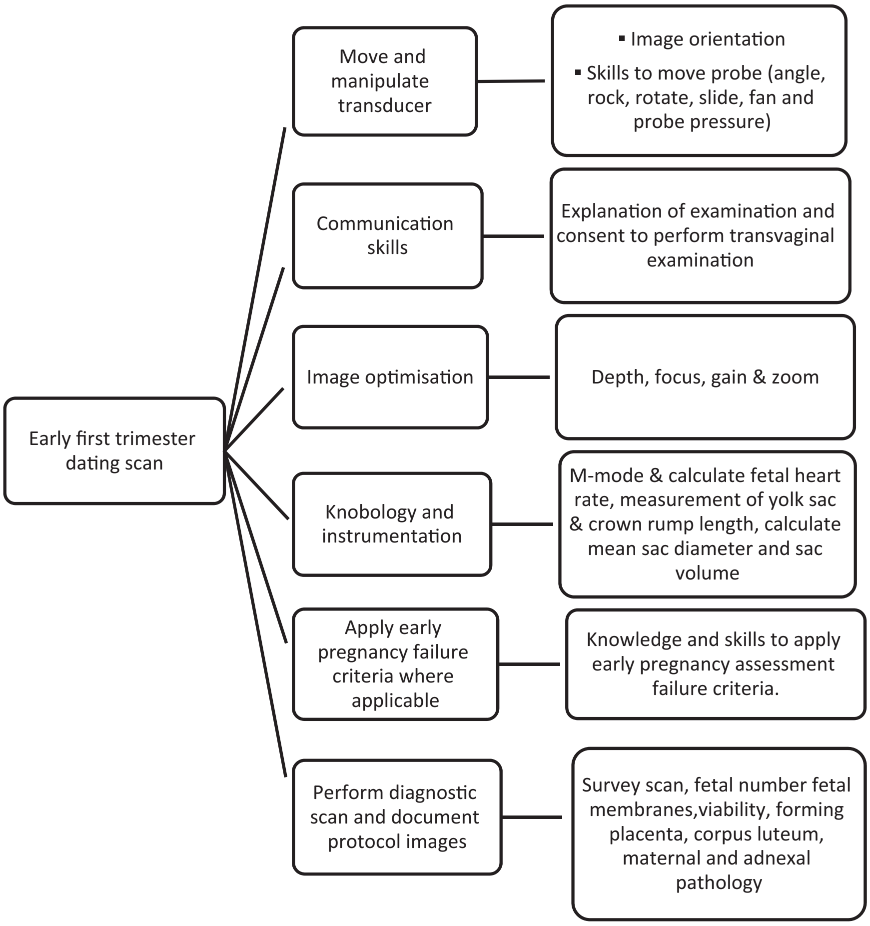

Figure 1. Skill task analysis to teach early first trimester dating ultrasound.

The use of e-learning technologies is one teaching strategy to provide the relevant resources and information required to perform a manual task, before learning the skill, without overloading or overwhelming the learner (Cosyns et al. 2015). An additional advantage of using this technology is that core knowledge and informatics relevant to skill acquisition and performance can be delivered synchronously or asynchronously via these multi-media technologies (Cosyns et al. 2015) at a time and location which is suited to an adult learner's workplace commitments (Dent & Harden 2009) and lifestyle.

Demonstration—Visualization

Teaching the sub-part of a psychomotor skill should *always* commence with the educator performing a silent rehearsal of a predetermined number of task elements. Adopting this instructional technique enables the learner's visual neural tract to focus on the motor movements linked to the skill, without the brain processing additional sensory information, such as auditory or tactile data (Leppink & Heuvel 2015). Cosyns et al. (2015) suggests that a silent video clip of a skill performance which portrays the motor movements and what the skill should look like at the conclusion of each step is a valuable use of e-learning technology to guide complex skill acquisition.

