Exploring the development of clinical reasoning skills among doctors-in-training

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Declaration of ethics

The research presented and reported in this thesis was conducted within the guidelines for research ethics outlined in the *National Statement on Ethics Conduct in Research Involving Humans* (1999), the *Joint NHMRC AVCC Statement and Guidelines on Research Practice* (1997), the *James Cook University Policy on Experimentation Ethics, Standard Practice Guidelines* (2001), and the *James Cook University Statement and Guidelines on Research Practice* (2001).

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Abstract

Clinical reasoning is complex, difficult to conceptualise and learn, and important as it is closely linked with medical expertise. Learning clinical reasoning skills is primarily an unguided and subconscious process for doctors-in-training, and there is a need for an evidence based, explicit approach to support the learning of these core skills. The focus of this research is the process by which doctors-in-training learn clinical reasoning skills within the context of General Medicine in north Queensland. The literature to date has been extensive but has struggled to identify a practical framework for doctors-in-training which clearly supports their learning of clinical reasoning skills.

This program of research investigated four factors identified in the literature as influencing the development of clinical reasoning skills: the metacognitive awareness levels of doctors-in-training; the learning climate of Intern doctors in their first year of clinical work; the influence of Consultants; and the role of Interns as learners.

The first factor was investigated by exploring whether metacognitive awareness correlated with performance in medical undergraduate examinations, and whether there was an increase in metacognitive awareness from the first to the fifth-year of the undergraduate medical course. Volunteer medical students completed the Metacognitive Awareness Inventory (MAI), as well as consenting to give access to their examination scores for this study. For the first-year undergraduate doctors-in-training there were correlations between the Knowledge of Cognition domain of the MAI and their end of year examination results, but not with the Regulation of Cognition domain. For fifth-year students there were correlations between both the Knowledge and Regulation of Cognition domains and their end of year examination results. This study found that the overall MAI scores were not significantly different between first and fifth-year undergraduates in this sample. The Regulation of Cognition domain and its sub-domains, regarded as key factors in clinical reasoning skill development, did not significantly differ between first and fifth-year undergraduate doctors-in-training.

The second factor investigated was whether the learning climate of Intern doctors-in-training was conducive to learning. The validated Dutch Resident Educational Climate Test (D-RECT) was used, and written responses invited to the question *'What three aspects of the junior doctor learning environment would you alter?'* The *Coaching and Assessment* and the *Relations*

between Consultants domains were identified as significantly lower in General Medicine than for other units, triangulating the written comments provided by the Interns.

The third factor investigated Consultant Physicians as role models for doctors-in-training learning clinical reasoning skills. The focus of the semi-structured interviews explored how the Physicians understood clinical reasoning, their understanding of how they had acquired these skills, and the ways they sought to foster these skills among their doctors-in-training. The seven Consultants described their journey to gaining clinical reasoning expertise as being unguided, generally subconscious and seldom discussed. Most Consultants spoke of being unaware of their own journey to gaining clinical reasoning expertise, and did not regard themselves as role models for doctors-in-training. Most Consultants indicated that acquiring clinical knowledge and learning to think about their decision-making processes (metacognition), were crucial for acquiring expertise, but very few Consultants explained how they could intentionally foster these skills.

The final factor was explored by investigating how Intern doctors-in-training understood their own development of clinical reasoning skills. At the start of their General Medicine term, Interns were presented with basic information about clinical reasoning. At the end of that term, participating Interns were interviewed. A paper copy of the presentation given at the start of the term was used to stimulate Intern reflections on their learning during the General Medicine term. The 27 Interns interviewed identified that learning clinical reasoning was a tacit, personal journey influenced by enabling and inhibitory factors. The Interns attributed the differences between their clinical reasoning skills and those of their Consultants as being primarily due to the experience and superior clinical knowledge of the Consultants.

A multi-methods research design was used to answer the research questions across the four studies. The first two factors were investigated using quantitative methods, while qualitative methods were employed for the last two. The multi-methods approach enabled findings from the separate studies to be triangulated, supporting confidence in the trustworthiness of the synthesised outcomes and reducing an over-dependence on any individual study.

The Synthesis and Proposed Framework chapter initially integrates the findings from the four studies to provide an overall understanding of how clinical reasoning skills are currently

fostered in north Queensland. These synthesised results are then used to propose an evidence-based learning model and a method for its implementation at the teaching hospital. The modified Cognitive Apprenticeship Learning Model (mCALM) could help to make expert thinking visible by explicitly supporting constructivist learning practices, metacognitive skills, deliberate practice and a conducive learning climate. The mCALM appears well suited to explicitly fostering the learning of clinical reasoning skills for doctors-in-training in north Queensland.

Abbreviations

Abbreviation	Name
AAA	Acute adult admissions
AHPRA	Australian Health Practitioner Regulation Agency
AMC	Australian Medical Council
CALM	Cognitive Apprenticeship Learning Model
DCT	Director of Clinical Training
DMS	Director of Medical Services
D-RECT	Dutch Residency Educational Climate Test
ED	Emergency Department
FRACP	Fellow of the Royal Australasian College of Physicians
GM	General Medicine
GS	General Surgery
JCU	James Cook University
KFP	Key Features Problems
MAI	Metacognitive Awareness Inventory
MBA	Medical Board of Australia
mCALM	modified Cognitive Apprenticeship Learning Model
MEU	Medical Education Unit
MSAT	Multi-Station Assessment Task
MSOD	Medical School Outcome Database
MTRP	Medical Training Review Panel
OSCE	Objective Structured Clinical Examination
QPMA	Queensland Prevocational Medical Accreditation
RACP	Royal Australasian College of Physicians
RACS	Royal Australasian College of Surgeons
THHS	Townsville Hospital and Health Service
TTH	The Townsville Hospital
WFME	World Federation of Medical Educators

Definitions

Term	Description
Consultant	Fellow of a specialist medical college e.g. Fellow of the Royal Australasian College of Physicians
Doctor-in-training	Refers to medical students and doctors in the first two years of clinical practice
Intern	Medical doctor in their first postgraduate year of clinical work who holds provisional registration with the Medical Board of Australia
Internship	The year of supervised training, accredited by the Australian Medical Council and approved by the Medical Board of Australia, an Intern must complete prior to being eligible for general registration
Learning climate	External contextual factors that may influence learning
Metacognition	Thinking about one's thinking that enables understanding, analysis and regulation of cognitive and decision-making processes
Self-regulated learner	Learners who set goals, devise and implement effective learning strategies, create an effective learning environment, seek feedback and help when necessary, show tenacity as well as self-monitoring and can effectively assess their progress towards specific goals

Publications and presented works

Publications

‘Metacognitive awareness and the link with undergraduate examination performance and clinical reasoning’

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* Supports Chapter 7

‘Learning and teaching clinical reasoning in daily practice’

Ralph Pinnock & Paul Welch

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‘Using the D-RECT to assess the Intern learning environment in Australia’

Ralph Pinnock, Paul Welch, Hilary Taylor-Evans, and Frances Quirk

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Conference Presentations

‘How Consultants understand clinical reasoning expertise – and why it matters’
Paul Welch [Oral presentation]
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‘Teaching and learning clinical reasoning’
Paul Welch, Ralph Pinnock, Louise Young [Pre-conference workshop]
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‘Metacognition as a predicator of clinical reasoning skills in medical students’
Paul Welch, Louise Young, Peter Johnson and Daniel Lindsay [Oral presentation]
Ottawa Conference and International Conference on Medical Education March 2016, Perth WA

‘Grounded theory and the clinical reasoning process’
Paul Welch & David Plummer [Oral presentation]
Australian and New Zealand Association for Health Professional Educators July 2015, Newcastle, NSW

‘The similarities between grounded theory and the clinical reasoning process: an opportunity to develop a coaching framework’
Paul Welch [Oral presentation]
2nd Montreal Conference on Clinical Reasoning October 2014, Montreal, Canada

‘Coaching and learning clinical reasoning’
Paul Welch, Louise Young & David Symmons [Workshop]
Australian and New Zealand Association for Health Professional Educators July 2014, Hunter Valley, NSW

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Chapter 1: Learning clinical reasoning: a scoping literature review

1.1 Background

Clinical medicine is complex and continually evolving. This literature review focuses on a key component of clinical medicine: the development of clinical reasoning skills. For medical knowledge to be clinically useful, it must be synthesised with information gathered from the patient to generate a diagnosis or management plan. Applying medical knowledge effectively is core to clinical practice. Accreditation and training institutions in Australia are increasingly explicit in expecting doctors-in-training to learn clinical reasoning skills (Royal Australasian College of Physicians 2017; Royal Australasian College of Surgeons 2018).

Clinical reasoning is a large and multifaceted construct which is explained and understood variously, depending on the individual's perspective or discipline. Gruppen (2017) likened it to the fable of the blind men feeling the various parts of an elephant, and therefore describing it in very different ways. It is important that doctors-in-training develop clinical reasoning skills. Trowbridge et al. (2015) stated that *'The broad and fundamental nature of clinical reasoning in medical training means that it is housed nowhere but should be taught everywhere'* (Trowbridge, Rencic & Durning 2015 chapter 3 para. 18).

The cognitive psychologist may view clinical reasoning through the lens of information storage and retrieval. This perspective contrasts with the medical administrator's focus on reducing errors and increasing patient safety. The clinical supervisor, however, may be focused on how to best teach clinical reasoning skills. Because of its complexity and the diversity of ways it can be viewed, clinical reasoning firstly needs to be defined. Once defined, its importance demands that methodologies are applied which enable these skills to be effectively fostered within the clinical setting. This literature review defines and explains the importance of clinical reasoning skill development before exploring early modalities of medical training.

Later in this chapter the rationale and methodology for a scoping review of the literature are detailed. The literature that explores how medical knowledge is encoded, stored, retrieved and

applied originates in the field of cognitive psychology. In addition to the cognitive perspective applied to understanding clinical reasoning, a second main branch of research literature explores learning as a social behavioural process. The summary section of this literature review proposes that effectively cultivating clinical reasoning skills in a specified location requires a learning framework that has been tailored for this purpose.

1.2 Defining clinical reasoning

Health professionals make use of clinical reasoning skills as they seek and gather patient data, synthesise it with their knowledge and then create a clinical impression, diagnosis or care plan (Young et al. 2018). Although clinicians seek to teach, assess and research clinical reasoning, an agreed definition across the different health professions remains problematic (Young et al. 2018). There are also widely differing understandings of what clinical reasoning means within the medical profession. In medicine, some clinicians may emphasise the cognitive and subconscious processes involved in clinical reasoning, while others may place greater importance on its social and dynamic components (Young et al. 2018). The literature on clinical reasoning is diverse and fragmented, in part due to the many different ways clinical reasoning is understood (Frank et al. 2010).

A recent concept analysis of the term 'clinical reasoning' (as applied to clinical medicine) by Yazdani et al. (2018), determined that the concept had several major attributes, including:

- Cognitive process involving gathering, analysing and interpreting patient information (Montgomery 2005);
- Knowledge acquisition which is then codified and applied (Bordage & Zacks 1984);
- Thinking as part of the process – involving both cognition and metacognition (Colbert et al. 2015);
- Patient data (Higgs et al. 2008);
- Context-dependent and domain-specific (Norman 2005);
- Iterative and complex processes (Marcum 2012; Welch et al. 2017).
- Multi-modal cognitive processes, including both tacit and explicit components (Eva 2005).
- Professional principles and health system mandates (Higgs et al. 2008).

The research of Yazdani et al. (2018) shed some light on the complexity of establishing a definition for clinical reasoning. In this thesis, the following definition by Eva (2005), will be used as a working definition of clinical reasoning:

Clinical reasoning is the ability to *'sort through a cluster of features presented by a patient and accurately assign a diagnostic label, with the development of an appropriate treatment strategy being the end goal* (Eva 2005 p.98).

Many researchers, including Croskerry, have regarded clinical reasoning as the physician's most critical competence (Croskerry 2009c; Nendaz & Bordage 2002; Norman 2005; Pelaccia, Tardif, Triby & Charlin 2011). Clinical reasoning, and its application to teaching, learning and assessment, have been studied for several decades and from several different perspectives.

1.3 Perspectives on clinical reasoning

The study of clinical reasoning has been an area of active research since the second half of the 20th century (Norman 2005). The table below shows some of the research approaches that have been adopted, as well as their relative strengths and limitations (Table 1.1).

Table 1.1 Approaches to understanding clinical reasoning

Discipline/approach	Areas explored	Strengths/ limitations
	Primarily cognitive	
Cognitive psychology	How information is encoded (Bordage & Zacks 1984; Charlin et al. 2007), stored, retrieved and applied (Pelaccia, Tardif, Triby & Charlin 2011) metacognition (Eichbaum 2014). Characteristics of decision making – including Type 1 and 2 (intuitive and analytical) (Norman 2009; Pelaccia, Tardif, Triby & Charlin 2011) types of error/ bias (Scott 2009). The roles of affect and motivation (Artino Jr, Holmboe & Durning 2012a).	Useful for developing methods for teaching and reflection (Chamberland et al. 2015; Croskerry 2003a); awareness of bias, errors (Graber, Franklin & Gordon 2005) and heuristics. Limitations: learning is also a social process situated in a pressured, complex learning climate (Durning & Artino Jr 2011).
Educational/ learning	Use of virtual patients and simulation technology (Bond et al. 2008; Hege et al. 2018; Posel, Mcgee & Fleiszer 2015).	Useful in developing cognitive dimensions of clinical reasoning. Limitation: Context may not accurately mimic clinical setting.
Assessment	Assessment methodologies have been developed including key features tests, script concordance test (Charlin et al. 2000; Hrynchak, Glover Takahashi & Nayer 2014)	Being able to assess clinical reasoning skills is highly desirable, but problematic. These skills cannot be measured directly (Rencic et al. 2016).
	Primarily Social	
Learning as a social process	Learning is a social process (Bandura & McClelland 1971; Lave & Wenger 1991; Vygotsky 1978) influenced by the learning climate, including role modelling (Irby 1986; Passi & Johnson 2016a; Roff & McAleer 2001).	Useful for understanding the context of learning, the motivators and barriers influencing them (Artino Jr, Holmboe & Durning 2012a) Limitations: Learning clinical reasoning is also a cognitive process.
Education/ learning	Case-based teaching, Problem based learning (Kassirer 2009; Savery & Duffy 1995).	These approaches are often used in social context. Limitations: Less emphasis placed on cognitive processes involved.

Much of the original research described in Table 1.1 first occurred in a range of non-medical disciplines, and was later adapted for use in explaining aspects of the clinical reasoning process. In some instances, despite continuing advances in an area of research, these developments may not have been widely integrated into medical education theory. For example, dual process theory posits that there are two distinct types of decision making: Type 1 – fast and intuitive, and Type 2 – slower and analytical (Kahneman 2012). Early research in this area in the disciplines of management and philosophy can be dated back to at least 1938. Barnard (1938) noted that under pressure, some individuals process knowledge without conscious effort that is intuitively. In the early 2000s, Stanovich et al. (2000) suggested that information processing occurs in a parallel manner with conscious deliberation (Type 2) and subconscious intuition (Type 1). Researchers proposed that Type 1 thinking was the default modality until such time as analytical thinking (Type 2) was required (Epstein 2003). Since the early 2000s, dual process theory research has become very popular as a way explaining decision making as part of the clinical reasoning process (Pelaccia, Tardif, Triby & Charlin 2011). The simplicity of the dual-process theory is appealing, but Custers (2013) argued that it is too basic and does not fully account for the breadth and complexity involved in the clinical reasoning process. The cognitive continuum theory (CCT) which Custer (2013) proposed, posits that Type 1 and Type 2 thinking are at either pole of a continuum, and that a clinical reasoning event is a quasi-rational process, involving a blend of Type 1 and Type 2 reasoning.

The cognitive forcing strategies developed by Croskerry (2003), aim to reduce the rates of clinical reasoning error by advocating explicit monitoring and regulatory strategies. Croskerry (2003) described three levels of cognitive forcing strategies: universal, generic and specific. Specific cognitive forcing strategies use a formal cognitive debiasing approach to help overcome known biases or thinking pitfalls. These cognitive forcing strategies rely on dual process theory as their theoretical underpinning. Croskerry et al. (2011) argued that making these remediation strategies more explicit, and therefore conscious, helps to reduce error rates. The assumption behind this is that tacit, subconscious decision making which is not explicitly regulated may be the primary cause of clinical reasoning error. This view has recently been challenged by Norman et al. (2017). They stated that both Type 1 and 2 decision-making processes are prone to error, but for different reasons. In this report, Norman stated that Type 1 reasoning may be influenced by cognitive biases, whereas Type 2 thinking is more affected by the limits on working memory. Current research has highlighted that although Custer's

theory may be regarded as an advancement of the dual-process theory, it has few advocates (Custers 2013; van Merriënboer 2014). Reasons for this may include the appeal and simplicity of the dual-process theory, and the ease with which it aligns with methodologies aimed at reducing cognitive errors (Croskerry 2003a). So, although the model developed by Custers may have greater explanatory power, it has gained little traction. Perhaps it is seen as having little practical benefit, either for teaching or reducing error rates. In writing this review, it was necessary to limit the scope of the literature discussed, and to focus primarily on those frameworks and theories that have been widely accepted and applied, even if they may have been further developed in other disciplines.

1.4 Scoping review – the rationale and methodology

Clinical reasoning literature encompasses a wide range of research approaches. While a scoping review accommodates a variety of study designs and methodologies, a systematic review often uses statistical methods to determine the effectiveness of a specific intervention. A systematic review tends to favour randomised control trial research design (Arksey & O'Malley 2005). A scoping review, however, seeks to provide a descriptive summary of the reviewed literature, and is particularly useful if the topic is complex or heterogenous (Mays, & Popay 2001). Scoping reviews differ from narrative reviews in that they require an analytical re-interpretation of the literature in order to give cohesive meaning to the variety of different studies included (Davis, Drey & Gould 2009; Levac, Colquhoun & O'Brien 2010). Analytical re-interpretation was important in this review due to the diversity of approaches taken within the clinical reasoning literature. Another benefit of the scoping review methodology was that it provided a robust approach to mapping the research area. The methodology adopted for this review was first described by Arksey and O'Malley in 2005.

Colquhoun et al. regarded a scoping review as:

'... a form of knowledge synthesis that addresses an exploratory research question aimed at mapping key concepts, types of evidence, and gaps in research related to a defined area or field by systematically searching, selecting and synthesising existing knowledge' (Colquhoun et al. 2014 p.1293).

Table 1.2 Stages of the Arskey and O'Malley Scoping review

Stages of the scoping review	Description
1	Identifying the broad research question
2	Identifying relevant databases; use of key terms
3	Use of inclusion/ exclusion criteria to identify relevant studies
4	Descriptively analysing information presented in the literature
5	Collating, charting, summarising and reporting of the literature
6	Consulting with external stakeholders then refining focus of review

Source: Arksey and O'Malley (2005)

Arksey and O'Malley (2005) regarded the sixth and final stage of consulting with external stakeholders as optional. Other researchers have disagreed, regarding it as an essential part of the scoping review process (Levac, Colquhoun & O'Brien 2010). In this research, consulting with clinical staff was regarded as essential in helping to finely tune the review, and to make it relevant to the research location. The review focussed on factors that influence the development of clinical reasoning skills among doctors-in-training as discussed below.

1.5 Literature search strategy

'Doctors-in-training' is a term used throughout this thesis and refers to medical students and doctors in the first two years of clinical practice. The overarching research question was: *'How do doctors-in-training develop clinical reasoning skills?'* The key terms used in searching for the relevant literature included: *clinical reasoning, medicine, decision making*, *diagnosis, education, teaching/method, cognition, metacognition, learning environment/climate* and *role modelling*. The databases searched included Ovid (Medline), PubMed (Medline), Scopus, PsycINFO and Web of Science. In addition to specific searches of the literature, 'snowball searching' was also periodically undertaken. This process identified over 1545 academic

references of interest from the period January 1970 – September 2018. These references encompassed both the English and non-English language literature. Only a few of the papers date from before 1960.

The fourth and fifth stages of the Arksey and O'Malley (2005) scoping framework process required organisation and synthesis of the literature in order to enable gaps in the literature to be identified. The literature review that follows is organised to initially provide a broad theoretical base, which then narrows to the research area explored in this thesis. Before concentrating on the details of clinical reasoning research, it is useful to review the fundamental changes to medical education that have taken place over the last century.

