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EDUCATION ARTICLE

# Using a clinical decision-making framework to foster sonographer student learning in the clinical setting

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## Abstract

Sonographers in clinical education roles have an important role in developing clinical skills in sonography students. These skills include technical (psychomotor) skills, image interpretation skills and clinical decision-making (CDM) skills. CDM in clinical practice is important for the quality of clinical services. Although, there is well developed and a growing body of knowledge on CDM in the health and medical literature, there is a paucity of information that sonographers or sonography students can draw on to facilitate the development of decision-making skills in the clinical setting. We postulate that a framework or model of CDM can be useful in teaching and evaluating critical thinking and clinical reasoning in sonography students. CDM frameworks can help students and their supervisors organise their learning to solve clinical questions by providing guidance, organisation and sequencing of learning experiences, scaffolding of learning, building of existing knowledge and skills through new real life experiences and promotion of deep learning. This paper outlines and discusses the elements of a CDM framework and how it can be used to in the clinical setting to develop CDM skills and provide a structure for clinical teaching.

## Introduction

Clinical educators (supervisors, mentors, tutors) of sonography students have very important roles in guiding students through their broad and complex clinical learning experiences. The clinical setting offers a learning environment, which cannot be attained in the academic setting as it provides role modelling for professional practice and integrates students into the professional team. It does present some challenges for students because the learning experiences may be unstructured, haphazard and present themselves as opportunities rather than scheduled events. The 'busyness' of a clinical site offers the learner a large number of widely varied cases. This broadens the learning experience although learning in this way is challenging for both the students and their supervisors to manage because the time available for teaching may be limited.

Clinical educators assist students to develop core technical (psychomotor), image interpretation and critical thinking skills. Critical thinking for health professionals is the process of making analytic clinical judgements about what to believe and how to act when their patient presents for diagnosis and treatment.[1] Critical thinking is necessary for accurate and relevant clinical assessment and is important for the delivery of quality clinical services.[2] Most clinical supervisors of sonography students would understand their responsibilities of role modelling and developing the student's practical skills. There is little information available to them to guide in developing this critical thinking and clinical decision-making (CDM) skills or how to link the student's existing knowledge with the practices and culture of the clinical site and professional practice more broadly. The gap between theory and practice can induce student anxiety and have a negative impact on their performance.[3]

The critical thinking that occurs in clinical practice, where knowledge is analysed relative to a specific clinical situation or patient, can also be referred to as 'clinical reasoning' or 'CDM'. There is discussion in the literature about the definitions and constructs of these interrelated terms,[4,5] but in this paper, we choose to use the term CDM. While there is a well-developed and growing body of knowledge on CDM in the health and medical literature,[6–10] there is a paucity of information on CDM in sonography practice. This is surprising in a profession,

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which has an implicit role in many diagnostic scenarios.[11] Reasons for this may relate to the lack of CDM in the formal education of many sonographers or the possible perception that the responsibility of the diagnosis does not lie with the sonographer but with the reporting medical specialist. According to the Australasian Sonographers Association Code of Conduct,[12] sonographers do have accountability around diagnosis, and we would argue that more attention should be paid to the CDM process for sonographers.

Many experienced sonographers believe that CDM is intuitive, but it has been shown that not all sonographers exhibit these skills, and age and experience are not necessarily related to a developed state of CDM skills in sonographers.[13] It has been proposed that CDM is a combined process of intuition (memory of previous experiences) and analysis.[14] Most sonographers would use intuition to deal with common clinical presentations but would defer to a more deliberate and detailed analysis when faced with less common or unfamiliar patient presentations. Students need to approach CDM with more deliberate analysis as their intuition is less developed because of limited clinical experiences.[14,15]

Frameworks for CDM can be used to organise knowledge and to solve clinical problems and have been attributed to accurate diagnosis.[16] This paper discusses the potential benefits of adopting a CDM framework to assist student learning, in the clinical environment and presents a primer for clinical educators to implement a CDM framework into their clinical teaching to facilitate student learning.