The five-step model by George and Doto specifies that the learner must see a complete skill rendition of the task and this importantly serves as a "….model of performance" or what the skill should look like (2001 p. 577). Additionally, this standard is used by the learner "to self-evaluate their own performance" (George & Doto 2001, p. 578). Furthermore, Cornford (1999) from a nursing perspective, suggests that the primary purpose of a real-time demonstration is to provide a mental model or schema of the skill. This exemplar demonstration serves as a visual standard of performance when learning skills across health disciplines (Milde 1988; DesCoteaux & Leclere 1995; Cornford 1999; George & Doto 2001; Raman & Donnon 2008; Foy & Evans 2009). Cornford (1999, p. 267) asserts that the exemplar should be performed by an expert, and provide both the correct *skill sequence* and *timing*. Additionally, Milde (1988, p. 420), again from the nursing literature, proposes that "in order to diagnose errors a learner must have a template or internalised standard of performance." Error detection by the learner is important when performing a simple or complex skill and relies on knowing the expected or "normal" sensory norms linked to competent skill execution. We suggest, this is important in order to be able to identify when the skill does not "look," "feel," or "sound right." This traditional skill teaching step has thus been further explained in the context of contemporary instructional practice.

Demonstration—Verbalization

After performing a silent rendition of the skill steps, the educator repeats the skill demonstration while simultaneously providing *a brief* description of the task steps being performed (Hammond & Karthigasu 2006; Abela 2009). To be able to demonstrate and succinctly narrate a limited number of skill steps, the educator must, prior to the teaching session: 1) identify the finite number of skills to be taught in the session (task analysis), 2) sequence the task parts (where appropriate) from simple to complex, and 3) identify and limit narration to include only the key points. The models by Walker and Peyton (1998) and George and Doto (2001) recommend demonstrating the task while describing the skill steps. Additionally, George and Doto (2001, p. 578) emphasize during this step to "describe in detail each step in the process." However, Leppink and Heuval (2015) and Young et al. (2014), assert that this instructional approach is deleterious to a learner when acquiring and learning a psychomotor skill for two reasons: 1) the learner's attention is divided between two sources of information (visual and auditory) entering the brain and 2) the volume of cognitive information (a verbose narration) and the duration over which the information is delivered to the brain overwhelms working memory. This is because the duration and the volume of data exceeds working memory capacity when the brain receives information from multiple neural tracts to process concurrently, (Leppink & Heuvel 2015). Providing a skill demonstration whilst briefly narrating the discrete task steps is an important instructional approach to counteract the impact of cognitive or information overload. Therefore, the demonstration—verbalization teaching step (which includes limiting the number of elements taught in any one skill teaching session) is an amalgamation of seminal and contemporary skill teaching literature.

Immediate error correction

It is important that the educator provides immediate error correction of incorrectly rehearsed or executed skills as they occur (Winstein 1991; Winstein et al. 1994; DeBourgh 2011). The purpose of error correcting feedback is to prevent a skill being practised, encrypted, and stored in long term memory with error (Kleim et al. 2004; Kantak & Winstein 2012). An incorrectly learned skill is recalled with error which may result in patient harm (Winstein 1991; Winstein et al. 1994; Kovacs 1997; DeBourgh 2011). Error correcting feedback is advocated and endorsed by authors in dentistry, surgical medicine, and nursing disciplines (George & Doto 2001; Brovelli et al. 2008; Masters et al. 2008a,2008b; Foy & Evans 2009; Roberts et al. 2009; DeBourgh 2011).

Limit verbal guidance and coaching

When teaching a psychomotor skill the communication between the educator and learner should be specifically limited to the skill teaching steps required to learn the task (Winstein 1991; Walsh et al. 2009). Importantly, this is not the time to be engaging in points of clarification with the learner or providing verbal skill guidance or coaching. For highly tactile skills such as medical ultrasound, non-verbal feedback in the form of providing physical guidance may be useful to learn the (sometimes inexplicable) multiple fine and gross motor movements. Given that most ultrasound skills are open and complex and therefore difficult to learn (Nicholls et al. 2014; Scott et al. 2014; Cosyns et al. 2015), non-verbal guidance may be required to move and manipulate the ultrasound transducer. However, this guidance should occur with limited verbal dialogue to enhance the learning potential.

Verbal guidance and coaching from the educator is problematic and detrimental to a learners' skill acquisition for three reasons. First, it takes the learner's focus and attention away from recalling or executing the task (Winstein et al. 1994; Walsh et al. 2009; Kantak & Winstein 2012). Important sensory and tactile information linked to the task are not learned because the learner is focused on the extraneous verbal information provided by the educator, rather than focusing on executing the task (Kantak & Winstein 2012). Second, overlaying a task with verbal guidance may potentially overload the limited and finite working memory, and divide attention while the learner attempts to process multiple domains of information concurrently (Young et al. 2014; Leppink & Heuvel 2015). Third, and most importantly, the skill is learned inclusive of the coaching and guidance provided by the educator, so the student may become reliant upon the educator to complete the task. This phenomenon is known as the guidance hypothesis (Schmidt 1975; Schmidt & Lee 1999; Poole 1991; Walsh et al. 2009; Kantak & Winstein 2012). Therefore, during the skill acquisition phase, when a learner is either verbalizing or executing skill steps, limit guidance and coaching to maximize the learner's skill acquisition potential and always immediately correct verbalized or skill execution errors, at the time they occur.