1.6 Early models of medical training

Medical training has evolved a great deal since Flexner delivered his landmark report to the Carnegie Institute in 1910 (Flexner, Pritchet & Henry 1910). Before this date, medical schools varied considerably in the content and duration of their teaching. For example, Abraham Flexner's brother Simon qualified as a medical doctor in less than a year, without ever having seen a patient or dissected a body (Dornan 2005). There was no agreed best way to teach or to learn, and the accreditation of medical training was still a long way off. Today, many jurisdictions, including Australia, the USA and the UK, require medical training to meet stringent accreditation requirements and take many years (World Federation for Medical Education 2018).

Flexner's detailed report to the Carnegie Institute highlighted the need for biomedical science to be at the core of medical training, followed by clinical training within teaching hospitals (Dornan 2005). Flexner's report is regarded as a watershed in the development of medical training. William Osler, a Canadian physician who also taught and practised medicine in the early twentieth century, is primarily remembered for his insistence that clinical medicine needed to be learned within the clinical context and with patients. Osler's famous quote succinctly sums this up:

'He who studies medicine without books sails an uncharted sea, but he who studies medicine without patients does not go to sea at all' (Osler 1914, p. 220).

In the years since Flexner's report, medical training at both undergraduate and postgraduate levels has seen many changes. These changes have involved both the structure and content of the courses. For example, curricula having a biomedical science focus have been dominant since the early decades of the 20th century (Frenk et al. 2010). More recent innovations included the development of Problem Based Learning (PBL). PBL aimed to integrate the medical sciences and clinical case presentations, with the aim of improving the way students applied their knowledge (Savery & Duffy 1995). In addition to changing the way students were taught, a huge quantity of medical knowledge has been added to the curriculum. Today, many components vie for inclusion in a crowded undergraduate medical curriculum, such as professionalism, communication skills and cultural training (Birden et al. 2013). However, helping doctors-in-training to mobilise their knowledge and then to apply it in a reasoned, relevant and ethical manner is of paramount importance (Frenk et al. 2010). The next sections detail how clinicians mobilise and apply their clinical knowledge.

1.7 Developing expertise in clinical reasoning

It is helpful to define expertise before relating it to clinical reasoning ability. Expertise may be thought of as *'consistently superior, replicable performance producing definable results within a specific domain'* (Ericsson, Prietula & Cokely 2007 p.2). Descriptions of its defining characteristics include mastering a large body of knowledge and gaining around 10,000 hours of experience over ten years (Ericsson, Prietula & Cokely 2007). The notion that this period is highly variable and depends upon the discipline is less frequently repeated in the same paper. Current research in medical education indicates that medical expertise is closely linked to an individual's performance in the area of clinical reasoning (Durning et al. 2012; Ericsson, Prietula & Cokely 2007). In clinical medicine, expertise requires extensive knowledge in addition to cognitive, motor and interpersonal skills (Ericsson et al. 2006). Expertise can be thought of as epistemic expertise – expertise because of what the person knows, and performance expertise – related to what they can do. Both epistemic and performance expertise are important in clinical medicine (Weinstein 1993). Since the early 1970s researchers sought to understand how an expert behaves differently to a novice (Norman 2005). Different research approaches have been followed in seeking to understand and foster the attributes of experts, which are discussed below.

1.8 How doctors-in-training learn

To understand how doctors-in-training learn within the clinical work environment, one must look initially at educational learning theories. The two main epistemological positions from which many of these theories are derived are *empiricism* and *rationalism*. Aristotle advanced the view that knowledge is the product of experience alone (*empiricism*). Meanwhile Plato developed the opposite approach - that knowledge is a product of the mind alone (rationalism). Educational theories that look at learning through a social and behavioural perspective have their roots in empiricism, while those looking through the cognitive lens are typically rationalist (Durning & Artino Jr 2011).

The following table shows how the literature review has been broadly organised into the empiricist and rationalist approaches. After these approaches have been discussed, three areas of research: the learning climate, role modelling and self-regulated learning (specifically metacognition), are then discussed under the title of 'situational factors'. These situational factors are used as an organising framework for the research described in the rest of the thesis.

Table 1.3 Approaches to understanding clinical reasoning skills

Empiricism (Learning through experience)	**Rationalism** (Learning as a cognitive process)
	'think-aloud'
Constructivism	Chess Grandmasters as a proxy for expertise
Social learning theories	Elaborated and encapsulated knowledge
Experiential learning	Script theory and illness scripts
	Dual process theory
	Impact of cognitive load

1.9 Empiricism – learning as a social and behavioural process

1.9.1 Constructivism

Constructivist epistemology states that extending one's learning is a process of adding new knowledge to pre-existing knowledge. It is a building process, in which *'...[t]he most important factor influencing learning is what the learner already knows'* (Ausubel, Novak & Hanesian 1968 p.iv). Constructivism had its origins within Kantian philosophy and was employed in the educational and learning context by Piaget (1955). Piaget expanded upon this idea by stating that experience is constantly being 'filtered' through pre-existing concepts and existing knowledge networks (Flavell 1963). As new knowledge is understood in the light of existing knowledge, it is added to a schema (or mental model) that is being created and developed in the mind of the learner. In the context of clinical reasoning, these schemas are called *'illness scripts'*. Illness scripts are networks of organised clinical knowledge constructed by the learner, which may be mobilised to help solve clinical problems (Charlin et al. 2007; Fournier, Demeester & Charlin 2008). As well as aiding in the diagnostic process or the management of the patient, illness scripts may motivate the doctor-in-training to seek additional clinical information in order to confirm their provisional diagnosis (Charlin, Tardif & Boshuizen 2000).

A feature of constructivism is that if new knowledge is not connected to pre-existing knowledge, then it may not necessarily extend the knowledge in a specific domain. If the new knowledge does not initially make sense to learners, then they reach out to their imaginations or develop a hypothesis to try and make sense of it by linking the new information to an existing schema. Seeking to make sense of new information is also the starting point for hypothetico-deductive reasoning (Dennick 2016). In seeking to make sense of additional information, the doctors-in-training 'filter' it as they try to link it to their pre-existing schema. The filtering process is vulnerable to thinking errors and bias which can distort, or even misdirect meaning-making. Some of these biases and errors are specific to the clinical environment, for example, the misidentification of a sign or a symptom (Bordage 1999). Other types of errors or bias are more generic, for example, the faulty estimation of prevalence (Norman et al. 2017; Tversky & Kahneman 1974). Clinical reasoning errors and bias are discussed in more detail in Section 1.11.

Constructivist theory helps explain how knowledge and skills are assimilated in the mind of the learner into schema, which may later be mobilised for clinical use. Schema-based instruction for medical students has been hypothesised to improve diagnostic accuracy and knowledge organisation (Blissett, Goldszmidt & Sibbald 2015). The rationale offered is that teaching using schemas links the clinical information in a way that is intentionally made memorable and ready for application (Blissett, Goldszmidt & Sibbald 2015).

Piaget's theory of learning through constructivism does not fully account for the social factors that influence learning. Clinical reasoning skills are learned in a workplace. That workplace is often made up of a variety of staff who may have widely varying roles, skills and levels of experience. Within the clinic or hospital, there are often Consultants, Registrars, Interns, medical students and nurses as well as other skilled personnel who work in teams. The clinical focus of these multi-disciplinary teams is the welfare of the patient. However, the learning that takes place within these teams is greatly influenced by social and behavioural factors such as teamwork and the willingness of senior staff to teach, and the motivation of doctors-in-training to learn.

Therefore, the medical staff working within these complex multi-disciplinary environments observe and learn skills, attitudes and beliefs from a range of sources. The effectiveness and speed with which learners recall, synthesise and then apply their knowledge, is affected by this clinical environment.

1.9.2 Social learning theories

Lev Vygotsky was born in 1896, the same year as Piaget, but lived in Russia during the time of the Russian revolution. His work was not translated into English until 1962, and was therefore inaccessible to a non-Russian audience. Vygotsky's *Sociocultural Theory of Cognitive Development* stated that human psychological development is the product of social interaction with the environment (Vygotsky 1978). His description of the *zone of proximal development* (ZPD) – the difference between what the learner can do with and without help, resonates strongly with constructs such as mentorship, role modelling and the scaffolding of learning (Vygotsky 1978). In these situations, either consciously or subconsciously, learners are supported to attain a level of performance which they could not achieve on their own. Vygotsky termed the person who helps the learner move across the ZPD, as the More

Knowledgeable Other (MKO). Within the context of medical education, the MKO could be a Consultant or clinical teacher, perhaps another health professional, or even a learner's peer who has more knowledge or expertise in a certain area. The notion of learning through an apprenticeship fits closely with the work of Vygotsky (Dornan 2005).

Like Vygotsky's earlier work, Bandura's Social Learning Theory emphasised the importance of environmental factors in explaining how a person learns. Bandura stated that how a person learned was a product of the personal, behavioural and environmental factors involved with their learning (Bandura 1986). Bandura called this *'triadic reciprocal determinism'* in which the person (which includes their cognition, self-efficacy, motives and personality), environment (situation, roles and relationships) and behaviour (complexity, duration and skill level) interact to influence learning. Social Cognitive Theory proposed that learning is effective when there is a close alignment between the learner and the person from whom they are learning, especially if the learner has a high degree of self-efficacy, which is a blend of determination and a belief that they can gain mastery of a skill (Bandura 1989). There is an established understanding in medical education that effective learning is closely linked with imitation, observation and role-modelling (Passi et al. 2013; Sternszus & Cruess 2016). The importance of role modelling in learning has recently attracted increased interest in the literature and is discussed later in this thesis (Passi & Johnson 2016a; Passi et al. 2013; Sternszus & Cruess 2016). Bandura's important pioneering studies may be regarded as one of the major starting points for a range of research studies that have linked environmental factors to the effectiveness of learning. These views may also be traced back to Aristotle's empiricist position that associates gaining experience with acquiring knowledge. Bandura's Social Cognitive Theory appears to have great relevance and application in medical education by assisting in the understanding of the influence of environmental factors on learning. The development of learning climate measuring instruments, such as the Dutch Residency Educational Climate Test (D-RECT) owe part of their theoretical foundations to Bandura's Social Cognitive Theory (Bandura 1989; Boor et al. 2011).

Learning within the clinical setting, both at an undergraduate and a postgraduate level, takes place within a complex social environment. Separating the context of learning from the learning itself may be regarded as too reductionist, as it risks misrepresenting the learning

experience (Bleakley 2010). A key aspect of learning is its experiential aspect, which was further developed by Dewey, Kolb and Mezirow as detailed below.

1.9.3 Experiential learning

In the early 1930s, John Dewey stated that one does not learn through gaining experience, but by reflecting on that experience (Dewey 1933). In other words, experience alone may not result in learning. Kolb's Experiential Learning Theory, published in the early 1980s, built on Dewey's observation and established a constructivist foundation by providing evidence that we learn through experience and by moving through the experiential learning cycle (Kolb 1984). According to Kolb's now well-established theory, we learn by moving through four stages: concrete learning, reflective observation, abstract conceptualisation and active experimentation. Kolb's theory is a broad starting point to better understand how experience helps to shape learning within the clinical context. However, the breadth and generality of Kolb's theory give only an overview of the transformative process going on in the mind of the learner, as additional information is synthesised, stored and then retrieved for use within the clinical setting.

Transformative learning theory, developed by Mezirow et al. (1997), stated that to extract meaning from an event, one must critically reflect on that experience. By critically reflecting on experiences it is then possible for learners to proactively challenge their own beliefs and assumptions, which may then lead to restructuring and then further building their understanding (Mezirow 2000). The trigger for such personal, critical reflection is often a disorientating dilemma or a realisation of ignorance in a specific situation (Taylor & Hamdy 2013). Critical reflection, as described by Mezirow, has a similar effect to Ericsson's process of deliberate practice (mentioned later in this chapter), and how it shapes the understanding of the learner (Ericsson 2004). In their important paper, Frenk et al. (2010) indicated that transformative learning theory provides a way of explaining how a learner can be helped to progress from informative to formative and finally to transformative learning. Frenk et al. (2010) stated that informative learning enables the learner to acquire knowledge and skills which may ultimately lead to them becoming experts, whereas formative learning produces professionals and transformative learning develops future leaders.

Problem-based learning (PBL), developed in the early 1970s, makes use of constructivist principles and is underpinned by the work of Kolb and his Experiential Learning Theory (Savery & Duffy 1995; Schmidt 2012). A core premise of PBL is that a person's extraneous learning is a function of their grappling to synthesise and generate a personalised understanding of how medical information fits together in order to make meaning. One of the main instructional principles of PBL is that all learning activities be anchored in solving a larger problem or task (Savery & Duffy 1995). These principles have strong parallels with Osler's belief that effective learning takes place within the clinical work context of caring for the patient (Osler 1914). The Oslerian view is that effective medical education requires a clinical context in order to make sense of, as well as to ground, a student's understanding of medicine. The close connection between clinical context and the learning of clinical reasoning skills is a frequently repeated theme in the literature.

To understand how the learning of clinical reasoning skills develops both empiricist and rational perspectives need to be understood (Braude 2012). Research aligning with the rationalist, cognitive perspective is detailed below.

1.10 Rationalism – learning as a cognitive process

1.10.1 'Think-aloud' - as a methodology

Researchers at McMaster University used 'think-aloud' techniques to describe the way in which experts solved clinical problems differently from novices (Norman 2005). As the experts worked through taking a patient history, making a diagnosis and then developing a management plan, they were encouraged to 'think-aloud'. These studies did not find evidence of generic problem-solving skills, but provided further evidence that experts knew more and made better decisions (Elstein, Shulman & Spaka 1978). In these projects, the McMaster researchers also found evidence that a hypothetico-deductive approach was sometimes used by experts for solving clinical problems. These studies also showed that there was a poor correlation between solving cases in different domains – a phenomenon called 'content specificity' (Elstein, Shulman & Spaka 1978). In other words, those who performed well in one domain did not necessarily perform so well when solving cases in different specialties. This was disappointing. It was hoped that expertise in one domain was a defined and transferable skill. The 'think-aloud' technique appeared not to be effective in illuminating how

experts think differently from novices. More recently ‘think-aloud’ has been promoted as an excellent method of making expert thinking explicit, or ‘visible’ to the learner (Beyer 1997; Houchens et al. 2017; Pinnock, Fisher & Astley 2016). By thinking aloud in the presence of a more senior clinician, gaps and connections in the novice thinking process can be identified, discussed and, if necessary, remediated (Houchens et al. 2017).

1.10.2 Chess Grandmasters and medical expertise

After these early ‘think-aloud’ studies, a different approach was taken in seeking to understand expertise. It was hypothesised that chess Grandmasters become experts by remembering up to 50,000 representative moves from previous games (Simon & Chase 1973). These representative cases were then able to be recalled for use in subsequent games. The study by Simon showed that the single best measure of chess players was their recall of a mid-game position after a five-second look at the game (Simon & Chase 1973). Researchers hypothesised that chess Grandmasters and physicians stored, retrieved and then applied knowledge by the same processes. However, remembering substantial amounts of detailed patient information did not seem to help physicians make better clinical decisions in the future (Schmidt & Boshuizen 1993b). Subsequent studies showed that expertise in chess is dissimilar to expertise in clinical medicine (Ericsson 2004).

This early exploration into understanding medical expertise demonstrates a crucial point. Although clinical knowledge is a key ingredient in gaining clinical reasoning expertise, it is not the only element (Cutrer, Sullivan & Fleming 2013). Clinical reasoning expertise is complex and multi-factorial (Custers 2018). Currently, much of the research, for example into areas such as cognitive psychology, expert performance and decision making, is not incorporated into mainstream medical education (Looi & Yong 2017; Trimble & Hamilton 2016). This is problematic and its omission may lead clinicians who are unfamiliar with the literature to assume a simplistic connection between accumulating knowledge and developing clinical reasoning expertise.

1.10.3 Elaborated and encapsulated knowledge

In the late 1980s, Schmidt and colleagues identified qualitative differences in knowledge structures which helped explain the variation in performance between novices and experts

(Schmidt & Boshuizen 1993b). They named this the *intermediate effect* as it refers to the difference between the way a novice and an expert recall a clinical case after both have briefly read through written case notes. Both novice and expert are given the same case to read and are then asked to recall the patient history, clinical data, diagnosis and management. The novice recalls the case in elaborate detail, whereas the expert is far more concise and focussed in their recall. Experts have their knowledge better organised or *encapsulated* (Schmidt & Boshuizen 1993b). Based on this research, Bordage et al. developed the concept of 'forceful features', later renamed 'key features' (Bordage, Grant & Marsden 1990). Key features are defined as important steps in unravelling a clinical problem (Hrynchak, Glover Takahashi & Nayer 2014). Testing trainees for their ability to identify key features in a clinical case is currently regarded as one method available for assessing clinical reasoning ability, along with the script concordance test described in Section 1.12 (Charlin et al. 2000; Hrynchak, Glover Takahashi & Nayer 2014). The key feature assessment approach was developed to overcome domain specificity and focussed only on decision-making. The script concordance test, however, was developed to try and capture the reasoning process using script theory, as it was felt that merely focusing on the decision alone was not sufficient. The focus of research in the early 1990s then shifted to investigating how knowledge is organised in the clinician's memory (Bordage & Lemieux 1991).

Schmidt (2007) described *encapsulated knowledge* as the extensive network of related knowledge possessed by experts (Schmidt & Rikers 2007). Simple and common case presentations do not require experts to rigorously examine their encapsulated knowledge. However, when the case is more complex, or the time allowed to diagnose reduced, experts will cognitively examine their encapsulated knowledge in their effort to solve the case (Aberegg et al. 2008). Discovering the knowledge of experts is organised differently from that of novices led to researchers identifying the stages through which learners progress as they develop clinical reasoning expertise (Boshuizen & Schmidt 2010; Schmidt & Boshuizen 1993a). More recently there has been renewed interest in teaching undergraduate medical students using schema-based instruction (Blissett, Cavalcanti & Sibbald 2012). The premise of schema-based instruction is that teaching employing schemas helps students rapidly build new knowledge into their own personal mental schemas. There is supporting evidence that students taught using schema-based instruction retain more structured knowledge and show a greater improvement in diagnostic performance (Blissett, Cavalcanti & Sibbald 2012; Blissett,

Goldszmidt & Sibbald 2015). However, this evidence should be treated with care, as using schemas may be a substitution for a more detailed understanding of the clinical problem (Coderre et al. 2003). Schema-based instruction is thought to be effective because it reduces the cognitive load placed on the learner, a process discussed further in Section 1.10.6. These findings are supported by the more fundamental premise: that learners must construct their schema based on what they already know. Therefore, schema-based instruction appears to encourage the learner to assemble new knowledge, to more easily formulate their understanding.

1.10.4 Script theory and illness scripts

By the end of the 1990s, exploring the way medical knowledge was stored and retrieved had gained a reputation as a productive area of research. Explanations for the reason that the knowledge of medical experts was stored differently from that of novices echoed the conclusions of cognitive psychology research at that time (Elstein, Shulman & Spaka 1978; Gilhooly 1990; Schmidt & Boshuizen 1993b). Researchers noted that medical experts drew on *compiled script-like knowledge* when making a diagnosis (Gilhooly 1990). The concept of the script is similar to that of the term schema, which is used in psychological research (Johnson & Hasher 1987). Feltovich et al. (1984) were pioneers among medical education researchers, describing the knowledge of medical experts as being compiled into *illness scripts*. Illness scripts were defined as networks of encapsulated knowledge, shaped by experiences that direct the selection, interpretation and memorisation of new information (Schmidt, Norman and Boshuizen 1990, Charlin, Tardif & Boshuizen 2000; Custers, Regehr & Norman 1996).