## CDM frameworks for teaching sonography practice in the clinical setting

Clinical decision-making frameworks may assist students in the clinical setting by helping them organise and apply theoretical knowledge to the situations they experience and observe and diminish the practice-theory gap.[16] CDM frameworks have been credited with organising knowledge, solving clinical problems and contributing to accurate diagnosis in medical practitioners.[16]

We identified three CDM frameworks for sonographers[17–19]; all of which follow a hypothetico-deductive reasoning model.[10] They each have sequential components and combine deductive and inductive reasoning and objective data to answer a question or formulate an opinion. Inductive reasoning is used to formulate a hypothesis, and deductive reasoning is used to test that hypothesis and draw a conclusion. Baun's framework[17] uses a five component process based on the scientific research process. The framework by Penny and Zachariason[18] is similar but claims a more clinical rather than scientific approach. Sim[19] developed a six component framework adapted from a CDM framework for nurses advocated by Banning 2007.[6] This framework is based on a hybrid approach of hypo-deduction and intuition (pattern recognition informed by memory). Table 1 allows comparison of the different components of each framework using colour coding to illustrate similar components of decision-making across the three frameworks.

The components of each framework include the following:

1. information gathering around the patient presentation;
2. hypothesis generation – the making of a tentative diagnosis based on the information gained in the previous component;
3. sonographic assessment to gather further information; and
4. the combination and cognitive synthesis of previous components to make a sonographic diagnosis.

The framework by Sim[19] adds an additional component where the sonographer reflects and consolidates their learning from the case. By returning to the patient problem, as it was originally presented, they may see how to have better reasoned their way through a situation and gained a better understanding of the patient's condition. This additional component facilitates reiterative problem-based learning,[20] which fosters self-directed learning and motivation so that students can actively evaluate their knowledge and problem-solving skills in a clinical context.

## Experience using a CDM framework

At the University of Auckland, in 2014, a CDM framework[19] was introduced into an academic 12-week intensive ultrasound course, which focussed on the fundamentals of clinical sonography. One of the key learning objectives of the course was for the students to develop CDM competency. A 1-hour weekly tutorial was dedicated to CDM, where students reviewed three request forms of differing patient presentations. As the semester progressed, the clinical scenarios increased in complexity. Embedded within each case study was a mix of cultural and social context, which required students to consider the intricate communication subtleties and the appropriate professional behaviour such scenarios would necessitate. During the first 3 weeks, the tutor sonographer provided role modelling and made explicit the cognitive pathways via the 'thinking aloud' technique and engaged students in CDM discourse.[21] As the students became more familiar with the process, the students then took turn assuming



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**Table 1** Comparison of clinical decision-making frameworks for sonography practice. Similar components across each framework have been designated common colours