Verbalization–execution

The next teaching step to psychomotor skill acquisition involves the learner describing the individual tasks before the educator performs the task. The action of describing the sequenced skill steps prior to executing the task components is referred to as "verbalization." This teaching strategy is used by the George and Doto (2001) and Walker and Peyton model (1998) to teach psychomotor skills. While Walker and Peyton (1998) do not explain the rationale for this teaching strategy, George and Doto (2001, p. 577) state "If the learner is able to narrate correctly the steps of the skill before demonstrating there is a greater likelihood the learner will correctly perform the skill." However, neither author provides an explanation as to why this action assists cognition of a psychomotor skill. Educators outside of the health field, Anderson (1997) and Gidley Larson and Suchy (2015) outline that verbalization or self-declarative instruction is an important cognitive strategy when acquiring and learning psychomotor skills. Additionally, Anderson (1997, p. 31) points out that self-instruction provides an opportunity for the educator to "eavesdrop on the learner's thinking" which reveals the learner's knowledge of the skill steps, sequencing, and timing. This is an important step, in conjunction with immediate error correction to encrypt an error free motor map for each skill element. A contemporized psychomotor skill-teaching model must include verbalization or self-declarative instruction as an instructional step skill when teaching task-based skills prior to skill performance.

Verbalization–performance

This steps involves the learner describing the skill steps before performing the task. Verbalization precedes the execution of the skill and this action focuses the learner's attention onto: 1) the skill elements and features when learning a skill routine-expediting acquisition of motor sequences and psychomotor skill accuracy (Sun et al. 2005; Gidley Larson & Suchy 2015) and 2) the important task aspects which assists in skill encoding, encryption, and recall (Cornford 1999; Kray et al. 2010) which are considered more essential than rote learning a psychomotor skill (Gidley Larson & Suchy 2015). When learning a task, verbalization is an important teaching tenet in conjunction with skill performance to guide the cognition of a skill and to create a schema for the skill in the motor cortex. A motor map or schema is required for each new skill being acquired and is a precursor to a skill being moved to long term memory, or being able to be recalled when required.

The verbalization–performance instructional approach is adopted in George and Doto's (2001) and Walker and Peyton's (1998) models to guide psychomotor skill acquisition without explanation. George and Doto (2001, p. 578) assert that the educator should provide "…feedback and coaching as needed." However, the contemporary literature presented in this paper identifies that this practice is deleterious and impedes task acquisition by the learner (Walsh et al. 2009; Kantak & Winstein 2012). Therefore, a contemporized psychomotor teaching model must include the verbalization–performance instructional step while acknowledging the importance of providing immediate error correction and withholding any other verbal feedback or coaching.

Skill practice

Learning a psychomotor skill which is correctly encrypted in the motor cortex is reliant upon both skill practice opportunities and terminal feedback. Ericsson et al. (1993) points out that skills are acquired through diligent practice. Importantly, Kleim et al. (2004) and DeBourgh (2011) identify that the frequency and repetition with which a task is practiced impacts on the encryption of motor maps, and therefore skill retention, recall, adaptation and transfer of learning to other environments (simulation and bedside). A learned skill is capable of being adapted and modified to each clinical scenario (Schmidt 1975; Schmidt & Lee 1999; Wise & Willingham 2009; Kantak & Winstein 2012). Foy and Evans (2009) corroborate the need for multiple short practice opportunities when encrypting the motor map for a skill. DeBourgh (2011) and Kantak and Winstein (2012) argue that long and infrequent practice sessions may deleteriously affect skill encryption. Numerous practice sessions (less than 60 min in duration) and variable task sequence practice opportunities facilitate the process of skill encoding, consolidation and recall (Poole 1991; DeBourgh 2011; Kantak & Winstein 2012; Spruit et al. 2014). Foy and Evans (2009) also assert that skill practise variation is important when learning psychomotor skills and this, we suggest, has implications when using low-fidelity simulation tools where practice conditions are relatively constant, to teach task-based skills. Therefore, skill practice is reliant upon: multiple spaced, short duration, and variable task practice opportunities to promote skill acquisition and long-term retention by the learner.