The philosophical premise for the development and refining of illness scripts has its origin in constructivist philosophy. Making use of new knowledge is part of a process of building on existing knowledge. For knowledge to be useful, it needs to be stored in a form which is linked to other information which can be retrieved for use in the clinical reasoning process when required. Constructing this knowledge from the elaborated form memorised by novices is a refining process. It takes time and experience. Time and experience alone, however, do not result in the development of expertise (Dewey 1933; Ericsson 2004; Trowbridge, Rencic & Durning 2015). If the experience gained by treating many patients is not deliberately reflected upon, the clinician may simply become an *experienced non-expert* (Dhaliwal 2015). Experienced non-experts may have gained a wealth of experience, but this has failed to

effectively refine their repertoire of illness scripts. The links between old and new information may not have been continually refined, and so the progression towards clinical reasoning expertise may have been slowed or inhibited. By failing to reflect upon and therefore learn from experience, the clinical performance levels of the experienced non-expert may plateau or even decline (Dewey 1933; Dhaliwal 2015).

As clinicians gain experience and their illness script repertoire is refined and expanded, they add exemplars and semantic qualifiers to these scripts. Exemplars are memorable case examples of a specific illness script. For example, a clinician may be able to recall many different presentations of a specific condition or syndrome. Some of these presentations may be unusual or have caused the clinician to miss the correct diagnosis when the patient presented. Instances of misdiagnosis are memorable. These exemplars, when added to the detail of a refined illness script, help the clinician to develop a heightened awareness for certain parts of the clinical history; its key features. The key features of a case enable the rapid activation of an illness script, often resulting in fast, intuitive diagnostic hypothesis generation (Charlin et al. 2000). Semantic qualifiers are adjectives that help to fully describe a presentation, for example, acute versus chronic (Bordage & Lemieux 1991). This intuitive, or type 1 thinking, makes use of the illness script repertoire belonging to the expert. Slow, analytical, hypothetico-deductive thinking is often reserved for complex or unusual presentations, for example, where an expert is aware that aspects of the patient's history are at odds with an intuitive diagnosis.

1.10.5 Dual process theory

The development of script theory has provided supporting evidence in explaining how fast, intuitive (Type 1) thinking is possible. In the context of medicine, Type 1 decision making is a type of pattern recognition that depends upon the rapid mobilisation of a suitably matching illness script (Pinnock & Welch 2014). With hindsight, a clinician may be able to indicate which aspects of the patient history or clinical data were cues for arriving at an intuitive decision. However, attempts to slow down this intuitive process, or to have the clinician explain how he/she made a specific (intuitive) decision retrospectively, are fraught with several problems: Type 1 decision making, as well as being fast, is also subconscious (Sinclair 2010). Therefore, trying to prove the validity of the clinician's recall after an intuitive decision is difficult. Think-aloud protocols have been used as a way of gaining real-time accounts of the clinical reasoning process (Section 1.10.1). This protocol, however, risks slowing down a

normally fast and subconscious process by making the clinician articulate their otherwise subconscious thinking.

Type 2, or analytical thinking is slower than Type 1 thinking and often uses cognitively demanding hypothetico-deductive processes. Importantly, Type 2 thinking happens consciously, and is therefore much easier to explain to the learner. Initially, it was thought that intuitive thinking was less reliable than analytical thinking, as it was regarded as more prone to cognitive bias and diagnostic error. It has been accepted for several years that Type 2 thinking is not necessarily superior to Type 1 thinking (Norman 2009). Recent research has indicated that intuitive decision making is a hallmark of expert clinical reasoning (Brush, Sherbino & Norman 2017). Thinking of decision making as a dual process is practically helpful, but may represent an over-simplification of a more complex process (Custers 2013).

1.10.6 Cognitive load and the construction of meaning

An important consideration in facilitating decision making is to reduce the cognitive load placed on the learner (Paas & van Merriënboer 1994; van Merriënboer & Sweller 2005). If the concept to be understood is complex (has a high intrinsic load) then the overall cognitive load may be too high for the learner to master. If, however, the learner is taught or coached in such a way as to make the concept more comprehensible, then the extraneous load is decreased, reducing the overall cognitive load (Young et al. 2014). The intrinsic load of the task does not change, but breaking it into manageable portions enables the learner to construct meaning more easily from the new information. This scaffolding effect makes the learning process more effective by helping learners organise their clinical knowledge better (Cutrer, Sullivan & Fleming 2013). Schema-based instruction, as discussed in Section 1.10.3, reduces the extraneous load and thereby reduces the overall cognitive demand placed on the learner (Chandler & Sweller 1991). Alongside the intrinsic and extraneous load, the third constituent of cognitive load is the germane load – the cognitive capacity available to synthesise the information which results in constructing new meaning (Sweller, van Merriënboer & Paas 1998; van Merriënboer & Sweller 2005). For a task to be understood and mastered the sum of the intrinsic, extraneous and germane load must not exceed the maximum cognitive load capacity of the learner (van Merriënboer & Sweller 2005).

By the early 1990s, a broad basic understanding of the process of clinical reasoning had begun to develop. Earlier studies had established that expertise in one domain did not confer expertise in another, and that there was no discrete expertise process (Elstein, Shulman & Spaka 1978; Schmidt, Norman & Boshuizen 1990). Medical experts organised their clinical knowledge in an encapsulated form, which enabled them to recall and apply it efficiently within the clinical work environment (Schmidt & Boshuizen 1993a). Understanding that experts had their knowledge organised differently from novices led to an increased interest in how clinical reasoning could be best taught and assessed. Reducing the cognitive load on the learner through schema-based instruction appeared to be beneficial to learning.

The practical benefits of better understanding the clinical reasoning process are twofold. Firstly, to identify and reduce errors caused by clinical reasoning failures, and secondly, to develop better, more effective ways, to teach clinical reasoning skills to doctors-in-training. The section that follows explores how clinical reasoning errors have been researched and explained.

1.11 Helpful heuristics, errors and bias

In recent years the widespread assumption that clinicians are rational decision makers has been challenged (Avorn 2018). Early work in the 1970s by Tversky and Kahneman, and more recently by Thaler in the diverse fields of cognitive psychology and behavioural economics, has provided a compelling narrative which explored these influencing factors further (Kahneman 2012; Leonard 2008). This research provided evidence that professional decision makers, such as clinicians, make predictable, irrational decisions. In his New England Journal of Medicine (NEJM) paper, Avorn (2018) goes further to describe how human emotions and motivation can be manipulated to influence clinical decisions. For example, pharmaceutical companies are adept at providing prescribers with persuasively salient information, in order to deliberately manipulate their prescribing habits.

Human unreliability in the clinical reasoning process has been understood for several years, giving rise to a detailed understanding of the types and causes of error and bias. Sometimes these biases are helpful, enabling clinicians to develop heuristics which may speed up effective decision making. Heuristics are cognitive rules of thumb used to organise cues and simplify a problem into a series of manageable choices (Simon 1990). They make use of bias and are

frugal, ignoring irrelevant parts of the available information. Due to these characteristics, heuristics help the expert clinical mind to manage uncertainty more efficiently than the unbiased mind (Gigerenzer & Brighton 2009). Early heuristic research was underpinned by three tightly held beliefs based on the 'accuracy-effort trade-off' theory of cognition. This theory, when applied to heuristics, assumed that heuristics are always second best and tend to be used due to cognitive limitations, and that analytical thinking is always better (Gigerenzer & Brighton 2009; Tversky & Kahneman 1974). In the context of clinical reasoning, there was an underlying assumption that more information was always better (Gigerenzer 2008). In the clinical reasoning literature, several of these heuristic elements such as anchoring, availability and repetitiveness heuristics are linked to negative biases that may lead to clinical reasoning errors (Croskerry 2003b).

Medical errors have been the focus of a great deal of attention since the publication of the Institute of Medicine (IOM) report '*To err is human: building a safer health system*' (Donaldson, Corrigan & Kohn 2000). The updated IOM report defines diagnostic error as *failure to make an accurate patient diagnosis in a timely way* (Balogh, Miller & Ball 2016). This report proposed that medical errors be categorised into three groups: systems errors, no-fault errors and cognitive failures (Graber, Gordon & Franklin 2002). Systems errors may include equipment, policy or training failures. Once identified, these system errors are relatively easy for organisations to address and improve. No-fault errors arise due to an atypical patient presentation, or the condition mimicking a more common disease, thereby confounding the treating clinician (Graber, Gordon & Franklin 2002) (Graber, Gordon & Franklin 2002). Classifying these as 'no-fault' clinical reasoning errors may appear to be a reasonable administrative categorisation. However, these diagnoses may also be regarded as complex cases of premature closure. The diagnosis may have been finalised prematurely, perhaps due to the way the clinical features of the patient's illness mimicked a different condition. It may however, have been possible for the clinician to navigate these case confounders, as the correct diagnosis was eventually made at post-mortem.

Cognitive errors are generally difficult to remediate due to their complexity. Errors in clinical reasoning do not generally occur due to a lack of knowledge or care but from cognitive failures exacerbated by a lack of time or the intricacies of the case (Graber, Franklin & Gordon 2005; Scott 2009). Extensive research over the years has enabled the identification of many types of

errors. To reduce the risk of clinical reasoning errors, there needs to be an understanding of how such errors occur in the first place (Croskerry 2003a). Table 1.4 provides a list of common cognitive errors along with a description.

The clinical requirement to integrate knowledge, gather case-specific patient information and then use this to make clinical decisions, is a demanding and complicated process. The medical specialties in which there may be a higher degree of uncertainty and incomplete information, such as Emergency Medicine, General Medicine and Family Medicine, have an increased risk of clinical reasoning errors (Croskerry 2003a). Despite the many initiatives to reduce the rate of clinical reasoning errors globally, including cognitive debiasing strategies, error rates remain stubbornly high (Croskerry 2003a; Ludolph & Schulz 2017; Nendaz & Perrier 2012). One alarming study published in the British Medical Journal (BMJ), stated that medical errors, including clinical reasoning errors, are the third leading cause of death in the USA (Makary & Daniel 2016). Additionally, a recent Organisation for Economic Co-operation and Development (OECD) document stated that clinical reasoning errors accounted for 15% of hospital expenditure in OECD countries, and were the fourteenth leading cause of global disease (Slawomirski, Auraaen & Klazinga 2017).

Table 1.4 Examples of cognitive error affecting patient diagnosis or management

Cognitive error	Description and effects
Availability heuristic	Tendency to accept a diagnosis because of ease in recalling a past similar case rather than based on prevalence or probability.
Anchoring heuristic	Tendency to fixate on first impressions - selected symptoms or signs or simple investigation results as predictors of specific diagnosis.
Premature closure	Acceptance of a diagnosis before it has been fully verified by considering alternative diagnoses and searching for data that challenge the provisional diagnosis.
Framing effect	Tendency for benefits and risks to be perceived differently if expressed in relative versus absolute terms or death versus survival.
Commission bias	Tendency to do something (or seen to be doing something) even if intended actions are not supported by robust evidence and may, in fact, do harm.
Extrapolation error	Tendency to generalise treatment experiences and clinical trial results to groups of patients in whom the treatment has not been properly evaluated.

Source: Scott (2009) p.339

Recent research has provided evidence that there may be no difference in the frequency of clinical reasoning errors, regardless of whether heuristics or analytical thinking have been used (Bodemer, Hanoch & Katsikopoulos 2015). Indeed, some recent research indicates that it would be wise to acknowledge the important role that heuristics play in everyday clinical practice and seek ways to understand and make better use of them (Bodemer, Hanoch & Katsikopoulos 2015).

Not all of the approaches to understanding clinical reasoning are relevant to this review of the literature, for example, little emphasis has been placed in this literature review on the recent functional magnetic resonance (fMRI) imaging studies, which seek to identify the regions of the brain involved in distinct aspects of the clinical reasoning process. These have been excluded from this study, as this scoping review has targeted how doctors-in-training develop clinical reasoning skills.

1.12 Teaching and learning clinical reasoning

The notion that doctors-in-training learn from more senior clinicians is not new. At the time Flexner wrote his report for the Carnegie Foundation in 1910, the notion of learning through apprenticeship was widespread (Flexner, Pritchet & Henry 1910). An apprentice is defined in the Concise Oxford English Dictionary (2001) as '*A learner of a craft, bound to serve, and entitled to instruction from, his or her employer for a specified period. Also, a beginner or novice*'. Learning through apprenticeship has its theoretical foundations in empiricism, and more recently in the work of Vygotsky and Bandura, as well as with Lave and Wenger (Section 1.9.2). In recent years, the concept of medicine as an apprenticeship has come under pressure due to the increased numbers of learners in the system, the shortening of clinical attachments and the increasing specialisation of medicine (Dornan 2005). There is also the suggestion that recent educational developments have over-simplified or 'atomised' professional expertise, reducing it to knowledge, skills and attitudes (Dornan 2005). This realisation has led to a renewed interest in exploring the benefits of apprenticeship for the modern learner (Lyons et al. 2017). Cognitive apprenticeships may be useful in developing clinical reasoning skills by helping to make expert 'thinking visible' for the learner (Collins, Brown & Holum 1991).

Within the context of apprenticeship being under pressure, there have been renewed efforts to teach clinical reasoning skills (Nendaz & Bordage 2002; Schuwirth 2002). Many of the early approaches were founded on the premise that making learners aware of how experts' reason, would, in turn, help them to reason like experts (Rencic 2011). Some of these interventions were based on research which had investigated how clinical knowledge was stored, retrieved and used. For example, teaching using illness scripts (Section 1.10.4) had some success. Using illness scripts was thought to be helpful, as the way knowledge is presented makes it easier for the learner to store, retrieve and clinically utilise information (Blissett, Cavalcanti & Sibbald 2012). Other efforts to reduce clinical reasoning errors have focussed on using cognitive forcing strategies, (described in Section 1.3) or encouraging self-explanation as a means of encouraging students to develop their metacognitive skills (Chamberland et al. 2015; Croskerry 2003a).

There is no agreed, single best method of teaching clinical reasoning skills (Trowbridge, Dhaliwal & Cosby 2013). Instead, as more research evidence becomes available, new approaches are tried, tested and refined. Developing an evidence-based approach which is

tailored for learners in a specific location appears to have merit. Often, however, there is little teaching provided to learners to improve their clinical reasoning skills (Trimble & Hamilton 2016). However there has been considerable effort made to develop ways of assessing clinical reasoning. Although assessing clinical reasoning ability is not a central focus of this research, it is often stated that assessment drives learning and the development of expertise (Larsen, Butler & Roediger III 2008; Wood 2009). An overview of approaches to assessing clinical reasoning is discussed below.

1.13 Assessing clinical reasoning

Assessing clinical reasoning skills for doctors-in-training has been the focus of much effort in the last few decades, but it cannot be measured directly (Rencic et al. 2016; Schuwirth 2009). It is regarded as relatively easy to generate assessments to determine student knowledge (Cooke & Lemay 2017). Assessing clinical reasoning performance, however, is problematic. Firstly, clinical reasoning takes place within the context of uncertainty (Fargason et al. 1997). To become a clinical reasoning expert the clinician must learn to tolerate a degree of uncertainty, both with the quality and quantity of patient data (Hillen et al. 2017). Secondly, there may be several interacting variables which may appear contradictory or incomplete, in addition to the clinical information. Additionally, there may be more than one correct answer. This situation poses a considerable challenge to medical students and their patients, who may subconsciously believe there can only be a single, correct diagnosis or management plan (Cooke & Lemay 2017).

As the importance of clinical reasoning has become more apparent, several qualitative methodologies have been developed that seek to assess it. Assessment using chart-stimulated recall requires the learner to use a patient chart in order to stimulate recall of their reasoning process about key aspects of the case. The assessor then evaluates the verbal recall of the examinee. Direct observation is another method of assessing clinical reasoning skills, in which the clinical reasoning and judgement of the examinee are compared to specific criteria (Addy, Hafler & Galerneau 2016).

The development of the script concordance test (SCT) by Charlin and van der Vleuten (2004) was a quantitative application of script theory, described in Section 1.10.4. SCT consists of short clinical scenarios followed by questions which incorporate a degree of uncertainty. The

SCT seeks to assess some key characteristics of the clinical reasoning process including the complex, ill-defined and uncertain nature of generating a diagnosis or management plan (Fox 2000). The similarity between the test tasks and the decision points encountered by the clinician during their daily practice is an important characteristic of the SCT (Fournier, Demeester & Charlin 2008). There are three parts to each question: Firstly, the question asks: *'If you were thinking of…'* - then a realistic diagnostic option is suggested. The second part of the question follows: '*…and then you find…*' – a clinical finding is offered, for example, a named pre-existing condition. The third part of the question requires the examinees to make a judgement on a few suggested options and asks: '*…then this option* [a suggested diagnosis] *would become …*' - and the examinee is offered a five-point Likert scale from 'very likely' to 'very unlikely'. The Likert scale enables the examinee to indicate how closely associated he/she estimates the link between the hypothesis, the clinical finding and the suggested diagnosis to be (Fournier, Demeester & Charlin 2008). Constructing and validating a SCT is a demanding and time-consuming task, but it enables aspects of clinical reasoning ability to be quantified within a specific domain (Boulouffe et al. 2014). There is currently a great deal of interest and effort being applied to finding ways to assess clinical reasoning skills.

The next section of the literature review is titled Situational Factors. Having reviewed the general literature relevant to the overarching research question, the researcher now turns to specific situational factors that may influence how doctors-in-training learn clinical reasoning skills. These situational factors need to be understood to enable the development of a nuanced framework to support doctors-in-training to better learn clinical reasoning skills in the research location.

1.14 Situational Factors

So far, this literature review has explored the empiricist and rationalist approaches to understanding clinical reasoning -- in other words, viewing the acquisition of clinical reasoning expertise through either a social learning or a cognitive processing lens. However, neither of these approaches on their own or in combination, are enough to provide a nuanced understanding of how clinical reasoning skills are acquired by individuals in a specific location.

Durning and Artino Jr (2011) state that it is essential to understand the situational factors of a location in order to tailor the learning to that context. The sections that follow detail key

situational factors specific to the learning and research context of north Queensland. These situational factors include the metacognitive awareness of the learners in that location, the learning climate, Consultant role modelling, and perceptions of the doctors-in-training. These situational factors align with either an empiricist or a rationalist approach. Once these situational factors have been understood, and the findings synthesised with the literature, it may be possible to create a tailored, location-specific framework to help cultivate clinical reasoning skills.

1.14.1 Metacognitive awareness

In the early years of formal education, a student's learning is largely regulated by others, such as teachers and parents. As the student matures, it is important that a shift take place during which the learner takes control of their learning (ten Cate et al. 2004). Self-regulated learning (SRL) is a proactive process that enables learners to control their beliefs along with their mental and verbal processes in order to achieve academic gain (Zimmerman 2008). The foundational constructs that support SRL are empiricist in nature, and can be traced back to Bandura's social learning theory (Section 1.9.2). Metacognition, which may be regarded as a component of SRL, is also a rationalist construct, as it encompasses the notion of cognitive control and regulation. Bandura posited that learning is a social process involving behavioural, social and, importantly, personal factors. In 1986 the following definition of SRL was agreed upon at the American Educational Research Association annual meeting:

'... the degree to which students are metacognitively, motivationally and behaviourally active participants in their own learning process' (Zimmerman 1986 p.137).

Medical regulatory authorities in Australia, UK and the USA currently express an expectation that trainees will identify their own learning requirements and use self-regulated learning strategies in order to improve their competency (Confederation of Postgraduate Medical Education Councils 2016; Great Britain. General Medical Council (GMC) 2016; World Federation for Medical Education 2018). There is a widespread belief that possessing a large body of knowledge equates to competence (Durning et al. 2015). While acquiring knowledge is undeniably important, SRL also emphasises the importance of the metacognitive processes involved in learning (Durning et al. 2015). Kiesewetter et al. (2016), proposed that clinical knowledge is not enough, and that higher levels of metacognitive awareness correlate with diagnostic accuracy (Bruin, Dunlosky & Cavalcanti 2017).

Metacognition, or thinking about thinking, was developed as an area of active research by Flavell in the late 1970s, and further developed by Schön in the early 1980s (Flavell 1979; Schön 1987; Schön & DeSanctis 1986; Schönrock-Adema et al. 2012). In their 2015 paper, Colbert et al. stated that despite the importance of metacognitive skills to enable individuals to monitor and regulate their cognition, metacognition has received relatively little attention in the medical education literature (Colbert et al. 2015). The attention metacognition has received has primarily been to emphasise its importance as a means of reducing cognitive errors (Croskerry 2003a; Cutrer, Sullivan & Fleming 2013; Marcum 2012). Recently, authors have indicated the need for a much greater focus on developing metacognitive skills and flexible thinking strategies, as a method of improving clinical reasoning skills (Eichbaum 2014; Spiro et al. 1988). While the literature is consistent in emphasising the importance of metacognitive awareness skills; there is a lack of evidence in the literature directly connecting metacognitive awareness with performance among doctors-in-training. Understanding and quantifying the metacognitive awareness of doctors-in-training is important in this program of research, particularly for developing a nuanced learning framework.