| Scientific method (Baun[17]) | Penny and Zachariason[18] | Sim[19] |
|---|---|---|
| Observation (indication for the examination)<br>• Sonographer observations<br>• Clinical information<br>• Patient input | Clinical history<br>• Age, race<br>• Signs and symptoms<br>• Previous diagnostic tests<br>• Pertinent illnesses and past surgical procedures | Pre-encounter data (review information gathered prior to meeting patient)<br>• Request form<br>• Other diagnostic tests<br>• Clinical history provided by other health practitioners<br><br>Encounter data (observe patient, ask questions of patients or relatives)<br>• Patient demographic<br>• Patient input<br>• Sonographer observes patient, performs basic clinical tests |
| Hypothesis (working diagnosis)<br>• Working diagnosis based on information available; may or may not be indicated on referral form | Clinical hypotheses<br>• Educated guess based on the clinical history gathered | Hypothesis generation (consider patient presentation, symptoms, pathophysiology, risk factors)<br>• Generate possible causes for patient presentation, justify requested examination<br>• Tentative diagnosis<br>• Does the tentative diagnosis support requested examination? |
| Data collection (patient assessment)<br>• Sonographer observations<br>• Patient input<br>• Ultrasound examination<br>• Critical thinking is sonographic information obtained adequate, does it need tailoring or altering? | Investigative imaging<br>• Ultrasound examination undertaken with clinical history and hypothesis in mind<br>• Evaluate, identify, demonstrate abnormalities<br>• Modify examination to match the gathered information | Hypothesis driven assessment (conduct examination)<br>• Select scanning technique<br>• What is standard imaging protocol?<br>• Does standard imaging protocol need modifying?<br>• What anatomy needs assessment? |
| Data analysis (diagnostic reasoning)<br>• Reviewing available cues<br>• Tentative diagnosis or technical impression formulated<br>• Gathering data relative to the tentative hypotheses.<br>• Use available data to discriminate between relevant hypotheses, eliminate incorrect hypotheses and reinforce possibly correct ones<br>• Interpretation, or diagnostic hypothesis to isolated the correct ones | Sonographic findings<br>• All imaging findings noted during the examination<br>• Focus on relevant findings rather than incidental findings | Hypothesis evaluation (report findings)<br>• What are the normal findings?<br>• What are the abnormal findings? (sonographic diagnosis)<br>• What findings are relevant? What findings are not relevant?<br>• Do the findings correlate with other information?<br>• What are the limitations of the examination? How confident are you in your findings?<br>• What are the possible alternate diagnoses? |
| Conclusion (sonographic diagnosis)<br>• Combining data cognitively to reach conclusion about a patient's health or specific physical condition | Clinical correlation<br>• Recalling information obtained in previous steps and evaluating for connections<br>• Clinical ambiguity is a common learning challenge, that is, the uncertainty about links between the clinical history and sonographic findings | |
| | | Reflect on clinical decision-making process<br>• Have I assessed what is needed?<br>• Have I answered the clinical question?<br>• Are there any gaps in your knowledge<br>• Are there other aspects on the examination your should consider: consent, communication, adapting technique to different patient presentations<br>• Review current professional ethical standards and protocols |

Blue, information gathering; orange, hypothesis generation; green, sonographic assessment; purple, combination and synthesis of previous components; brown, reflection and consolidation.



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responsibility to share their CDM thought processes for each clinical scenario. The tutorial sessions were dynamic and interactive learning sessions, which included active questioning by students. They aimed to encourage students to adopt a structured, analytical and evidence-based approach to CDM. Students also had the opportunity to learn how to seek and obtain information from patients in a culturally sensitive and professional manner. Focus groups revealed that the students found the weekly CDM tutorials were one of the most useful learning activities in the course. They valued the instantaneous feedback they received during the tutorial sessions but also found the model useful for working their way through the CDM process and for assignment writing (Sim J 2014, unpublished data). This feedback highlights that in the absence of the tutor, the CDM model became important for students. As such, in an unstructured learning environment, such as the clinical workplace the role of the CDM framework may be valuable.

In 2015, at the University of South Australia, the same framework[19] was introduced into musculoskeletal sonography courses. In its first iteration, it was introduced into the assessment of an advanced external course where students were accredited, experienced sonographers with more than 5 years of experience. Some sonographers indicated that while the CDM framework prompted them to reflect on their clinical reasoning process, some believed that they had already developed that skill. There were suggestions that the framework had potential as a teaching tool in the clinical setting and could assist in providing a learning structure for less experienced students who were undertaking programmes to gain accredited sonographer status (Thoirs K 2015, unpublished data). The CDM was then integrated into a case-based face-to-face workshop (2016) with non-accredited students. The workshop students indicated that they enjoyed using the case-based approach integrated with the framework and the systematic framework and process of enquiry that it offered (Thoirs K, 2016, unpublished data).

This feedback has led us to speculate that a CDM framework can be used to assist student learning in the clinical environment, by organising their observations, actions and interpretations and through the use of a consistent and reasoned approach. If using the framework is juxtaposed with case-based learning, in the academic setting, this presents a model of education, which has potential to bridge the theory–practice gap for students.