Post skill-execution feedback

Motor skill acquisition is reliant upon task practice and feedback (Archer et al. 2015). Feedback refers to the unique information provided by the educator to the learner, on an observed skill performance (Schmidt & Lee 1999). The primary goal of feedback is to progress skill performance. Notwithstanding skill rehearsal and repetition, feedback is the single most influential teaching practice to promote motor learning. Psychomotor skill feedback may be intrinsic, derived from the learners' own sensory realm based on the mental model of the skill or extrinsic and provided by the educator after observing the performance (Poole 1991; Winstein 1991; Walsh et al. 2009). Examples of extrinsic feedback include: error correction, concurrent, and terminal feedback. Terminal feedback is provided at the conclusion of an observed skill performance (Poole 1991; Winstein 1991; Walsh et al. 2009) and provides information on the task performance and success (Ende 1983; Salmoni et al. 1984; Walsh et al. 2009; Dent & Harden 2009). The timing and form of feedback are influential to a learner's mental cognition which guides future motor actions.

The Pendelton feedback model (Pendleton et al. 1984) is one tool to structure and sequence motor skill feedback, although the model was not specifically intended for this purpose. Salmoni et al. (1984) point out that educator feedback should be withheld until the conclusion of the skill. This allows the learner to practise whilst focusing on the sensory, motor, and tactile skill elements without receiving a bombardment of verbal information (Salmoni et al. 1984; Schmidt & Lee 1999). Significantly, terminal feedback influences the encryption of correct motor sequences or skill encoding during the acquisition phase (Kantak & Winstein 2012). Terminal feedback which is based on motor skill actions is crucial to effect modification of motor behavior and future practice performance (Salmoni et al. 1984; Poole 1991). The quantity, timing, and type of feedback provided by the educator to the learner during performance of a motor skill is therefore important and may enhance or be deleterious to motor skill learning.

Conclusion

Modern health professionals, as a part of their clinical practice, are required to learn and perform a diverse range of complex psychomotor skills. Motor learning theorists have long posited using a stepped instructional approach to guide skill acquisition. However, recent literature has identified, with regards to skill acquisition and retention, that there is limited evidence to suggest the widely accepted four step (Walker & Peyton 1998) and five step (George & Doto 2001) skill teaching models, have application to teach a complex skill. Despite this, these archetypal tools continue to be used to teach simple and complex tasks.

Contemporary motor learning literature points out that there are important teaching approaches which collectively guide and develop skill acquisition and retention by a learner. However, these steps have not made their way into the skill teaching process. This article presents the instructional steps to teach complex psychomotor skills premised upon seminal and contemporary literature. We have highlighted eleven evidence-based skill teaching approaches that are necessary to teach complex multi-part tasks to ensure that they are learned, both recalled from long-term memory and are resistant to error.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

Notes on contributors

Delwyn Nicholls, BAAppSc (MedRad), GDMedus, DMU (vascular), GDHEd, GCH.Ed, is a sonographer, clinical skill coordinator, and tutor. She has worked as a tutor sonographer for more than 15 years and has lectured extensively on key aspects relevant to skills education and sonographer clinical supervision. Delwyn is a second year PhD student at Flinders University, Adelaide, Australia.

A/Prof. Linda Sweet, BNg, MNgS, PhD, GCEd, is a nurse and midwife with broad experience in many different clinical environments, education, management and research. Whilst working full time in academia, Linda has a strong background in developing clinical educators and interests in improving clinical educational practices to enhance learning.

Dr. Amanda Müller, BA (Hons), PhD, GC (H.Ed), has a bachelor in psychology and a doctorate in English. She has worked as an educator for over 20 years and a major branch of her research involves looking at cognitive approaches to instructional design and language skill learning.

Professor Jon Hyett, MBBS, BSc, MD, MRCOG, FRANZCOG, is a specialist obstetrician in high risk obstetrics and the Head of Department at Womens' and Babies, Royal Prince Alfred Hospital, Sydney. He is a lecturer at Sydney University and a prolific publisher. Jon has a strong interest in obstetric and sonographer education and improving clinical practice outcomes for patient through the many research programs he either co-ordinates or contributes to.

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