1.14.2 Learning climate

The educational learning climate is an empiricist construct, and made up of many interconnected factors. These factors influence how sympathetic a specific work context might be to learning for the doctor-in-training (Genn 2001a). The learning climate includes the level and type of supervision and the willingness of senior clinicians to teach doctors-in-training (Boor et al. 2011). These social factors depend upon the inclination of the staff and of specific groups within a location and will vary between hospitals. Because of the staff mix, the learning climate in one hospital or unit may favour learning, while stifling learning in another unit. In a specific hospital, the staff may struggle to work effectively together or may be focused almost exclusively on their clinical work because of lack of staff or a high patient load. These types of learning climates may be less favourable for learning.

It has been known for some time that a climate conducive to learning is vital for successful training (Hutchinson 2003). Training includes the learning and refining of clinical reasoning skills amongst doctors-in-training. Social learning theories, including social constructivist

models of learning, were discussed in Section 1.9.2. These theories provide compelling evidence of the importance of the learning climate for effective and sustainable learning.

The Dundee Ready Educational Environment Measure (DREEM) was developed in 1997 by Roff and Harden to measure the undergraduate learning environment and has been widely accepted (Roff et al. 1997). The DREEM seeks to measure the observations of learners and teachers of their academic context (Bennett et al. 2014). Roff et al. (2005) also developed the Postgraduate Hospital Educational Environment Measure (PHEEM). The PHEEM is one of the earliest efforts to measure factors influencing the learning of doctors-in-training (Roff, McAleer & Skinner 2005). The PHEEM is a 40-item testing instrument that covers perceptions of autonomy, teaching and social support.

In their 2012 paper, Schönrock-Adema et al. stated that three key domains should be included when assessing the educational context: personal development/goal direction, relationships, and system maintenance and change (Schönrock-Adema et al. 2012). Since the development of the PHEEM in the early 2000s, the Dutch Residency Educational Climate Test (D-RECT) has been developed, which encompasses the recommendations of Schönrock-Adema et al. The D-RECT instrument consists of 50 items within 11 sub-domains (*Supervision, Coaching and Assessment, Feedback, Teamwork, Peer Collaboration, Professional Relations between Consultants, Work adapted to Resident, Consultants' Role, Formal Education, Role of the Supervisor* and *Patient Handover*). Since its development of the D-RECT in 2011, the D-RECT has been widely used, and its reliability and internal validity have been verified (Boor et al. 2011; Silkens et al. 2015).

To improve the development of clinical reasoning skills, it is necessary to better understand the learning climate. Once the learning climate of a location has been evaluated it is possible to develop a learning framework attuned to meet those demands (Norman 2012). In the busy work context of the research hospital, the D-RECT is a valid and reliable instrument for measuring the learning climate (Boor et al. 2011). The D-RECT provides quantitative data, which can be used in conjunction with other methodologies to inform how conducive to learning the hospital is to doctors-in-training. Another important situational factor specific to the location are the clinical role models for the doctors-in-training.

1.14.3 Consultants as role models

Role modelling by senior clinicians has a powerful effect on the learning of skills, attitudes and knowledge, as well as the ethical and professional behaviour of doctors-in-training (Irby 1986). Role modelling is an empiricist construct, and only one expectation of many required of clinical supervisors (Harden et al. 1999). Doctors-in-training observe how their senior colleagues manage and tolerate uncertainty in their clinical decision making (Cooke & Lemay 2017). Irby (1986) described the influence of role modelling as a powerful educational strategy and a process particularly well suited to learning in clinical medicine (Irby 1986; Passi & Johnson 2016a). Role modelling is also a core concept in both Bandura's social cognitive theory and Brown's cognitive apprenticeship learning model (Bandura 1991; Brown, Collins & Duguid 1989). Both these theoretical frameworks highlight the importance of learning by observation and emulating role models. The current literature about role modelling in medical education focusses mainly on the attributes of the role model themselves, as opposed to the process of role modelling (Passi & Johnson 2016a). The importance of role modelling to learning in clinical medicine is well established (Passi & Johnson 2016b; Sternszus & Cruess 2016). Less clearly understood is how senior clinicians comprehend how they developed clinical reasoning skills, and how they might endeavour to cultivate these skills among their junior medical colleagues. Clinical role models have an important function in helping to shape the learning of doctors-in-training (Irby 1986; Passi & Johnson 2016a).

1.14.4 Interns as learners

Intern doctors in Australia are in their first year of clinical work, having previously graduated from a university-based medical course. Intern doctors are at a pivotal stage in their clinical education. While they are undergraduates, doctors-in-training have no clinical responsibility. During their internship, however, Interns must manage some clinical responsibility as well as seeking to further develop their own clinical education. This is a highly demanding time of change and learning for the doctor-in-training (Sheehan, Wilkinson & Bowie 2012). Exploring how Interns understand their own development of clinical reasoning skills is central to this program of research.

1.15 Summary

This scoping review has identified clinical reasoning skills as a core component of medical practice (Eva 2005). Developing these skills is a complex, mainly subconscious and multidimensional process that takes a prolonged period of time (Berkhout et al. 2015; Ericsson 2004). In the past, doctors-in-training passively relied on an apprenticeship model of learning, which is now under pressure (Dornan 2005). Early in this scoping review, the multifaceted definition of clinical reasoning was explored (Yazdani & Abardeh 2018; Young et al. 2018). For different individuals, the meaning of the term 'clinical reasoning' may vary. This variation is not surprising as the construct includes cognitive factors, social learning, self-regulated learning, medical knowledge and clinical data as essential components.

The focus of this scoping review was to explore key relevant ideas affecting the development of clinical reasoning skills for doctors-in-training. In synthesising this literature review, the researcher identified two relevant theories of research. One research theory (rationalism) views learning clinical reasoning skills as a largely cognitive process, which encompasses how clinical knowledge is stored, retrieved and applied. Through research in this area, it is now widely accepted that there are definable developmental learning stages (Schmidt & Boshuizen 1993b). Characterising these stages was a necessary step before assessment methodologies, such as the script concordance test and key feature problem examinations, could be developed (Charlin et al. 2000; Hrynchak, Glover Takahashi & Nayer 2014). Metacognitive awareness, which is thinking about and monitoring thinking, is regarded by several authors as a vital component of the acquisition of clinical reasoning expertise (Colbert et al. 2015; Croskerry 2000; Ericsson 2004). Understanding metacognitive awareness, in the context of learning clinical reasoning skills among doctors-in-training, is understudied.

The second theoretical perspective views the development and application of clinical reasoning skills as a largely social process (empiricism). Early research by Bandura and Lave and Wenger, viewed learning from a situational and social perspective (Bandura 1986; Lave & Wenger 1991). Synthesising several different strands of research together, it seems clear that the metacognitive awareness of the learner, the learning climate, the influence of clinical role models and the learners themselves are crucial ingredients in the learning process (Boor et al. 2007; Harden 2001; Irby 1986; Passi & Johnson 2016b).

In addition, the clinical reasoning literature makes a compelling case for an increased focus on developing metacognitive awareness among doctors-in-training (Chew, Durning & van Merriënboer 2016; Colbert et al. 2015; Croskerry 2000; Medina, Castleberry & Persky 2017). As well as its key role in self-regulated learning, metacognitive awareness helps to reduce cognitive error and is regarded as a defining characteristic of clinical reasoning experts (Colbert et al. 2015; Cutrer, Sullivan & Fleming 2013; Turan, Demirel & Sayek 2009). There is, however, a paucity of literature focused on the evidence linking metacognitive awareness with performance among undergraduate doctors-in-training.

This scoping literature review has explored how rationalist (cognitive) and empiricist (social factors) help to explain the clinical reasoning process. From the breadth of literature discussed, it is evident that there are many approaches to understanding clinical reasoning. Chapter 2 describes the context, rationale and approach taken in this program of research. The subsequent chapters explore research in each of the four situational factors described above. The integrated research findings and recommended learning framework are discussed in Chapter 7 - Synthesis and Proposed Framework.

Chapter 2: Context and approach

2.1 Introduction

Chapter 1 identified cognitive and social factors as important influences on how effectively doctors-in-training learn to generate a diagnosis or patient management plan. The aim of this thesis is to understand the situational factors influencing the development of clinical reasoning skills among doctors-in-training in north Queensland.

This chapter provides the context and rationale for the program of research that follows, and starts by exploring the policy and organisational framework within which doctors-in-training work. Included in this chapter is information about the hospital and medical school where the research took place. Connecting the lived, everyday context of doctors-in-training with the literature, enabled the researcher to identify knowledge gaps and to understand better how doctors-in-training develop clinical reasoning skills. These four research areas, briefly described in Section 1.14, provide a complementary perspective on how clinical reasoning skills are developed. (Liamputtong 2013). Table 2.1 outlines how the research questions relating to the four studies were answered, along with the rationale underlying their methods.

The research described below focus on exploring how clinical reasoning skills are currently acquired by doctors-in-training and how this process may be further improved. The final parts of this chapter provide an outline of the subsequent chapters.

2.2 Policy background and context of learning

Medical training and practice are carefully regulated in Australia, with several regulatory authorities each having differing responsibilities. The Australian Medical Council (AMC) is the accrediting body for courses of study, as well as registering medical students and practitioners (Medical Board of Australia 2018). The Australian Health Practitioner Regulation Agency (AHPRA) supports the MBA administratively, regarding medical registration to practice and accreditation (Australian Health Practitioner Regulation Agency 2018). Also, AHPRA maintains an online registry of health practitioners, where employers and the public can readily view the details of registered practitioners along with any restrictions on their

practice. The functions of AHPRA are governed by the Health Practitioner Regulation National Law Act 2009 (Queensland Health 2009).

The AMC works with the Medical Board of Australia (MBA) and AHPRA as an independent medical education and training body. The AMC has a vital role in accrediting medical courses and also developing educational standards for prevocational training within Australia.
The stated purpose of the AMC is to:
'*ensure that standards of education, training and assessment of the medical profession promote and protect the health of the Australian community'* (Australian Medical Council 2018a, p.1).

Each year the Australian Government Department of Health publishes the Medical Training Review Panel (MTRP) report (2016). This report is compiled using data supplied by the Medical Deans Australia and New Zealand, the AMC, AHPRA, the specialist medical colleges and the State and Territory Health Departments. The purpose of the MTPR report is to present a cohesive analysis of training from medical school to prevocational training through to trainees on specialist college training programs leading to Fellowship. It is through the information gathered in this report, as well as the report from the Medical Schools Outcome Database (MSOD) that training trends and gaps can be identified according to population needs, and policies developed to address deficits (Medical Deans Australia and New Zealand 2017).

2.2.1 James Cook University College of Medicine and Dentistry

One of the most important gaps identified in the medical workforce has been the on-going maldistribution of medical professionals in regional, rural and remote areas of Australia when compared to metropolitan centres (Larkins et al. 2015). The regional, rural and remote population has fewer healthcare workers per head of population and is therefore under-serviced in terms of service per head compared with those living in metropolitan areas (Larkins et al. 2015). As well as being under-serviced, the dispersed nature of settlements within the rural populations means that access to healthcare workers is also often problematic. This medical workforce maldistribution is attributed to several factors, including the availability of suitable training pathways and the attraction and opportunities offered by working in the large metropolitan centres (McGrail et al. 2017). This inequality is common to many countries and leads to a wide variation in health outcomes between populations based on location (Dolea 2010). To help address the problem of workforce maldistribution, James Cook University

(JCU) started its regionally-based medical program and welcomed its first cohort of students in 2000 (Sen Gupta et al. 2018). The purpose of establishing this new medical school was: *'increasing the number of medical graduates who understand rural, remote, indigenous and health issues and who would subsequently choose rural (non-metropolitan) practice'* (Veitch, Underhill & Hays 2006, p.1).

The six-year undergraduate medical program at JCU has approximately 200 students in each year (2016). Due to these high student numbers, and the relatively small population centres in north Queensland, the medical school has adopted a decentralised training model with major training sites and teaching hospitals at clinical schools in Townsville, Mackay, Cairns and Darwin, and a series of smaller rural and remote placement sites across north Queensland (Woolley, Sen Gupta & Murray 2016). The success of the medical school at JCU in selecting and training medical students for practice in regional and rural areas is well documented (Larkins et al. 2015; O'Sullivan et al. 2018; Sen Gupta et al. 2013; Woolley, Sen Gupta & Bellei 2017).

2.2.2 The Townsville Hospital and medical internship

The Townsville Hospital (TTH) is the site of JCU's largest clinical school. The hospital is a large tertiary referral teaching hospital with over 500 beds and most specialities represented (Australian Institute of Health and Welfare. MyHospitals 2018). Annually, TTH employs approximately 77 Australian medical graduates for their one-year internship. Approximately half of these Interns are JCU graduates. From the whole graduating cohort of JCU medical students, approximately 67% undertake their internship in non-metropolitan centres, including TTH (Sen Gupta et al. 2018).

Medical internship in Queensland is regulated by the Queensland Prevocational Medical Accreditation (Queensland Prevocational Medical Accreditation 2018), which is a member of the Confederation of Postgraduate Medical Education Councils (Confederation of Postgraduate Medical Education Councils 2018). All Australian domestic medical school graduates are guaranteed an Intern position starting in January after graduation (Australia. Department of Health 2016).

Internship programs across Australia require an Intern to complete five terms over the year. Three terms, in the specialities of General Medicine, General Surgery and Emergency Medicine, are mandated as core terms. One and a half terms are elective, whereby an Intern chooses an available accredited unit for the term. An Intern is normally required to take their annual leave in one, five-week block, which constitutes half a term.

The General Medicine unit at TTH is of interest for this research thesis for several reasons. Firstly, the unit tends to receive a wide variety of patients with undifferentiated medical presentations. Secondly, a high proportion of the clinical reasoning literature is grounded within the context of General Medicine, and the need to develop a patient diagnosis and management plan. Finally, the researcher had access to this population of Intern doctors-in-training to research clinical reasoning skill development, explained further in Section 2.6.

The General Medicine unit is composed of several teams, each led by a Consultant General Physician who has gained their Fellowship of the Royal Australasian College of Physicians (FRACP). Interns undertaking their General Medicine term are assigned to one of these teams. In addition to a Consultant and Interns, the team is composed of several other doctors who normally each have 2-5 years post-graduate experience.

The Director of Medical Services (DMS) is a senior manager and a medical doctor at TTH. The DMS oversees and manages the medical staff at the hospital and has a special interest in improving the educational reputation of the hospital. A key function of the Medical Education Unit (MEU) at TTH is to ensure compliance with the QPMA Intern accreditation standards. The head of the MEU is the Director of Clinical Training (DCT), a Medical Consultant with an interest in Intern education and wellbeing. A key role of the DCT is to oversee the progress of their Interns and to ensure that QPMA requirements for accreditation are being satisfied. Successful completion of each term is a requirement by QPMA for Interns to gain general registration at the end of their internship. If the Intern fails to meet the required standard, the DCT along with the supervising clinician, develop a remediation plan with the aim of assisting the Intern to successfully pass the term. At the end of the year, the DCT liaises with QPMA to notify them of the doctors-in-training who have completed internship.

2.3 Undergraduate learning of clinical reasoning skills

The literature provides evidence that increasing numbers of medical schools regard the explicit teaching of clinical reasoning skills as important, formally including it in their curricula (Fuks, Boudreau & Cassell 2009; Gay, Bartlett & McKinley 2013; Irby 2014; Schmidt & Mamede 2015). Teaching and learning clinical reasoning at JCU includes recruiting junior clinicians to run case-based tutorial sessions for students. These tutors seek to help the students apply their scientific knowledge, the information gathered from a patient history, imaging data and sometimes a physical examination, to arrive at a provisional diagnosis or management plan. With the tacit expectation that these tutors have the knowledge and experience necessary to coach clinical reasoning skills it is not difficult to see that these tutors have a complex and demanding role to fulfil.

While on hospital placement, students observe clinical work and may participate to a limited extent. During these placements, students are taught by practising clinicians. It is reasonable to expect that among a group of clinicians there will be variation in their inclination and expertise in teaching medical students. Due to the complexity of clinical reasoning, it is also reasonable to hypothesise that hospital clinicians will have varying degrees of knowledge and experience in coaching clinical reasoning skills. So, because of this variation between teaching clinicians, due to attitude, aptitude and experience, doctors-in-training may have very different experiences of learning clinical reasoning. To support a consistent minimum standard, it may be beneficial to use a bespoke learning framework which explicitly supports doctors-in-training to acquire clinical reasoning skills in their working context.

Methods for assessing clinical reasoning were discussed earlier in the literature review (Section 1.13). As clinical reasoning cannot be measured directly, several types of assessment are regarded as helpful in their evaluation (Rencic et al. 2016). The assessments used at the undergraduate level include the Key Features Problem (KFP) examination and Objective Structured Clinical Examination (OSCE) to help assess clinical reasoning skills (Harden & Gleeson 1979, Harden 1988; Hrynchak, Glover Takahashi & Nayer 2014; Page, Bordage & Allen 1995). The OSCE and KFP assessments are discussed in more detail in Chapter 3.

2.4 Postgraduate learning of clinical skills

The importance of learning and applying clinical reasoning skills is a repeated theme in the literature (Graber 2009; Gruppen 2017; Pelaccia, Tardif, Triby & Charlin 2011). Learning clinical reasoning skills is an essential aim of both undergraduate and postgraduate medical education (Gruppen 2017).

As discussed in the literature review, accreditation authorities as well as specialist medical colleges, stipulate the need for clinicians to proactively cultivate their clinical reasoning skills (Section 1.1). The Intern end of term report does not explicitly require reporting on clinical reasoning skill development and may therefore provide insufficient scrutiny of the development of core clinical reasoning skills of the individual interns (Norman 2005). Instead, the document requires the Intern be graded on how they:
'*Perform and document a patient assessment - incorporating a problem-focused medical history with a relevant physical examination and generate a valid differential diagnosis'* (Australian Medical Council 2018b, p.2).

Up until the last few decades, the notion of learning medicine through an apprenticeship model was widespread (Bleakley 2002; Dornan 2005). More experienced, senior doctors acted as clinical reasoning role models or coaches for a doctor-in-training during their apprenticeship. In terms used by Vygotsky, the senior doctors acted as the More Knowledgeable Other, helping the doctor-in-training to bridge the Zone of Proximal Development (Vygotsky 1978). The apprenticeship model of learning is under pressure, (Section 1.12) and this may detrimentally impact the ability of doctors-in-training to learn clinical reasoning skills (Dornan 2005). Also, advances in technology have encouraged an increasing reliance on imaging reports for making a clinical diagnosis (Nishimura & Warnes 2017). While imaging reports are useful, over-reliance on them at the expense of deploying a rigorous clinical reasoning process may lead to diagnostic errors or further unnecessary tests (Keijzers et al. 2018).

Compared to their urban colleagues, clinicians working in regional, rural and remote areas tend to have less easy access to some imaging technologies and laboratory-based tests. For these clinicians, it is therefore especially important that they have developed effective clinical reasoning skills as they will not be able to rely on the availability of the technologies readily available to their urban counterparts to assist them in making clinical decisions. The mandate

for establishing the medical school at JCU was to train doctors for work in rural, non-metropolitan locations. Explicitly coaching doctors-in-training, many of whom will work in remote and rural locations, in their learning of clinical reasoning skills is important, and consistent with the aims of the JCU College of Medicine and Dentistry.

Conceptualising and learning clinical reasoning skills is complex and problematic, and it is common for doctors-in-training to have difficulties learning these skills (Audétat et al. 2013). These difficulties are compounded by aspects of the clinical reasoning process being subconscious, and therefore hidden from the learner, for example, intuitive or Type 1 thinking (Cutrer, Sullivan & Fleming 2013). It is helpful if the clinical teacher is familiar with the clinical reasoning literature. Familiarity with the clinical reasoning literature is a demanding requirement, given that it covers many different disciplines including cognitive psychology, educational psychology, medical education and clinical medicine, as discussed in Section 1.3.