## Potential benefits to adopting a CDM model in clinical teaching

A CDM framework in sonographer clinical education could offer a learning structure for both students and their supervisors in the busy clinical setting where structured teaching is a challenge. Students could use it to self-manage their learning either through observation or active contribution to patient cases. The framework can be used to identify and prioritise learning, promote reflection and facilitate decision-making and diagnostic thinking processes. It assists in guiding active learning conversations about cases[22] and assists in identifying focussed clinical learning experiences that link closely to academic learning. Wolpaw[20] was able to demonstrate these benefits using a framework for medical students in outpatient clinical rotations. Students reported that by using a framework they felt capable of identifying their own unique learning objectives, which they based on prior rotations and experience. They found the framework easy to learn because it was based on established clinical practice, and they were grateful for the opportunity for focussed and self-directed learning. Their preceptors reported that they enjoyed teaching the students who were engaged and asked relevant questions, which relieved the pressure on the preceptors having to think up learning points to generate an interactive discussion. Similarly, in a study across eight allied health disciplines, it was reported that students who used supervisor generated 'thinking steps' as a structure and framework to prompt their thinking were able to justify and explain their clinical reasoning and decisions and to distinguish between different clinical presentations.[23]

Clinical supervisors, as expert practitioners, may find it difficult to teach CDM, as the reasoning processes they use themselves occurs at an unconscious level and is therefore difficult to pass on to students.[24] A framework may be useful to make those thinking processes explicit to themselves and their students.

## CDM framework

A CDM framework has potential to help clinical supervisors scaffold learning for students. Scaffolding is considered as an essential element of effective teaching and refers to the instructional process where students are progressively led to stronger and deeper understanding and more independence in the learning process by successive removal of learning supports and the additions of new learning challenges.[25] In sonography training, a model of progressive independence[26] is commonly used where students progress from observing examinations, to undertaking the examinations themselves, with reducing levels of direct supervision. Scaffolding needs to be carefully designed so that individual needs of students and opportunities are identified at a particular time.[27] If this is not achieved, then there is a risk that students cannot build on their existing knowledge and fail to meet their



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personal expectations and the expectations of their supervisors. There are two main features of the scaffolding process: 'questions and platforms',[28] which can be used to tailor the learning experiences to the level of the student. The 'questions' are used to steer the learning forwards, and 'platforms' are the supporting structure for the supervisors to ask questions within a context and for the students to guide their responses. The CDM framework can be considered as the 'platform', from which the supervisor can create questions for the student, within the context of any case that presents in the clinical setting. The supervisor can select one or more components from the framework, depending on the stage of the learner and the complexity of the case. For example, one component of the framework can be addressed in isolation in complex cases for novices or addressed as a whole for the more advanced learner.

The preceding discussion profiles how a CDM framework might facilitate effective clinical learning using evidence-based principles, which include a theoretical framework to guide opportunistic learning, systematically organise and coherently sequence clinical instruction, guide the student to develop and build on existing knowledge and skills through new experiences, scaffold the learning, apply learning to real life cases and promote 'deep' learning by organising information for investigation and comprehension.[29]

## A primer for applying CDM to teach sonography students in clinical practice

In this section, we introduce a detailed outline of a CDM framework[19] (Figure 1). This outline adds information about the underpinning knowledge required for each framework component and a series of actions, cues and questions to assist with the interpretation and synthesis of the knowledge in the context of a clinical case. This is a tool for students and will also help clinical supervisors reveal and unpack the 'hidden' elements of their own thought processes using thinking steps.

### Components 1: pre-encounter and component 2: encounter

These first two components focus on information gathering, which involves sourcing information about the patient from patient records and from the patient directly. Students will also consider clinical, cultural, ethical and patient mobility information. Clinical supervisors assist the students in understanding the clinical context of the examination and factors that may impact on the technical approach, safety of the patient and sonographer and the communication approach.

### Component 3: hypothesis generation

In this component, the clinical supervisor helps the student formulate the focus of the examination based on the previous information gathering components. This includes assisting with identifying possible conditions that might exist in the patient and prioritising those conditions based on discriminating clinical features.

### Component 4: hypothesis driven assessment

This component refers to the sonographic examination and how it is conducted. It is informed by previous information gathering and hypothesis generating components and the knowledge of protocols and the equipment that is used to undertake the examination. During the examination, additional information may be collected, which requires the examination technique to be modified. This may occur because of the physical and/or sonographic presentation of the patient. For example, sonographic appearances may be unfamiliar or confusing to the student or the image may be degraded because of body habitus, both of which will require a modified approach. The clinical supervisor's role is to ensure the examination is conducted appropriately and to challenge the student to provide rationales and justifications for the actions proposed.