In summary, past methods of teaching and learning clinical reasoning skills, such as learning through the apprenticeship model are under pressure (Dornan 2005). Additional pressures to learning and applying clinical reasoning skills include the demands imposed by the exponential growth in medical knowledge, as well as the increasing number of treatment options available (Keijzers et al. 2018). The prevalence and cost of litigation arising from medical errors, including clinical reasoning failures are increasing (Makary & Daniel 2016; Slawomirski, Auraaen & Klazinga 2017). There is, therefore an imperative to better understand how clinical reasoning skills are currently learned, and then to identify methods which better foster these skills for doctors-in-training to help them serve the regional and rural populations.

2.5 Overarching approach to research design

Clinical reasoning is a multi-faceted construct which may be divided into rationalist and empiricist perspectives, as discussed in Chapter 1. These perspectives represent a range of epistemological positions and make use of different methodological approaches in their research. Both quantitative and qualitative methods are important, and their use is determined by the type of research question they address. Quantitative methodologies may be used to identify significant statistical relationships between concepts. Qualitative methods are important in helping to generate cohesive meaning, as well as situating research results within their context. Although medical sciences may be sceptical of qualitative methods, it is

noteworthy that clinicians regularly use qualitative enquiry when making clinical decisions (Malterud 2001; Sofaer 2002). Creating meaning from different types of clinical data, regardless of whether they are numerical or descriptive, and then using previously acquired knowledge to create understanding, means that clinical reasoning is an interpretive practice (Montgomery 2005). The crux of this research project explores how doctors-in-training gather, learn to interpret clinical information and then use this interpretation of events to make a patient diagnosis or generate a management plan.

This program of research uses both qualitative and quantitative methods to explore the four situational factors initially mentioned in Section 1.14, namely *'Self-regulated learning – metacognitive awareness'*, *'Learning climate'*, *'Consultants as role models'* and *'Interns as learners'*. Data from the two qualitative studies ('*Consultants as role models'* and '*Interns as learners'*) triangulate the data from the quantitative studies to support the trustworthiness of the overall research findings (Liamputtong 2013). The qualitative studies demonstrate a complementarity of approach by exploring different vantage points of the same learning process from the Intern and Consultant perspectives (Liamputtong 2013). The reliability and credibility of the combined research findings are supported by integrating these triangulated approaches into the overall research design. As well as articulating the rationale behind the overarching research design, it may also be helpful to understand the background and perspective of the researcher.

2.6 Researcher perspective

I have an academic and employment background as a secondary school science teacher. Before this research project, I worked in the Medical Education Unit of the Townsville Hospital, and then later at James Cook University College of Medicine and Dentistry. During this time, I became interested in how to improve the way doctors-in-training learn clinical reasoning skills. My role and the support of colleagues enabled me to seek volunteers for this research project from medical students, Interns and Consultant Physicians. The lens through which this research was undertaken was influenced by my education-focused, non-clinical background as well as my employment at the same hospital and university researched in this thesis. Having an educational rather than a clinical background may have influenced the way I interpreted and synthesised meaning from this research. However, two of my Supervisors were medical doctors which helped to provide a greater clinical perspective on the design and analysis of the research.

2.7 Research questions

The aim of this program of research was to understand how doctors-in-training learn clinical reasoning skills. The secondary focus was to then identify a learning framework, based on the research outcomes, to better support the learning of clinical reasoning skills for doctors-in-training.

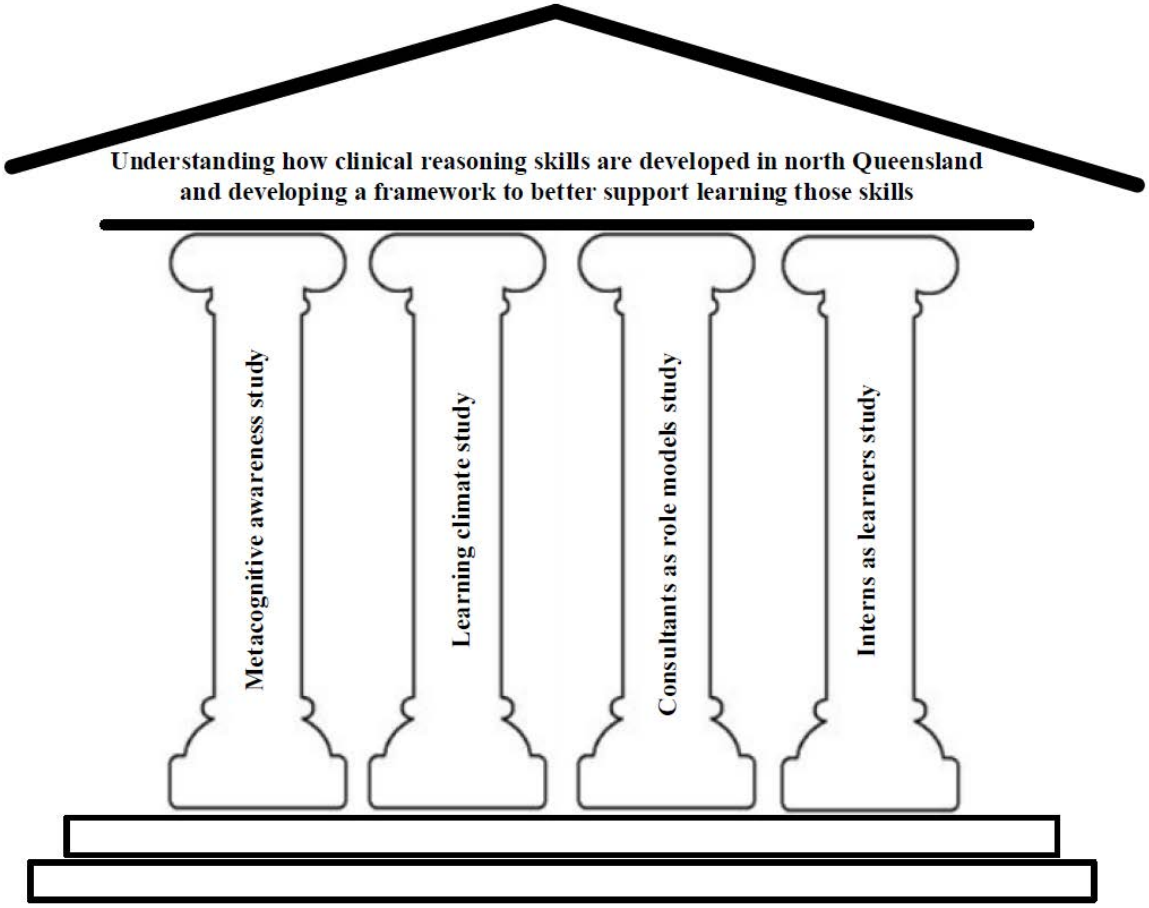

Figure 2.1 Overview of the program of research

The research questions for each of the four situational factor studies are outlined below. Individually they provide only a single perspective in helping to answer the overarching research questions. Figure 2.1 shows how together these complementary research lenses support a more comprehensive understanding of how clinical reasoning skills are learned and may help to provide evidence for how this could be improved. The data from the four studies were synthesised in Chapter 7, in conjunction with the current literature, to identify a 'good fit' learning model. Table 2.1 below, provides an overview of the research within each of the four situational factors.

Table 2.1 Overview of the four situational factor research studies

Name of situational factor study	**Research questions**	**Method**	**Rationale for methodology**	**Type of data generated**	**How the study complements the overarching research question**
1. Self-regulated learning - *Metacognition*	1. Does metacognitive awareness correlate with performance in undergraduate medical examinations? 2. Is there an increase in metacognitive awareness from first to the fifth year of the undergraduate medical course?	Use of the Metacognitive Awareness Inventory (MAI) (Schraw & Dennison 1994)	The MAI is a suitable, valid and reliable instrument. Provides data that can be correlated with undergraduate examination performance.	Quantitative. Scores in MAI and undergraduate examinations correlated.	Metacognitive skills (monitoring and regulation of cognition) are important for clinical reasoning expertise. Results may indicate metacognitive skills need to be coached at the undergraduate level and postgraduate level as indicated in the literature (Burman, Boscardin & Van Schaik 2014; Colbert et al. 2015)
2. *Learning climate*	3. To what extent is the learning climate in the General Medicine unit conducive to learning?	Use of the Dutch Residency Educational Climate Test (D-RECT) (Boor et al. 2011)	The D-RECT is a relevant, reliable and valid instrument designed for use in this context (Pinnock et al. 2013; Silkens et al. 2015)	Quantitative. Likert scale	Provides Intern perspective on their learning climate across key domains.

Name of situational factor study	Research questions	Method	Rationale for methodology	Type of data generated	How the study complements the overarching research question
3. *Consultants as role models*	4. What do Consultants understand clinical reasoning to be? 5. How do they understand they acquired their clinical reasoning skills? 6 How do they seek to foster these skills among doctors-in-training?	Semi-structured interviews with General Medicine Consultants. Audio recorded, transcribed verbatim and then thematically analysed (Braun & Clarke 2006)	Understand how Consultants understand and seek to cultivate clinical reasoning skills for doctors-in-training	Qualitative. Interview transcripts	Provides Consultant perspectives on what they the way they understand clinical reasoning, and how they seek to coach it.
4. *Interns as learners*	7. 'How do interns in medicine experience learning clinical reasoning skills'	Initial teaching session. Subsequent stimulated recall interviews audio-recorded transcribed verbatim and then thematically analysed (Braun & Clarke 2006)	Stimulus material aids recall of learning occasions during the Intern General Medicine term	Qualitative. Interview transcripts	This study provides triangulation for situational factor study numbers 1 and 2. Additional themes developed from interviews may be incorporated into the tailored clinical reasoning learning framework

2.7.1 Four situational factor research studies

2.7.1.1 *'Metacognitive awareness'*

Metacognition is the process of reflecting upon, and then being able to regulate one's thinking (Flavell 1979). Metacognitive skills are regarded as a core attribute of clinical reasoning expertise but are not generally taught or assessed at undergraduate or postgraduate levels (Burman, Boscardin & Van Schaik 2014; Colbert et al. 2015).

The research questions were:

1. *Does metacognitive awareness correlate with performance in undergraduate examinations?*
2. *Is there an increase in metacognitive awareness from first to the fifth year of the undergraduate medical course?*

The answers to these questions will help inform the identification and subsequent modification or refinement, of a learning framework to support doctors-in-training to learn clinical reasoning skills in north Queensland.

2.7.1.2. *'Learning climate'*

Doctors-in-training learn clinical reasoning skills within the clinical context (Durning, Ratcliffe, et al. 2013; Gruppen 2017), and the learning climate of that context is important for learning (Boor et al. 2011; Roff & McAleer 2001). The General Medicine term of internship is a focus of study in this program of works (Section 2.2.2).

The research question was:

1. *To what extent is the intern's current learning climate conducive to learning'?*

Measuring the learning climate across each of the core Intern terms enabled a comparison between them.

2.7.1.3 *'Consultants as role models'*

Consultants are regarded as clinical reasoning experts, acting as mentors and clinical supervisors to doctors-in-training. Consultants role model clinical reasoning skills to doctors-in-training (Irby 1986; Passi & Johnson 2016a). This study sought to explore how Consultants understood their own development of clinical reasoning skills, as well as how they seek to foster these skills among doctors-in-training.

The research questions were:

1. *What do Consultants understand clinical reasoning to be?*
2. *How do they understand they acquired their clinical reasoning skills?*
3. *How do they seek to foster these skills among doctors-in-training?*

2.7.1.4 *'Interns as learners'*

The Intern doctors-in-training are at a critical transition stage in their professional development. This study sought to comprehend how Interns understand their own development of clinical reasoning skills complemented by the findings from research in situational factors 2 and 3 and develop an understanding of the barriers and enablers to them learning.

The research questions were:

1. *'How do interns in medicine experience learning clinical reasoning skills'*

Taken as a whole, the research questions provide a framework to understand the different ways clinicians experience and learn clinical reasoning skills. The thesis structure outline that follows briefly describes how these studies were undertaken, and then how they were synthesised to provide evidence for the proposed learning framework.

2.8 Structure of the thesis

Chapter 1 concluded by identifying four situational factors that influence how doctors-in-training acquire clinical reasoning skills. The research questions that link with each of these situational factors are detailed above. The following chapters explain how these situational factors were each explored. The final sections of the thesis synthesise the results from the four

separate situational factor studies to propose a context-specific learning framework, supported by the outcomes of this program of research.

Chapter 3 explores situational factor 1, '*Metacognitive awareness'*. Self-regulated learning is regarded as vital for adult learners, and recent studies have shown that senior medical students are increasingly aware of its importance (Bruin, Dunlosky & Cavalcanti 2017; Carr & Johnson 2013). Metacognitive awareness is a key component of self-regulated learning, helping the learner to monitor and regulate their thinking and potentially reduce cognitive error rates (Cutrer, Sullivan & Fleming 2013; Kiesewetter et al. 2016). The literature provides compelling evidence that metacognitive awareness is linked with expertise in clinical reasoning (Colbert et al. 2015; Croskerry 2000; Dunphy et al. 2010). However, cognitive and metacognitive skills are not correlated with each other (Burman, Boscardin & Van Schaik 2014). This study measured the metacognitive awareness of medical undergraduates using the Metacognitive Awareness Inventory (MAI) survey instrument (Schraw & Dennison 1994). The medical undergraduate MAI scores were then correlated with their examination scores. Some of the undergraduate examinations, such as the Key Features Problem (KFP) examination and the Objective Structured Clinical Examination (OSCE), discussed in Section 2.3, are regarded as important indicators of clinical reasoning ability (Hrynchak, Glover Takahashi & Nayer 2014). In addition, the variation in metacognitive awareness scores across progressive years of undergraduate study was reported and discussed.

Chapter 4 explores situational factor 2, '*The Learning climate'* of Intern doctors-in-training at The Townsville Hospital, where the research was conducted in north Queensland. The learning climate was measured using the Dutch Resident Education Climate Test (D-RECT) instrument (Boor et al. 2011). Using the D-RECT, the three core Intern terms (General Medicine, Emergency Medicine and General Surgery) were quantitatively compared across eleven domains. The importance of these domains in acquiring clinical reasoning skills was evaluated and discussed.

Chapter 5 explores situational factor 3 – '*Consultants as role models'* Learning through the help of role models is regarded as an important modality in medical education (Passi et al. 2013). A semi-structured interview framework was developed and used when interviewing the general physicians at the north Queensland hospital. The interviews explored how Consultant

physicians understood, experienced learning, and seek to nurture clinical reasoning skills among their doctors-in-training. The interviews were transcribed verbatim and then thematically analysed to generate themes which were then discussed.

Chapter 6 explores situational factor 4 – '*Interns as learners'*. This study investigated how Interns in their General Medicine term experienced learning clinical reasoning skills. At the start of each of the five terms, a presentation exploring basic information about clinical reasoning was given to each cohort of Interns. The presentation ensured all Interns in this study were given the same information at the start of the term. Consenting volunteers agreed to be interviewed at the end of the term. A stimulated recall method was used to explore how Interns had experienced learning clinical reasoning skills during that term (Lyle 2003). The stimulus materials for the interviews were paper copies of the PowerPoint slides from the presentation at the start of the term. The interviews explored how Interns reflected on their experiences of learning during the previous term. Twenty-seven Intern interviews, over five terms were audio-recorded, transcribed verbatim and then thematically analysed and discussed.

The final part of the thesis is Chapter 7 – Synthesis and Proposed Framework. Integrating the research findings identified the local enablers and barriers to learning clinical reasoning skills. Understanding these enablers and barriers, in conjunction with a careful examination of the literature, facilitated the identification of an overarching learning framework. Informed by the literature and this program of research, the modified learning framework is likely to better foster the development of clinical reasoning skills by doctors-in-training in north Queensland.

Chapter 3: Metacognitive awareness

3.1 Introduction

Chapter 2 identified four situational factors which influence how doctors-in-training learn clinical reasoning skills. This chapter explores metacognitive awareness. The first part of this chapter investigates the construct of metacognition and its relevance to the development of clinical reasoning skills. Metacognitive skills form part of self-regulated learning (Bruin, Dunlosky & Cavalcanti 2017; Gönüllü & Artar 2014). The focus of this chapter explores the metacognitive awareness skills of doctors-in-training and their correlation with their undergraduate examination performance. At the undergraduate level, clinical reasoning skills are assessed using several different types of examination, as no single assessment instrument is regarded as adequate (Rencic et al. 2016). The research questions, the method and results lead to the discussion section at the end of this chapter. Based on the findings from this study, recommendations are proposed, while the limitations of this study are acknowledged.

3.2 Self-regulated learning and metacognition

Understanding self-regulated learning among medical students has attracted attention from medical educators in recent years for two reasons (Bruin, Dunlosky & Cavalcanti 2017; Song, Kalet & Plass 2011). Firstly, self-regulated factors have been identified as a source of differences in achievement between students (Zimmerman & Pons 1986). Secondly, self-regulated learning (SRL) has been demonstrated as an effective means of raising student achievement (Schunk 1981). In the 1980s, Schunk observed that students who are proactive self-regulators set goals, devise and implement effective learning strategies, create an effective learning environment, seek feedback and help when necessary, show tenacity as well as self-monitoring and can effectively assess their progress towards specific goals (Zimmerman & Schunk 2011). Studies have shown that metacognitive skills, a component of SRL, increase during adolescence, plateau during early adulthood and then decline in older age (Palmer, David & Fleming 2014; Weil et al. 2013). Effective SRL skills are positively associated with superior levels of student achievement, as well as with the development of expertise in clinical reasoning (Zimmerman & Schunk 2011).

3.3 Metacognition

Cognition relates to processes associated with learning, thinking and memory (Corsini 2001). Metacognition, however, encompasses the ability of a person to understand, monitor and regulate their thinking, and is important for facilitating problem-solving and for controlling reasoning processes (Medina, Castleberry & Persky 2017; Schraw & Dennison 1994). Clinicians use metacognitive skills to identify their own learning gaps, which is important for career-long learning (Murdoch-Eaton & Whittle 2012; Schön & DeSanctis 1986). Cognition and metacognition both involve using information to solve problems and make decisions.

It is important to recognise, however, that cognitive and metacognitive skills do not necessarily correlate with each other (Burman, Boscardin & Van Schaik 2014). Several studies indicate that doctors-in-training may have limited metacognitive skills and that these skills are normally not assessed during training (Bruin, Dunlosky & Cavalcanti 2017; Burman, Boscardin & Van Schaik 2014; Colbert et al. 2015). What is clear from the literature, however is that metacognitive skills have an important function in helping to monitor and regulate the clinical reasoning process.

Metacognitive awareness skills can be broadly split into the knowledge of cognition and the regulation of cognition (Schraw & Dennison 1994). Knowledge of cognition enables people to have knowledge about their thinking and learning processes (Gönüllü & Artar 2014; Schraw 1998). The regulation of cognition enables individuals to self-monitor the effectiveness of their learning and decision making; skills vital to all clinicians, regardless of whether they are students or experts (Bruin, Dunlosky & Cavalcanti 2017).

Knowledge of cognition is comprised of declarative, procedural and conditional knowledge. Declarative knowledge consists of knowing about things, and covers facts, information, events, rules and processes. It involves networks of facts, is public knowledge and originates from what a teacher states or declares (Anderson 1982). In order for it to be understood, knowledge must be encoded declaratively and then interpreted. For knowledge to be converted into behaviour, it must first go through this interpretive stage. Declarative knowledge may be thought of as conceptual, propositional, descriptive or explicit knowledge.

When declarative knowledge is put to work and transforms into knowing how to do something, it becomes procedural knowledge, during the transformation of which it undergoes a process of continual refinement with increases in processing speed. Procedural knowledge implies the use of knowledge or implicit knowledge and is a behaviour or skill. If knowing when, and why to use a particular skill is important, it becomes conditional knowledge, which involves the regulation of memory, thought and learning (Ackerman & Zalmanov 2012).

Regulation of cognition helps students to control or manage their learning or decision making, for example, medical students may ask themselves if they understood the significance of a specific piece of clinical data, or if they understood the rationale behind a clinical decision or management plan. Regulation of Cognition comprises planning, information management, monitoring, debugging and evaluation (Schraw & Dennison 1994).