### Component 5: hypothesis evaluation

In the hypothesis evaluation component, the information from all CDM components is integrated and synthesised to inform the sonographer report. Knowledge and learning cues are provided as prompts for discussions between the student and supervisor.

### Component 6: reflection

In the reflection component of the CDM framework, students self-assess their performance and knowledge, including ethical, cultural or communication issues. With guidance from the clinical supervisor, the student can be encouraged to identify and address unresolved issues by looping back to earlier components of the framework, to identify any gaps in the examination or their knowledge and to devise an action plan to address those gaps.

A CDM framework can be used in both academic and clinical teaching. The teaching of CDM can be used to prepare students for the clinical setting through teaching pedagogies such as case-based and problem-based learning, which are commonly used in academic settings. In the academic setting, the framework can be applied using a structured, controlled and linear approach, but



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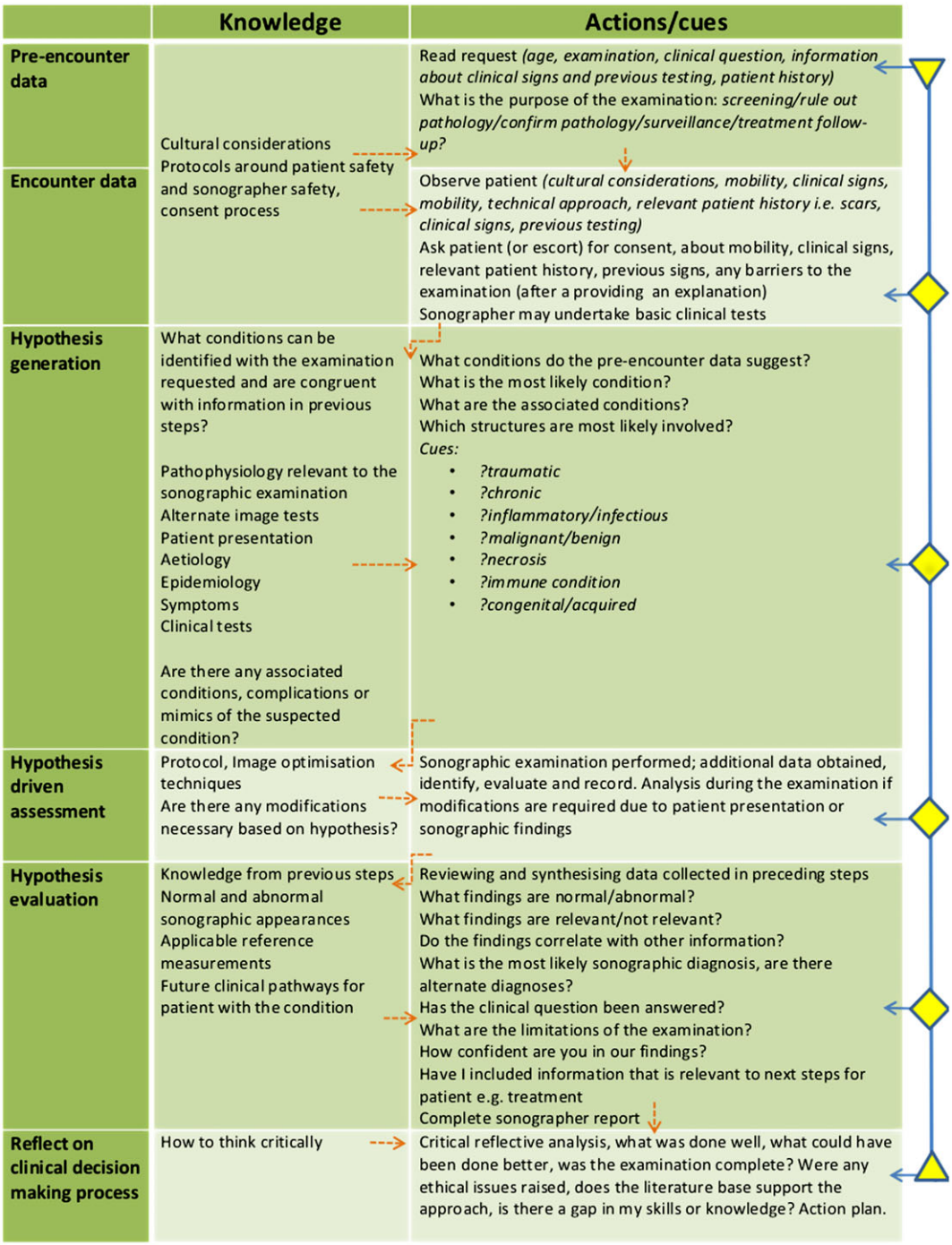


**Figure 1** Components of CDM[19] and associated prerequisite knowledge, questions and cues.

in the more chaotic clinical environment, a more flexible approach may be required, as students may not have developed knowledge that is mature enough to support a complete understanding of what is happening in the clinical environment at the time. Academic and clinical teachers, with a mutual understanding of the framework, can encourage the student to identify their own personal clinical learning goals within the framework, which are aligned to their existing knowledge and skills.

The clinical supervisor can use the framework to progress student learning by reviewing the information that is identified through each step and help the student to categorise, analyse and interpret that information. This will also help the supervisor to identify the level of the



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students' knowledge and skills. Clinical supervisors can use their advanced CDM skills to identify learning opportunities within the CDM framework, which is appropriate to the level of the student and the case complexity.

The novice learner defined by Dreyfus and Dreyfus[30] is rule driven and has limited ability to filter, prioritise and synthesise information. The student will not have many previous experiences to draw on so will therefore be reliant on the CDM framework to build an overall picture of the case. The novice learner will often be observing their clinical supervisor as a role model and also undertake partial or full examinations with close supervision. The clinical supervisor can use the framework during 'observation' to stimulate discussion and reflection about the case, creating an 'active' learning experience. The focus may be on one CDM component in isolation at the beginning of training, and as the student progresses, they work towards integrating further components of the framework. The clinical supervisor can refer the student to the basic knowledge relating to the case at hand and help them to consolidate that knowledge by clarifying what information in the clinical presentation is important and relevant and what is not. Discussion can be limited to a few of the most important or most common hypotheses in context of the case.

The advanced beginner, described by Dreyfus and Dreyfus,[30] has more experience to draw on and is more capable to sort through information to decide what is relevant and what is not. The student requires less support and the clinical supervisor takes on more of a coaching role, where they help the student to understand the more meaningful pieces of clinical information and also consider the less common hypotheses. The student should be encouraged to start integrating the CDM framework as a whole, using feedback loops, which is more aligned to intuition. This means that at times the student will be encouraged to revisit the knowledge and information gained in a previous component to inform their actions with potential for modification. The supervisor can encourage the student to use verbal critical reflection so that they acquire and consolidate knowledge by 'talking aloud'. With continual repetition of this process across many cases, the student will eventually be able to apply these skills independently and have a solid foundation to support continued learning after they have completed their programme of study. The advanced beginner should be undertaking complete examinations with direct supervision that is progressively withdrawn to become more indirect.

The competent student[30] can work across a greater range of patient presentations of increasing complexity with indirect supervision. They will demonstrate responsibility and an emotional connection to patient outcomes. At this stage, the clinical supervisor should hold the student responsible for their CDM. The student will become less dependent on the CDM framework, using their collection of experiences to draw on instead. They will look at their cases as a whole rather than as individual components of the framework.[31]

## Conclusion

Sonographer learning is more than the development of psychomotor (scanning) and image interpretation skills. It also includes CDM skills, which require integrated intellectual learning of a knowledge base relevant to sonographic practice. In this paper, we limited our discussion to developing CDM in sonography students who are seeking accredited sonographer status and how a CDM framework can structure and organise clinical learning for these students and their supervisors. CDM is relatively unexplored in the sonography literature, and there are other aspects to this topic, which could be addressed in future discussions and research. These areas include clinical assessment of CDM, the role of CDM in advanced practice roles and the impact of CDM in sonography on diagnostic accuracy.

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