Planning involves choosing the best strategy as well as managing the required information, to achieve the desired outcome. Monitoring refers to the ability to self-test the progress being made on a task. Debugging strategies involve intentionally looking for dis-confirmatory evidence, in order to reduce the risk of confirmation biases and premature closure. Croskerry explains the passive tendency to sidestep debugging one's thinking succinctly: '*When the diagnosis has been made, the thinking stops'* (Croskerry 2003b, p. 778).

Actively looking for dis-confirmatory evidence, which is likely to challenge the decision-making momentum, requires additional cognitive effort. Finally, evaluation refers to the ability to globally assess the progress towards solving a clinical problem or gaining mastery in learning.

3.4 Metacognition and clinical reasoning

Metacognition is 'thinking about thinking' and has been studied since the early 1970s (Colbert et al. 2015; Fernandez-Duque, Baird & Posner 2000; Flavell 1979). Kuhn (2000) noted that as metacognition becomes more explicit, powerful and effective, it increasingly comes under conscious control. However, not all adults can bring their metacognitive capabilities to the level of conscious control, which greatly limits their ability to self-regulate their thinking and learning (Kuhn 2000).

The constructivist theory of learning proposes that we assimilate new information by synthesising it with existing knowledge (Piaget 1959). This process of constructing knowledge builds and expands the individuals' knowledge, contributing to the development of expertise (Section 1.9.1). For new knowledge to be assimilated, there needs to be some relevant existing knowledge and understanding onto which the new knowledge can be added. This building, synthesising and linking of new information with an existing schema is partly controlled using the metacognitive skills of the individual (Fraser & Greenhalgh 2001).

For a doctor-in-training, the complex, high-stakes nature of the clinical work environment underscores the need to monitor and regulate their clinical reasoning processes (Marcum 2012). Figure 3.1, below, shows how sub-domains of the Knowledge Cognition domain help the clinician to encode and interpret new information by linking it to existing knowledge structures, such as their pre-existing illness scripts (Sections 1.10.3 and 1.10.4). This new knowledge may then be used in the clinical reasoning process. Knowledge already possessed by the doctor-in-training may then guide them to seek additional patient data, as well as helping them to make meaning from the clinical findings. As the individual plans, monitors and evaluates new information in the light of existing knowledge, the constituents of the Regulation of Cognition sub-domains interact with all stages of the clinical reasoning cycle. As doctors-in-training make use of debugging strategies they test their reasoning for its robustness (Croskerry 2003a). Clinical reasoning is an iterative process (Charlin et al. 2012). It may take place rapidly and with little guidance, but this may increase the clinical reasoning error rate (Croskerry 2003b; Graber 2003; Kiesewetter et al. 2016). Figure 3.1 below shows how metacognitive awareness is involved in clinical reasoning processes.

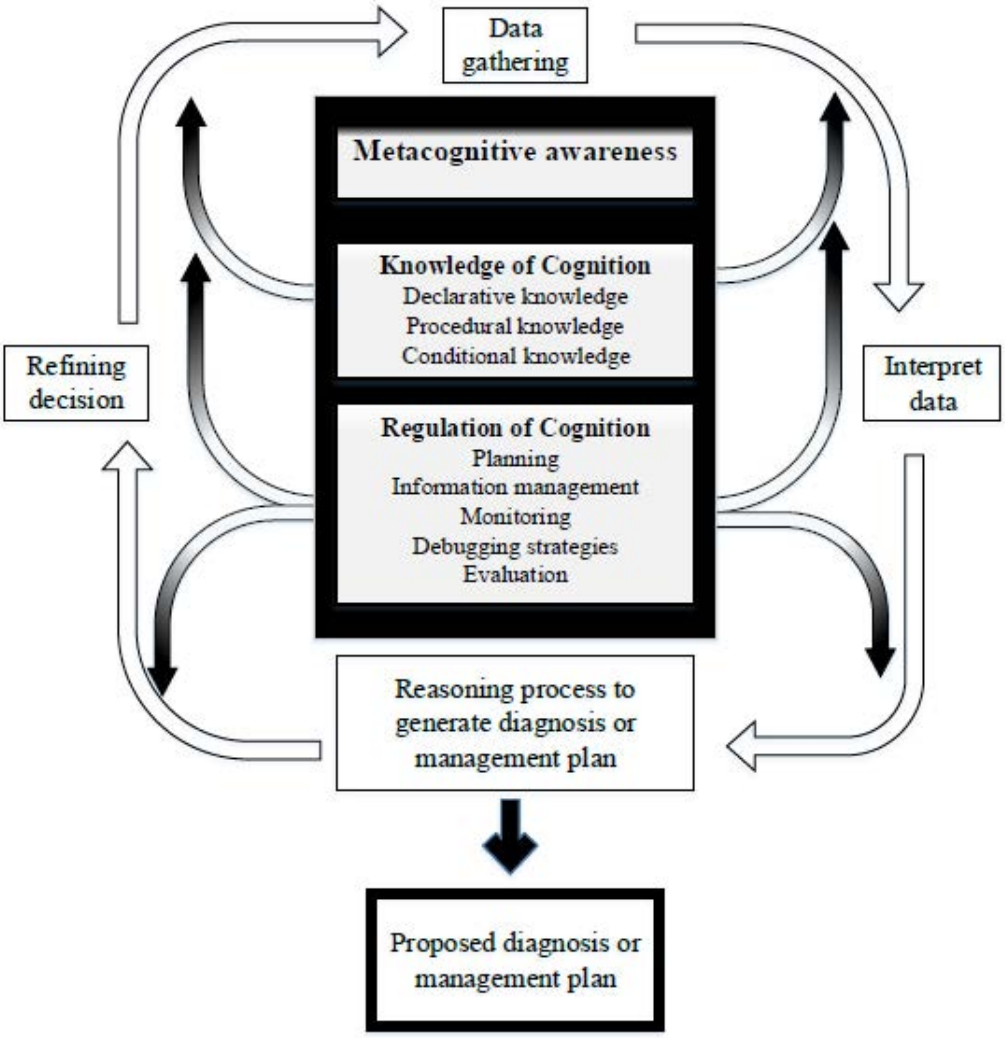

Figure 3.1 The role of metacognitive awareness in the clinical reasoning process

Source: Welch et al. (2018) p.4

3.5 Metacognitive failures linked to clinical reasoning errors

Clinical reasoning failures in medical practice have significant consequences, which were discussed in Section 1.11. These failures impact upon patient safety and increase the risk of malpractice claims (Nendaz & Perrier 2012; Shojania et al. 2003). In addition, increased time in hospital after complications due to diagnostic delay or error is a major cost to health authorities and insurance companies (Saber Tehrani et al. 2013; Slawomirski, Auraaen & Klazinga 2017). The literature provides a compelling case that many of these errors may be due to preventable failures in human thinking (Croskerry 2003a). Clinical reasoning errors are not generally related to inadequate knowledge, but to flaws in data collection and the way

information is synthesised (Nendaz & Perrier 2012; Shojania et al. 2003). Errors in clinical reasoning suggest metacognitive failures in the monitoring and regulation of decision making (Croskerry 2003b). The importance of being able to self-detect and then correct faulty thinking is important for reducing errors. Effective metacognitive skills are a core necessity for developing, and maintaining medical expertise (Mamede, Schmidt & Rikers 2007). This view is also supported by Hays et al. (2002), who indicated that a lack of metacognitive awareness deprives clinicians of their ability to self-regulate their practice, as they lack the skills to both detect and then subsequently improve their performance (Kruger & Dunning 1999). Medical accreditation authorities now seek to mandate the development of self-regulated learning skills, including metacognitive skills.

3.6 Medical accreditation and metacognition

Many accreditation authorities indirectly identify metacognitive skills as important. The Australian Curriculum Framework for Junior Doctors (ACFJD) states the importance of metacognitive skill development by requiring that a junior doctor: '*…identifies and addresses personal learning objectives*' and '*seeks opportunities to reflect on and learn from clinical practice*' (Confederation of Postgraduate Medical Education Councils 2016).

Using the terminology of metacognition, this could be explained in terms of regulation of cognition by monitoring their learning strategies, and evaluation of their performance and the strategies used after a learning event (Schraw & Dennison 1994). Medical residents in Canada have similar requirements to regulate their cognition using evaluation skills and are expected to: '*demonstrate insight into their own limitations of expertise via self-assessment*' (Frank 2005, p. 11).

The Australian and Canadian regulatory requirements are similar to those of the USA and UK. The expectation is that junior doctors will possess and be able to efficiently apply metacognitive skills to foster their own learning.

3.7 Measuring metacognitive awareness

The Metacognitive Awareness Inventory (MAI) was developed to quantify the different components of metacognitive awareness (Schraw & Dennison 1994). This study uses the MAI

instrument which has been used before in medical undergraduate research (Hong et al. 2015; Panchu et al. 2016). However, the MAI has not been statistically validated for use in the medical education context. The MAI has sub-scales within the Knowledge of Cognition domain including *declarative knowledge*, *procedural knowledge*, and *conditional knowledge* (Table 3.1). From the perspective of clinical reasoning, it is important for clinicians to understand how knowledge is added to what they already know about the signs and symptoms of a patient. This knowledge about patient medical data is declarative knowledge (Schraw & Moshman 1995). Procedural knowledge is concerned with how practical procedures are sequenced and executed, for example how a patient abdomen is palpated to feel for an enlarged liver. Conditional knowledge is knowing why and when to apply various cognitive actions, for example knowing which heart sounds to listen for, based on the result of a patient ECG and history (Schraw & Moshman 1995).

The second domain of the MAI is Regulation of Cognition and is associated with controlling one's thinking and learning. There are five sub domains within this domain including *Planning*, *Information Management*, *Monitoring*, *Debugging* and *Evaluation* (Schraw & Dennison 1994). *Planning* involves controlling thinking and actively developing a strategy for solving a clinical problem. *Information Management* means actively reflecting on whether there has been enough information gathered to enable a decision making. If there is insufficient information, the clinician may develop a strategy to obtain the extra information he/she needs to make the decision. *Monitoring* means the real-time awareness of how the clinicians are utilising the information they are receiving and checking how they are performing clinically. *Debugging* techniques may be used to correct understanding and performance errors.

Table 3.1 Components of the Metacognitive Awareness Inventory (MAI)

	Knowledge of cognition	**Regulation of cognition**
Sub-scales		Planning
	Declarative knowledge	Information management
	Procedural knowledge	Monitoring
	Conditional knowledge	Debugging strategies
		Evaluation
	Overall Metacognitive Awareness Inventory score	

Source: Schraw & Dennison (1994)

For example, a student may consider why he/she placed undue emphasis on a particular clinical detail which then took his/her thinking to an incorrect conclusion. Finally, the *Evaluation* sub-scale is linked with analysing the whole decision-making process and reflecting on its effectiveness. This evaluation step is particularly important in enabling the learner to deliberately and consciously make better decisions next time (Ericsson 2004).

3.8 Medical undergraduate examinations

A variety of examinations are used by the JCU College of Medicine and Dentistry to test knowledge and clinical skills, including the OSCE, KFP and MSAT. An OSCE is a focused examination consisting of approximately 20 stations at which students may be asked to take a patient history, examine a part of the body or interpret a laboratory report (Harden 1988). These tasks form part of the information gathering and analysis components of the clinical reasoning process (Welch et al. 2017). The OSCE is a commonly used and highly regarded method of assessment around the world, both in undergraduate and postgraduate examinations (Harden & Gleeson 1979).

The KFP examinations were designed as a means of evaluating clinical problem solving and decision-making skills (Page, Bordage & Allen 1995). The examination is a written test consisting of between 15-20 brief cases in which the student is required to make qualified decisions based on the information presented. The MSAT has strong similarities to the OSCE, but is adapted for medical students in years 1-3 at JCU.

Studies have shown that metacognitive awareness allows individuals to plan, sequence and monitor their learning in a way that improves their overall examination performance (Swanson 1990). Metacognitive skills are essential for any complex learning process, but there is a lack of evidence connecting metacognitive awareness with performance in medical school examinations. This study investigated how metacognitive skills are associated with performance in undergraduate medical examinations.

3.9 Research hypotheses

It was firstly hypothesised that that metacognitive awareness levels would positively correlate with undergraduate examination scores. Secondly, it was hypothesised that there would be an increase in metacognitive awareness scores between the first and the fifth-year of the medical course at JCU.

3.10 Ethical considerations

Ethical approval H6008 was obtained from the Human Research Ethics Committee (HREC) of James Cook University, Queensland. The researcher had no direct connection with medical undergraduates and was therefore not in a position of influence over them. Undergraduates in the first and fifth-year were invited to participate in this study by email. All academic performance data was de-identified by the College of Medicine and Dentistry Assessment Unit before analysis by the researcher. The data was stored in and retrieved from password protected electronic files.

3.11 Method

The Metacognitive Awareness Inventory (MAI) detailed in Appendix 1, was deployed via the *Smart Sparrow* online platform and consisted of a series of 52 short statements (Schraw & Dennison 1994; Smart Sparrow accessed on Sept 1 2014). *Smart Sparrow* was used in this study to enable the participants to complete the MAI survey instrument online. *Smart Sparrow* collated the completed MAI surveys for statistical analysis by the researcher. This study sought to determine if there were changes in metacognitive awareness between the first and fifth-year undergraduate students. Participants also gave permission for the researcher to access their examination scores.

The inventory required participants to indicate their level of agreement with each statement by positioning a sliding point on a 10-point scale bar. The far right of the scale bar (10) indicated strong agreement, while the far left (1) denoted strong disagreement. Individual statement item scores ranged from 1-10, and scores for each sub-scale were totalled and recorded as a percentage of the maximum available for each sub-scale. Following online completion and

submission of the MAI, participants were given a breakdown of their percentage scores in each of the eight sub-scales and feedback about how they could improve their skills in each domain.

The MAI Knowledge of Cognition domain was calculated as the mean score of the *declarative*, *procedura*l and *conditional knowledge* scores, while the Regulation of Cognition domain score was the mean score for the *planning, information strategies, monitoring, debugging strategies* and *evaluation* sub-domains.

For participating first-year medical undergraduates (43 from a total of 197; 22%, with 19 male and 24 female students), the mean age was 19.19 (SD = 2.7) years. The ratio of female participating students was the same as for the first-year cohort, 56%. For the fifth-year students (13/177; 8%, with seven male and six female students) their mean age was 25.69 (SD= 6.16) years. The ratio of female participating students was 46%, lower than the proportion of female students in the fifth-year cohort, 53%. This study was undertaken in September 2015. The student participation rates for this study were much lower than expected, which was an important limitation of this study and is addressed in more detail in Section 3.13 and Chapter 7 - Synthesis and Proposed Framework. Two types of measurement instrument were used, medical school examination results and the metacognitive awareness inventory (MAI). Table 3.2 shows the different domains of the MAI and the number of questions asked in each domain.

Table 3.2 Composition of the MAI

Domain ID	Domain	No. of questions	Percentage
DK	Declarative Knowledge	8	15.4%
PK	Procedural Knowledge	4	7.7%
CK	Conditional Knowledge	5	9.6%
P	Planning	7	13.5%
IMS	Information Management Strategies	9	17.3%
M	Monitoring	7	13.5%
DS	Debugging Strategies	5	9.6%
E	Evaluation	6	11.5%
	Blank	1	1.9%
	Total	52	100%

Appendix 1, Source: Schraw & Dennison (1994)

The following student examination scores were obtained from consenting participants, depending on their year of the undergraduate medical program.

- First year: Overall year mark, end of year Multi-Station Assessment Task (MSAT) examinations, Key Features Problem (KFP) examination scores.
- Fifth year: Overall year mark, end of year Objective Structured Clinical Examination (OSCE) and their Key Features Paper (KFP).

Descriptive statistics were used to characterise the sample. The data were not normally distributed so Spearman's correlation was used for correlation calculations. The Spearman's coefficient, r_s**,** the 95% confidence intervals, CI, and the p values are indicated below for Tables 3.3 and 3.4 along with the scale used for interpreting the Spearman's correlation coefficient. The effect size may be determined by comparing the r_s value with scale for interpreting the Spearman's correlation coefficient. Mann-Whitney tests were performed to examine any differences in MAI scores between first- and fifth-year students.

3.12 Results

The results in Table 3.3 and 3.4 below show the results for the first-year (MBBS Year 1) and fifth-year (MBBS Year 5) student MAI scores correlated with their examination scores. Only significant correlations are shown for ease of comprehending the data. Where there is no significant correlation (ns) between the domain or subscale and the examination result, this is indicated in the respective Table.

Table 3.3 Metacognitive awareness study results for first-year undergraduates

Overall examination results					
Knowledge of Cognition	r_s (CI)	p	Regulation of Cognition	r_s (CI)	p
Declarative knowledge	0.31 (0.01 – 0.55)	0.04	Planning		ns
Procedural knowledge		ns	Information Management strategies		ns
Conditional knowledge	0.33 (0.03 – 0.57)	0.03	Monitoring		ns
			Debugging strategies		ns
Knowledge of Cognition domain	0.32 (0.02 – 0.56)	0.04	Evaluation		ns
MAI overall		ns	Regulation of Cognition domain		ns
MSAT year 1 / OSCE year 5					
Knowledge of Cognition	r_s (CI)	p	Regulation of Cognition	r_s (CI)	p
Declarative knowledge		ns	Planning		ns
Procedural knowledge		ns	Information Management strategies		ns
Conditional knowledge	0.29 (0.00 – 0.49)	0.04	Monitoring		ns
			Debugging strategies		ns
Knowledge of Cognition domain		ns	Evaluation		ns
MAI overall		ns	Regulation of Cognition domain		ns

KFP					
Knowledge of Cognition	r_s (CI)	p	Regulation of Cognition	r_s (CI)	p
Declarative knowledge	0.4 (0.04 – 0.58)	0.03	Planning		ns
Procedural knowledge		ns	Information Management strategies		ns
Conditional knowledge	0.33 (0.02 – 0.57)	0.03	Monitoring		ns
			Debugging strategies		ns
Knowledge of Cognition domain	0.32 (0.04 – 0.58)	0.03	Evaluation		ns
MAI overall		ns	Regulation of Cognition domain		ns

Scale for interpreting the Spearman's correlation coefficient

r_s, = 0.0 - 0.3 negligible; r_s, =0.3 - 0.5 low positive; r_s, = 0.5 - 0.7 moderate positive; r_s, = 0.7 - 0.9; high positive; r_s, = 0.9 - 1.0 very high positive (Hinkle, Wiersma & Jurs 2003)

Confidence intervals (CI); **Probability** (p) significant and reported if $p < 0.05$; ns = not significant

Table 3.4 Metacognitive awareness study results for fifth-year undergraduates

Overall examination result					
Knowledge of Cognition	r_s (CI)	p	Regulation of Cognition	r_s (CI)	p
Declarative knowledge	0.58 (0.27- 0.82)	0.04	Planning		ns
Procedural knowledge		ns	Information Management strategies	0.60 (0.28 – 0.84)	0.04
Conditional knowledge	0.61 (0.31 – 0.83)	0.04	Monitoring		ns
			Debugging strategies		ns
Knowledge of Cognition domain	0.69 (0.33 – 0.80)	0.04	Evaluation		ns
MAI overall		ns	Regulation of Cognition domain		ns
OSCE year 5 / MSAT year 1					
Knowledge of Cognition	r_s (CI)	p	Regulation of Cognition	r_s (CI)	p
Declarative knowledge		ns	Planning	0.61 (0.18 – 0.82)	0.04
Procedural knowledge		ns	Information Management strategies	0.58 (0.11 – 0.77)	0.04
Conditional knowledge		ns	Monitoring		ns
			Debugging strategies		ns
Knowledge of Cognition domain		ns	Evaluation		ns
MAI overall		ns	Regulation of Cognition domain	0.48 (0.07 – 0.71)	0.04

KFP					
Knowledge of Cognition	r_s (CI)	p	Regulation of Cognition	r_s (CI)	p
Declarative knowledge	0.74 (0.33- 0.94)	0.01	Planning	0.50 (0.18 – 0.74)	0.04
Procedural knowledge	0.62 (0.18 – 0.84)	0.02	Info. Management strategies	0.58 – (0.21 – 0.79)	0.03
Conditional knowledge	0.76 (0.33 – 0.92)	0.01	Monitoring		ns
			Debugging strategies		ns
Knowledge of Cognition domain	0.82 (0.41 – 0.95)	0.01	Evaluation	0.50 (0.21 – 73)	0.04
MAI overall	0.63 (0.30 – 0.83)	0.01	Regulation of Cognition domain	0.62 (0.26 – 0.82)	0.02

Scale for interpreting the Spearman's correlation coefficient

r_s, = 0.0 - 0.3 negligible; r_s, =0.3 - 0.5 low positive; r_s, = 0.5 - 0.7 moderate positive; r_s, = 0.7 - 0.9; high positive; r_s, = 0.9 - 1.0 very high positive (Hinkle, Wiersma & Jurs 2003)

Confidence intervals (CI); **Probability** (p) significant and reported if $p < 0.05$; ns = not significant

The first research question hypothesised that MAI scores would correlate with examination scores. The first-year students' overall examination result for the year had a low, but significant correlation with the Knowledge of Cognition domain scores of the MAI (r=0.32, p<0.04) and their Key Features Problem examination result also had a low but significant correlation with the Knowledge of Cognition domain score (r=0.32, p<0.03). There were no significant correlations within the Regulation of Cognition domain scores for the first-year student examination results.

The fifth-year students' overall end of year examination result was moderately correlated with the Knowledge of Cognition domain score (r= 0.69, p<0.04) and their Key Features Problem examination (KFP) were highly correlated with the Knowledge of Cognition domain (r= 0.82, p<0.01). The Regulation of Cognition domain was moderately correlated with performance in the KFP examination (r= 0.62, p<0.02) and there was a low correlation with the Regulation of Cognition domain score for their OSCE examination (r= 0.48, p<0.04). The fifth-year overall MAI score was moderately correlated with performance in the KFP examination (r= 0.63, P<0.01).

In comparing the first and fifth-year overall MAI results, no statistically significant differences were found. There were also no significant correlations between first and fifth-year students for the Regulation of Cognition domain or any of its subdomains.

3.13 Discussion

The MAI enabled measurement of a generalised trait in contrast to instruments such as the Script Concordance Test which are used to measure decision making in a specific domain (Section 1.13). This paradox is explained by the need for the doctor to possess and manipulate specific domain knowledge for decision making. How that clinical knowledge is used requires a variety of cognitive and metacognitive skills, some of which are of a more general nature – such as metacognitive awareness.

The sample size for this study was low, affecting the stand-alone validity and reliability of the results. The metacognitive awareness study, however, was one of four studies in the multi-methods research design, and offers a useful perspective for understanding how doctors-in-training learn. The multi-methods research design avoids reliance on an individual study, and

is supported by the results from the other three studies (Section 2.7). The overall examination performances of the first and fifth-year students were not significantly different from the overall mean results for their cohorts, meaning the participants in this study were representative of their year cohort.

For first-year students, the Knowledge of Cognition domain and some of its sub-scales were correlated with examination performance. However, the relative unimportance of the Regulation of Cognition domain would imply that performing well in first-year examinations is not significantly correlated with the skills of self-monitoring, self-evaluation and information management strategies (some of the sub-scales of the Regulation of Cognition domain).

When undergraduate students reach their fifth-year, both the Knowledge and Regulation of Cognition domains show important correlations with undergraduate examination performance. The most notable difference between the first and fifth-year students is the increased importance of the Regulation of Cognition domain. For the fifth-year students, the results of this research show an increasing necessity to regulate their cognition in clinical examinations like the KFP and OSCE.

During the fifth-year students spend a much greater proportion of their time within the clinical environment. Trowbridge et al. (2015) argued that examinations such as OSCE and KFP are aimed at developing clinical skills and testing the application of knowledge in a clinical setting. The purpose of the OSCE examination is to assess clinical competence in a planned and structured manner, while KFP is designed to assess clinical reasoning. (Harden 1988; Hrynchak, Glover Takahashi & Nayer 2014). This study provides evidence that performance in both the KFP and OSCE examinations appears to be correlated with performance in the Regulation of Cognition domain of the MAI. It is noteworthy, however, that there was no significant difference between the overall Regulation of Cognition domain of first and fifth-year undergraduates, or any of its sub-domains. This could be concerning, given the increasing importance of Regulation of Cognition for fifth-year undergraduates, and the known close link between the regulation of cognition and the development of clinical reasoning expertise (Sections 3.3 and 3.4).

The second finding from this research is that there was no significant increase in metacognitive awareness from first- to fifth-year students. From the findings of our earlier results, we can see that metacognitive awareness becomes increasingly correlated with performance in the fifth-year examinations. If there is no significant change in a student's metacognitive awareness from first to the fifth-year, a lower scoring student may struggle in the later years of medical school where metacognitive awareness appears to be more important. Secondly, and of relevance to graduates, the literature indicates there is a strong link between high levels of metacognitive awareness and clinical reasoning expertise – a crucial factor in clinical practice. (Croskerry 2003a).

One limitation of this study was that the MAI had not been validated for use in undergraduate medical education research, although it has been used in this context before. An important limitation of this study was the low response rate, reducing the reliability of the conclusion from this study. The low response rate may have been due to undergraduates deciding not to participate in this study. This program of research was not contingent on this study, but the overall findings, discussed in Chapter 7, are generated by the triangulated results of the four studies as well as the literature. While it would have been preferable to have more participants in this study to make the results more statistically robust, this study established a connection between metacognitive awareness and undergraduate performance and thus warrants further research. One further limitation was that the methodology used in this study was not able to provide any information as to what the actual relationship would be between metacognition and clinical reasoning. Any effects, however small, could be explained by a higher level of subconscious (Type 1) decision-making, so reducing the level of complexity of the learning problems, and as such allowing more cognitive resources for metacognition. In this case metacognition would be a result of better clinical reasoning rather than a contributory factor. The single site location of this study means that the results cannot be generalised to other contexts.

Future research should aim to validate the MAI for use in the context of medical education. Repeating this study on a larger scale may confirm that MAI scores do not vary significantly between first and fifth-year medical students and that there are correlations between components of the MAI, OSCE and KFP examinations for fifth-year students. Future research may profitably extend this study to include students from other medical schools in both

Australia and internationally. Studying the metacognitive awareness of practising clinicians may help by investigating the relationship between their performance in Script Concordance Tests or postgraduate clinical fellowship examinations and their MAI scores (Boulouffe et al. 2014).

3.14 Conclusion

This study found there was no statistically significant difference in metacognitive awareness between this small group of first and fifth-year medical students. Given the importance of metacognitive awareness for developing clinical reasoning expertise, described in the postgraduate-focused literature, the results of this study warrant further research and validation. The positive correlations between the sub-scales of the Regulation of Cognition domain and the fifth-year KFP and OSCE examinations highlight the importance of metacognitive awareness for undergraduate clinical examination performance. The findings from this study and the literature support reviewing the need to raise metacognitive awareness among doctors-in-training (Berkhout et al. 2015; Bruin, Dunlosky & Cavalcanti 2017).

The next chapter explores the second situational factor: '*The learning climate'* of doctors-in-training in the research hospital. In Chapter 7 – Synthesis and Proposed Framework, the findings from the four-individual situation factor studies are synthesised to identify a learning framework which better supports the development of clinical reasoning skills.

Chapter 4: Learning climate

4.1 Introduction

This chapter explores the second situational factor, '*The learning climate'*. The learning climate within which Intern doctors-in-training work influences the way they learn clinical reasoning skills (Section 1.14.2). In Australia, Interns undertake their internship year after graduating from medical school. The research question posed in this study was:

'*To what extent is the learning climate in the General Medicine unit conducive to learning?*'

The Intern learning climate at TTH was investigated using the D-RECT survey instrument (Boor et al. 2011). The results across the 11 subscales of the D-RECT were statistically compared across the three core terms. In addition, Interns were given the opportunity of providing written responses. The method used to thematically analyse these responses was described in Section 5.4.3. The concluding section of this chapter integrates and synthesises the results of the quantitative and qualitative responses to answer the research question.

The learning climate provides information about the context of the learners, their interaction with other healthcare workers, and is influenced by the organisational structures in which they work (Boor et al. 2011). Often self-reported surveys are regarded as weak data (Kirkpatrick 1998). However, in this study, having Interns report on their learning climate was the most viable method for measuring their insights

4.2 Doctors-in-training: Internship

In recent years the number of Intern positions in Australia has expanded rapidly (Joyce 2013). The three core terms of internship are: General Medicine, Emergency Department and General Surgery. The Intern workforce is essential to the functioning of the medical team, and their duties range from admitting the patient on arrival at hospital to completing a discharge summary which is sent back to their general practitioner.

The transition from medical student to practising doctor is a steep learning curve, supported within the hospital by the Medical Education Unit (MEU). Sheehan et al. (2012) identified the

key areas of medical graduate development during internship as concrete tasks, project management and identity formation. Concrete tasks include cognitive competencies such as charting patient fluids, or procedural skills such as cannulating a patient. Project management skills refer to responsibilities such as ordering tests and following up results and being part of an inter-professional team, as well as ensuring the efficient use of personal time and resources. Identity formation includes learning where Interns fit in an inter-professional team and how to manage a range of novel situations. As well as learning in these three areas, Interns must develop their ability to learn and apply knowledge in increasingly complex situations. Learning through experience (empiricism) is influenced by the learning climate, as explained in Section 1.8. Many authors regard a healthy learning climate as of primary importance for effective learning and training to take place (Genn 2001a, 2001b; Harden 2001; O'Sullivan 2015).

4.3 The learning climate

The learning climate is a combination of the formal and tacit aspects of the clinical working context, as perceived by doctors-in-training (Roff & McAleer 2001). The notion of doctors-in-training building a personal understanding of their learning climate aligns with the theoretical model of constructivism (Section 1.9.1). As doctors-in-training experience learning and working in their clinical workplace they build a personalised worldview, gathered from their own learning and experience (Creswell & Plano 2007).

Many different approaches have been taken in constructing instruments to measure learning climates with each tailored to a slightly different context (Schönrock-Adema et al. 2012). In addition, Schönrock-Adema et al. (2012) stated that there appeared to be a lack of a generally agreed conceptual framework for measuring the learning climate. Prideaux (2002) made clear that it is important that new research is aligned to pre-existing studies, and it is helpful for the conceptual framework to be explicitly identified (Bordage 2009; Prideaux & Bligh 2002).

Moos, a psychologist working in the 1970s, identified that human environments may be described by common dimensions that include:

- 'Personal development or goal direction dimensions',
- 'Relationship dimensions' and
- 'System maintenance and system change dimensions'

(Moos 1973).

The ‘Personal development or goal direction dimension’ involves having clear, defined learning objectives, receiving constructive feedback with the learning relevant to the work undertaken (Moos 1973). The ‘Relationship dimension’ relates to the extent that the person feels positively supported and part of a friendly, socially cohesive group characterised by open communication’ (Moos 1973). The ‘System maintenance and system change dimension’ involves the predictability and clarity of expectations, as well as the degree to which work pressures influence learning (Moos 1973).

The systematic review undertaken by Schönrock-Adema et al. (2012) sought to identify an overarching theoretical framework for measuring the learning climate. By mapping common elements of eleven medical learning climate instruments, including the D-RECT, they identified that 94% of the items aligned with Moos’ theoretical framework. Their research proposed that Moos’ framework should underpin future instrument design (Boor et al. 2011; Moos 1973; Schönrock-Adema et al. 2012).

4.3.1 Measuring the learning climate

There has been a growing interest in measuring the learning climate of Interns, using, for example, the Postgraduate Hospital Educational Environment Measure (PHEEM) (Roff, McAleer & Skinner 2005). In addition, there have been several other instruments developed to measure the learning climate within differing medical learning contexts, for example in specialist training programs, such as diagnostic radiology and surgery (Bloomfield & Subramaniam 2008; Cassar 2004).

The PHEEM was initially thought to be a suitable instrument for measuring the learning climate at The Townsville Hospital, but recent research has challenged its validity and underlying factor structure (Bennett et al. 2014; Boor et al. 2011). There has also been confusion over the reporting of the instrument sub-scales in different journal papers (Boor et al. 2007; Roff 2005; Schönrock-Adema et al. 2009). Silkens et al. (2015) confirmed that the D-RECT is a reliable and valid instrument for measuring the Intern doctor-in-training learning climate. The D-RECT also related well to the conceptual framework for measuring a learning climate, identified in the research of Schönrock-Adema et al. (2012). A key strength of the D-RECT is its ability to measure different aspects of the learning climate, for example, patient handover and professional relations between Consultants (Boor et al. 2011). The D-RECT also

contained the greatest number of items representing sociocultural aspects of the learning climate.

4.3.2 The Dutch Residency Educational Climate Test (D-RECT)

The questions that comprise the D-RECT instrument were originally refined by using the Delphi method with an expert panel (Boor et al. 2011; Dalkey, Brown & Cochran 1969; Fink et al. 1984). Exploratory factor analysis was then used to identify clusters of related variables (Field 2005). Two types of factor analysis were used; Varimax rotation, which assumes no correlation between the factors, and Oblimin rotation, which assumes some correlation between the factors. Using the Component Correlation Matrix it was determined that there was a degree of correlation between the factors, so Oblimin rotations were used from then on (Field 2005). Items with a weak factor loading were eliminated and the internal consistency of the factors determined by calculating the Cronbach alpha (Boor et al. 2011; Cronbach 1951; Gliem & Gliem 2003; Tavakol & Dennick 2011).

The items were scored on a 5-point scale from 1- Strongly agree, to 5 – Strongly disagree. The subscales to facilitate statistical analysis were: *Supervision*; *Coaching and Assessment*; *Feedback*; *Teamwork*; *Peer Collaboration*; *Professional Relations between Consultants*; *Work Adapted for the Intern*; *Consultants' Role*; *Formal Education*; *Role of the Educational Supervisor* and *Patient Handover*.

Interns are both legally and morally required to be supervised by suitably qualified medical staff (Queensland Prevocational Medical Accreditation 2018). QPMA requires a specified ratio of Interns to supervisors in order to ensure adequate supervision. In addition, the supervisor must be a Fellow of the respective specialist College. For example, to supervise an Intern doctor-in-training in the Emergency Department, the supervisor must be a Fellow of the Australasian College of Emergency Medicine (FACEM). The availability and quality of supervision offered to the Intern is important, both for the safe clinical working of the Intern and for the quality of potential learning.

The '*Coaching and Assessment*' sub-scale relates directly to the quality of learning from the supervisor during the term. Interns used the 5-point scale to rate the quality of direct coaching observations and evaluation by the supervisor. The amount of time devoted to interaction with

Interns and the active interest and involvement of the supervisor will have a marked effect on the Intern learning during the term, and thus the score the Intern allocates. Feedback is a crucial part of learning in the clinical setting (Hays et al. 2002; Norcini & Burch 2007).

Interns work within mixed professional teams of doctors, nurses and allied health staff. The effectiveness and efficiency of these teams have significant impacts on the learning climate for the Intern. A good working relationship with these staff members is beneficial to Intern learning. Conversely, poor working relationships within the team may inhibit Intern learning and facilitate poor clinical decisions. The '*Peer Collaboration'* subscale seeks to evaluate how effectively the Interns work with each other.

The '*Professional Relations between Consultants*' subscale evaluates how well the supervisor Consultants get along with their peers. If Consultants have a smooth and harmonious relationship with their peer group, this is likely to have a beneficial impact on the Interns who work for them. Conversely, if the Consultants do not get along with each other, the Interns may find themselves caught up between rival Consultants, and their learning may be detrimentally affected.

The '*Work is Adapted for the Intern'* subscale seeks to determine if the scope of practice for Interns has been defined. The QPMA stipulates that Interns must agree to their scope of practice with their supervisors at the start of the term (Queensland Prevocational Medical Accreditation 2018). The aim is to identify and define tasks that are reasonable for Interns to undertake, as well as to set parameters around them. The conversation with supervisors at the start of the term also encourages Interns to identify skills or tasks they may wish to learn during the term. A team with high number of patients, and is therefore likely to be under time pressure, will not have the time it's participants might wish for discussing and learning from cases. Instead, the supervisor may instruct Interns to perform specific tasks with no time to discuss the rationale behind them.

The D-RECT instrument was designed in the Netherlands and published in the international journal *Medical Education* (Boor et al. 2011). It was modified in two ways to add clarity for this project. The term 'attending physician' was changed to the Australian term 'Consultant' and the term 'Educational Supervisor' was used instead of 'Specialty Tutor'. Written

permission was sought and gained for modification from Klarke Boor (St Lucas Andreas Hospital, Amsterdam, The Netherlands) on 5th March 2012.

The '*Consultant's Role*' subscale determines the quantity and quality of interaction between Interns and their Consultant. The items within this subscale seek to ascertain if the Intern is treated as an individual with his/her own learning needs, as well as having the time to seek advice and assistance from his/her Consultant.

In Queensland, each hospital with Interns is required to provide them with a Facility Education Program. At the Townsville Hospital, this weekly one-hour session covers a range of topics over the course of the year, and all Interns are encouraged to attend. The D-RECT instrument can be used to quantify how easy it is for Interns to make use of their protected teaching time to leave their clinical tasks and attend these sessions. A clinical unit may additionally run its own teaching, journal club or mortality and morbidity review meetings. In General Medicine, General Surgery and the Emergency Department, additional, specific one-hour sessions are held, which are targeted at learning within these specialties. The items within the *Formal Education* subscale seek to quantify how efficiently these sessions are organised, and the quality of the teaching given in them.

The *Role of the Educational Supervisor* subscale seeks to quantify the degree to which supervisors are involved in guiding and monitoring the performance of Interns over the course of the term. The last of the eleven subscales tests efficiency as well as the learning that takes place during *Patient Handover.* Clinical reasoning errors often stem from patient handover (Bordage 1999; Eggins & Slade 2015).

For this study, the D-RECT instrument was also modified to add the option for an Intern to write comments to answer the question: '*What three aspects of the junior doctor learning environment would you alter'?* The D-RECT instrument yields quantitative data, using a 5-point scale, while the Intern comments yield qualitative information which adds richness and depth to this study (Creswell & Plano 2007; Liamputtong 2013).

4.4 Research question

The focus of this program of research was primarily to explore the acquisition of clinical reasoning skills within the context of General Medicine. The General Medicine unit receives patients mainly from the Emergency Department. Working in this unit exposes the Interns to a wide variety of complex medical presentations. Much of the literature and research about clinical reasoning has taken place within the physician-based disciplines, focusing around General Medicine.

The research question was: '*To what extent is the intern's current learning climate conducive to learning'*

4.5 Ethical considerations

Ethical approval HREC/12/QTHS/37 was gained from the Townsville Hospital Health Service and JCU (H4628) for Intern involvement in this study.

4.6 Method

Intern doctors-in-training at TTH were invited to complete the D-RECT survey instrument (Appendix 2). Participation was offered to Interns across all units within the hospital during the middle of the 2012 Intern year. Participation was voluntary. Medical units are comprised of a Consultant, a Registrar, frequently two resident medical officers (RMO) doctors and three Interns. They will often care for up to 30 patients at a time on the ward. The middle term was chosen, as Interns would then be settled into the hospital context. It was thought important that the Intern had spent sufficient time in their current term to enable them to effectively evaluate it using the D-RECT suvey. Interns who agreed to participate in the study submitted their completed D-RECT surveys anonymously.

Of the 60 Interns at TTH, 53 participated in this study (88%). The statistical software SPSS was used to analyse the quantitative data (SPSS 2012). Initially, the data was examined in order to determine the internal reliability of each subscale. This was done by calculating the Cronbach alpha (Tavakol & Dennick 2011). The qualitative responses were thematically

analysed using the method described by Braun and Clarke (2006). This process is detailed in Section 5.4.

4.7 Quantitative results

4.7.1 Cronbach alpha

Calculating the Cronbach alpha enabled the internal reliability of the items within each subscale of the D-RECT to be calculated (George & Mallery 2003).

Table 4.1 Cronbach alpha for each subscale of the D-RECT

	Subscale	**Cronbach's Alpha**	**No. of Items**
1	Supervision	.54	3 (1-3)
2	Coaching and assessment	.91	8 (4-11)
3	Feedback	.52	3 (12-14)
4	Teamwork	.67	4 (15-18)
5	Peer collaboration	.78	3 (19-21)
6	Professional relations between Consultants	.87	3 (22-24)
7	Work is adapted to residents' competence	.43	4 (25-28)
8	Consultants' role	.92	8 (29-36)
9	Formal education	.79	4 (37-40)
10	Role of the educational supervisor	.88	6 (41-46)
11	Patient Sign Out (handover)	.77	4 (47-50)
	Overall Scale (50 items)	**.95**	**50 (1-50)**

Interpretation of Cronbach alpha coefficient (George & Mallery 2003).:
Excellent > 0.9 Good 0.8-0.89 Acceptable 0.7-.079 Questionable 0.6-0.7
Poor 0.5 - 0.6 Unacceptable <.05

4.7.2 Differences between the three core terms

The mean subscale scores for the three core terms of Emergency Department, General Medicine and General Surgery were examined against each other using ANOVA across the 11 subscales of the D-RECT instrument. Where the assumption of homogeneity of variance was violated, between-group differences were assessed by non-parametric tests (Kruskal-Wallis or Mann-Whitney).

The mean scale score for the whole scale (50 items) was 3.84 (SD=0.5). However, the overall mean scale score differed significantly by specialty ($F=3.34$; $p<.05$). The mean scale score was significantly lower for those in General Medicine ($X=3.92$; $SD=.3$) than for those in Emergency Department or General Surgery.

Table 4.2 D-RECT mean sub-scale scores

Sub-scale name	**Mean**	**SD**
1 - Supervision	3.44	.80
2 - Coaching and assessment	4.06	.62
3 - Feedback	3.34	.78
4 - Teamwork	4.21	.51
5 - Peer collaboration	4.18	.62
6 - Professional relations between Consultants	3.59	.87
7 - Work is adapted for residents ‘competence	4.00	.48
8 - Consultant’s role	3.92	.80
9 - Formal education	4.14	.69
10 - Role of educational supervisor	3.79	.78
11 - Patient sign out	3.73	.81

The *Coaching and Assessment* subscale score for General Medicine was significantly lower than that for the Emergency Department or General Surgery ($F=5.07$; $p<.05$). The generalisability analysis from the Boor et al. (2012) research calculated the number of Interns required for reliability in the *Coaching and Assessment* subscale to be six Interns. All three

core terms had more than six respondents, ensuring statistically reliable results for this subscale (Boor et al. 2011).

Table 4.3 Coaching and assessment subscale results

				95% Confidence Interval for Mean	
	N	**Mean subscale score**	**SD**	**Lower Bound**	**Upper Bound**
ED	16	4.31	0.46	4.07	4.56
GS	7	4.29	0.65	3.68	4.89
GM	13	3.62	0.77	3.15	4.08
Total	36	4.06	0.69	3.82	4.29

ED = Emergency Department; GS = General Surgery; GM = General Medicine

Professional Relations between Consultants scores were significantly lower for General Medicine than for Emergency Department or General Surgery ($F=4.81$; $p<.05$). The minimum number of Interns required in this subscale for generalisability analysis was nine Interns, but in General Surgery there were only seven respondents (Boor et al., 2007).

Table 4.4 Professional relations between Consultants' subscale scores

				95% Confidence Interval for Mean	
	N	**Mean subscale score**	**SD**	**Lower Bound**	**Upper Bound**
ED	16	3.56	0.70	3.19	3.93
GS	7	3.86	0.42	3.46	4.25
GM	13	2.82	1.03	2.20	3.44
Total	36	3.35	0.88	3.05	3.65

ED = Emergency Department; GS = General Surgery; GM = General Medicine

The *Formal Education* results were significantly higher for the Emergency Department than for General Medicine or General Surgery ($F=3.26$; $p<.05$). The minimum number of Interns

required in this subscale for generalisability analysis was 7 Interns ensuring the reliability of these results (Boor et al., 2007).

Table 4.5 Formal education subscale scores

				95% Confidence Interval for Mean	
	N	**Mean subscale score**	**SD**	**Lower Bound**	**Upper Bound**
ED	16	4.41	0.50	4.14	4.67
GS	7	3.89	0.83	3.13	4.66
GM	13	3.93	0.50	3.63	4.23
Total	**36**	**4.13**	**0.61**	**3.93**	**4.34**

ED = Emergency Department; GS = General Surgery; GM = General Medicine

The *Role of the Educational Supervisor* was rated to be statistically significantly higher in Emergency Department than in either General Medicine or General Surgery ($F=1.81$; $p<.05$). The minimum number of Interns needed for generalisability analysis was seven Intern respondents in each core term. These results are therefore statistically reliable.

Table 4.6 Role of the educational supervisor subscale scores

				95% Confidence Interval for Mean	
	N	**Mean subscale score**	**SD**	**Lower Bound**	**Upper Bound**
ED	16	4.24	0.52	3.96	4.52
GS	7	3.71	0.78	2.99	4.44
GM	13	3.35	1.11	2.68	4.01
Total	**36**	**3.81**	**0.90**	**3.51**	**4.12**

ED = Emergency Department; GS = General Surgery; GM = General Medicine

There were no statistically significant differences between specialties observed for any other subscales ($p>.05$).

4.7.3 Differences between ward and non-ward based terms

In some of the terms, the Interns spent most of their clinical time on the wards looking after patients. In other terms, the clinical work did not involve ward-based patients at all. By grouping the terms as ward, and non-ward based it was possible to determine if there was any difference in perception based on the type of clinical work undertaken by the Interns.

The terms identified as 'non-ward' based terms were Emergency Department (n=16), Radiology (n=1) and General Practice (n=4). The remainder of the terms were grouped as 'ward based' terms: General Surgery (7), Orthopaedics (2), General Medicine (13), Infectious Diseases (1), Paediatrics (2), Neurology (2), Gastroenterology (1), Medical Oncology (1), Haematology (1), Endocrinology (2) and Palliative Care (1). Although General Surgery may appear to involve work that is not based on the ward, almost all the Interns' time is spent with patients either before or after their surgery on the ward. The difference between the ward and non-ward terms was examined using an independent samples t-test.

The overall mean scale score was higher for Interns categorised as non-ward (X=3.97; SD = .33) than ward-based terms (X = 3.75; SD = .59), but this difference did not reach statistical significance (t =-1.83; df=50; p>.05).

The coaching and assessment subscale results were significantly higher for the non-ward compared to the ward-based terms (t=-2.35; df=51; p<.05).

Table 4.7 Coaching and assessment; Ward versus non-ward based term scores

	N	**Mean subscale score**	**SD**
Ward	32	3.21	0.81
Non-ward	21	3.54	0.70

The formal education subscale results were significantly higher for the non-ward compared to the ward based terms (t=-2.74; df=51; p<.01).

Table 4.8 Formal education; Ward versus non-ward based term scores

	N	Mean subscale score	SD
ward	32	3.94	0.74
non-ward	21	4.44	0.48

The role of the educational supervisor subscale was statistically significantly higher for the non-ward compared with the ward based terms (t= -3.39; df =51; p<0.001).

Table 4.9 Role of educational supervisor; ward versus non-ward based terms

	N	Mean subscale score	SD
Ward	32	3.52	0.82
Non-ward	21	4.20	0.51

There were no other significant differences by ward status for any other subscales.

4.7.4 Responses to the D-RECT by gender

Between-group differences in mean scale score for gender were examined by independent samples t-tests. There were no significant differences between the male and female respondents to the D-RECT survey responses (p > 0.05).

4.8 Quantitative result analysis

The overall Cronbach alpha was ‘excellent’ (0.95). The high overall Cronbach alpha, when compared to some of sub-domains may appear surprising, but could be explained by the instrument having 50 items (Tavakol & Dennick 2011). It is also possible to explore this anomaly further by calculating a stratified alpha, and then comparing this value with the original Cronbach alpha calculation. An alternative method could involve estimating what the subscale alphas would be if they had the same number of items as the total questionnaire, by

using a Spearman Brown prophecy, or entering the results in a generalisability study and performing a decision study with 50 items.

Some of the subscale results were concerning. The lowest reliability was subscale 7 (*Work is adapted for residents' competence*) with a Cronbach's alpha = 0.43. This item was comprised of four sub-items, and according to George and Mallery (2003), the reliability is 'unacceptable', meaning there is little consistency between responses between the four items. The subscales for *Supervision* (subscale 1) and *Feedback* (subscale 3) were also of concern. It is possible that the poor reliability of these four subscales may be a result of the sample size and the small number of items in some subscales (Tavakol & Dennick 2011). The written responses of the participants added reliability and trustworthiness to the quantitative data (Liamputtong 2013).

The literature provides compelling evidence that coaching and assessment are both important for successful learning (Sections 1.8, 1.9 and 1.13). The D-RECT General Medicine term scores were significantly lower than the General Surgery and Emergency Department terms for the subscale of C*oaching and Assessment*. This is a cause for concern as it may negatively influence the learning of clinical reasoning skills by Interns during their General Medicine term.

The D-RECT subscale of *Professional Relations between Consultants* was significantly lower for the General Medicine term, than for the General Surgery or Emergency Department terms. The impact on learning for Interns is influenced by the interrelationship between Consultants, and the low score is likely to compromise optimal learning and patient care. Determining the exact effect of low levels of collegiality between different Consultants is complex and problematic. Thematic analysis of the written responses relating to the Consultants is explored further in Section 4.10.

The Emergency Department scores for *Formal Education* and *Role of the Educational Supervisor* were significantly higher than they were for the General Medicine or General Surgery terms. The different way that Interns work and are taught in the Emergency Department may explain this result. In the Emergency Department Interns were given protected teaching time each week outside of the unit. At the start of the session, the roll was taken to

ensure that all the Emergency Department Interns were present. The teaching was carefully planned, and a roster published well in advance, which normally featured Consultants teaching on pre-defined topics, with practical components to the sessions. At the start of the session, the roll was taken to ensure that all the Emergency Department Interns were present. The teaching was carefully planned, and a roster published well in advance, which normally featured Consultants teaching on pre-defined topics, with practical components to the sessions. The teaching program for the Emergency Department was called More Learning in Emergency (MoLIE). This teaching program was developed in response to the concerns of some Emergency Department Consultants regarding the increase in Intern numbers, and the rise of their supervisory workload. The group-teaching of Interns away from the unit was an acceptable concession to the Consultants who did not want an increase in Intern numbers. The MoLIE program created a well-structured time for purposeful Intern teaching, which may account for the higher scores in the *Formal Education* and *Role of the Educational Supervisor* subscales for the Emergency Department term.

The likelihood of a program like MoLIE being implemented in either the General Surgery or General Medicine terms is low. In both terms, there is a great deal of paperwork involved, which includes charting patient notes, in addition to the discharge summaries which are required by general practitioners (Section 4.3). Within the General Surgery and General Medicine terms the type of work does not require the same degree of supervisory involvement as the clinical work within the Emergency Department. Additionally, there is neither the funding or willingness to increase the number of Interns available in either of these units.

The two studies detailed in Chapters 5 and 6 (*Consultants as role models* and *Interns as learners*) also triangulate the quantitative results reported in this chapter and improve the credibility and trustworthiness of the combined results synthesised in Chapter 7 (Liamputtong 2013).

4.9 Qualitative themes and analysis

In addition to the quantitative responses gained from completing the D-RECT survey instrument, the Interns were invited to give written responses to the question: *'What three aspects of the junior doctor learning environment would you alter'*?

The written comments were thematically analysed using the Braun and Clarke (2006) method detailed in Section 5.5.4. The comments below align with the three core terms of Emergency Department, General Medicine and General Surgery.

4.9.1 Emergency Department qualitative comments

When the comments from the 16 Emergency Department Interns were thematically analysed, three themes were generated, adding to the richness of the Intern quantitative D-RECT data:

- *'Consultant attitudes'*,
- *'Registrar attitudes'*, and
- *'Communication and teaching'*.

The theme of *'Consultant attitudes'* is related to the subscale of the *'Consultant's role'*. Within the D-RECT survey, this subscale asks questions which focus on Consultant attitudes towards the Interns, as well as their availability and willingness to teach and assist. The D-RECT results for the '*Consultant's role*' subscale were not statistically significantly different between the core terms of Emergency Department, General Medicine and General Surgery.

The Emergency Department Intern comments gave qualitative depth to the subscale. For example:

'Most Consultants were great; however, some ED Consultants were kind of hostile and outwardly rude to Interns - I would change this!' ED16

'Ensure that Consultants are reminded that teaching is part of their job description in QLD Health.' ED6

The comments of ED6 and ED16 indicate that there is variability in Consultant attitudes to the Interns, as well as variability in the perceived awareness of the expectation and willingness to teach. The attitudes of a Consultant may adversely impact the Intern learning climate. If Interns feel that some of the Consultants are hostile and unwilling to teach, they may attempt to distance themselves and limit the number of interactions with those Consultants. This behaviour will reduce the learning Interns are able to acquire from the Consultant, as well as potentially increasing the risk of clinical errors and time wasting.

The second of the thematic groups is associated with the D-RECT subscale of *Coaching and Assessment*. The quantitative statistical results identified General Medicine as being significantly lower than ED or General Surgery on this subscale. The mean scale score for ED in the subscale of *Coaching and Assessment* was the highest of the three core terms. There were, however, areas for improvement as identified from the Intern comments below:

'Involve Interns as part of the resuscitation team.' ED15

'More opportunities to participate in activities such as resus' ED2

'Time set aside for discussion of interesting cases and management' ED15

'Debriefing with Reg/Consultant when death/trauma would be a great learning experience' ED5

'More supervision on night shifts' ED7

The Intern comments indicate they would have liked more coaching in specific practical skills, in addition to the formal education programs they already receive. The desire for this kind of teaching was not evident from the quantitative data obtained in the D-RECT survey, but only from the qualitative written comments from the Interns. The repeated mention of Interns wanting to be included on the resuscitation team implied they are currently excluded. The Interns regarded gaining resuscitation team experience as an important part of their training.

The request of time for debriefing and coaching from Consultants in how to deal with difficult patient conversations and management scenarios is an important observation. The inference from these comments is that Interns feel insufficiently prepared to give difficult news to patients. They may have had poor experiences when they have done so in the past. Negative experiences, or the fear of having these situations arise may have a detrimental impact on the confidence of the Interns. Comparably, the comment about wanting '*more supervision for the night shift'* implies that the Intern felt that the degree of supervision currently provided may be insufficient, leading to anxiety as well as perception of lack of support in making important clinical decisions. Artino et al. (2012) provided additional evidence that negative emotions such as anxiety adversely influence the learning climate.

4.9.2 General Surgery qualitative comments

The seven General Surgery Interns who participated in the D-RECT survey wrote comments which were thematically grouped into the two areas of *Consultant engagement* and *Consultant teaching*.

During the General Surgery term, the Interns often spend the majority of their time on the wards looking after patients before or after surgery. Consultants, however, tend to spend a small amount of time on the wards, with the bulk of their time in the operating theatre. It is therefore not surprising that Interns see their Consultant a great deal less in General Surgery than in General Medicine or the Emergency Department. This sentiment was identified by an Intern, who commented:

'Needs to be more Consultant-resident contact - Consultants are largely absent when it comes to resident teaching and advice.' GS2

The reduced time the Intern spends with the Consultant makes the *Role of the Consultant* subscale aspect of the learning climate very different from General Medicine and the Emergency Department. In both the General Medicine and Emergency Department terms the Consultant is readily available most of the time.

The reduction in time spent with the Consultant (and Registrar who is often also in theatre) decreases the amount of teaching the Intern receives overall – as reflected by the Intern comments:

'Would like more bedside teaching. More practical skills teaching would be good.' GS4

'There needs to be more clinically oriented teaching sessions, for example teaching rounds in medicine, simple hands-on training for general skills in surgery such as suturing, wound management etc.' GS2

'More formal education' GS1

'Encouraging junior doctors to think on their feet and enabling them to activate management plans drafted by themselves after gaining approval from a Consultant.' GS2.

This comment suggests they feel that junior doctors, feel they were not stretched or developed in their ability to think and act for themselves. Intern GS2 reflected that they were given tasks that they can currently perform. Instead, the Intern wanted to work in an environment where they were learning new practical and cognitive skills. The Intern wanted to be given more responsibility within a supportive learning framework. The Intern articulated that they felt his/her current role was to do simple tasks, leaving complex management decisions to others.

4.9.2 General Medicine qualitative comments

The 12 General Medicine Interns who participated in the D-RECT survey wrote comments which were thematically grouped around two areas: '*Influences of the Consultant*' and '*Attitudes of Senior Doctors*". These comments added depth and triangulate the Intern quantitative D-RECT data.

Some of the Intern comments displayed strong opinions about the attitude of their Consultant, which relate to the *Consultant's role* subscale of the D-RECT. Intern comments included:

'... Consultants are always willing to explain their thought process/clinical reasoning; there often is not enough time.' GM1

'I am aware of other Consultants being very supportive, open, encouraging. However, this is not my experience' GM8

'... the Consultant appears not to value Intern input into clinical scenarios' GM8

'The Intern experience - owing to Consultant personality - is not a good one and provokes anxiety.' GM8

'Better teamwork and respect for everyone on the team' GM6

Intern GM3 made similar comments but chose to use excessively strong language. The strong language shown in these comments indicates the way in which some Consultant attitudes have adversely affected the working environment, and therefore the learning climate for those Interns. The comment from Intern GM3 painted a picture of a professional team where the learning climate was not conducive to explicit teaching and learning. Intern GM1, who was in

a different team, wrote of a positive working and learning experience in which the limitations of time, rather than a negative attitude and role modelling, limited their learning.

The second theme generated from the GM Intern comments was *'Attitudes of senior doctors to teaching'*. This theme aligns with the *Coaching and Assessment* subscale of the D-RECT. One of the Interns commented on the tension between clinical education and their work:

'Make sure seniors (reg's) [registrars] *encourage education attendance instead of pulling the team from meetings to work.'* GM11

The continual tension between education and clinical work was often noticed, resulting in the variability in Intern attendance at formal teaching, along with the occasional sudden exit of an Intern from teaching in response to a phone call.

The Intern comments also highlighted non-formal teaching, which includes bedside teaching and case management meetings:

'I've had NO teaching on the wards! Didn't know they were supposed to.' GM3

'More teaching by registrars would be appreciated. Often no time. Less paperwork and more time to see patients/do procedures.' GM7

'Weekly team meetings for acute teaching session or feedback or time to reflect' GM6.

These indicate time pressure within the general medical teams as well as a possible unwillingness to teach, and an absence of planning for case management meetings and discussions. One of the Interns made a concerning comment about how they were made to feel if they sought clarification:

'Allow an Intern to ask questions without feeling like they are wasting time, making a stupid question or will be shut down.' GM6

This comment implied the Intern is working within a team that is unsupportive, and so the Intern rarely sought clarification. Also linked to Registrar teaching was the following comment:

'... perhaps a medical reg/educational reg in charge of RMO education rather than Consultants, as the gap in knowledge is too big between RMO and Consultant.' GM4

The Interns GM4 and GM7 suggested a change in the way that their teaching is organised as they felt the Registrars would be better placed to understand what they already know, and then to extend their knowledge more effectively. The constructivist theory of learning supports the idea that passing on information without seeking to base it on existing knowledge may not add to their knowledge and understanding (Section 1.9.1).

One of the Interns commented on the high number of Registrars they had during the term:

'Aim to minimise the turnover of registrars. After nine weeks I have worked with eight regs.' GM8

A fast rate of Registrar turnover may reduce the learning benefits derived from a more stable team. The educational benefits of lower staff turnover may include the Intern developing a rapport with their Registrar, and gaining insights as to how they think and reason. The impact of a high staff turnover rate in addition to a high workload, is likely to be detrimental to the Intern doctor-in-training learning climate.

4.10 Discussion

This research study explored the Intern learning climate at TTH, focussing particularly on the General Medicine unit. Figure 4.1 shows the two subscales from the D-RECT instrument in which the General Medicine Intern data was significantly lower than the Emergency Department or General Surgery. Figure 4.1 also shows the two themes generated from the qualitative information gathered from the Interns answering the question: '*What three aspects of the junior doctor learning environment would you alter'*? The right-hand column of the figure shows the Intern comments that contributed to creating the theme.

The attitudes of the Consultants both between themselves and with the Interns, were highlighted in the quantitative and qualitative components of this study, as an area of concern. The numerical and qualitative responses triangulate well and add trustworthiness to the findings that Consultant attitudes are influential, and at times may detrimentally affect the learning climate within General Medicine.

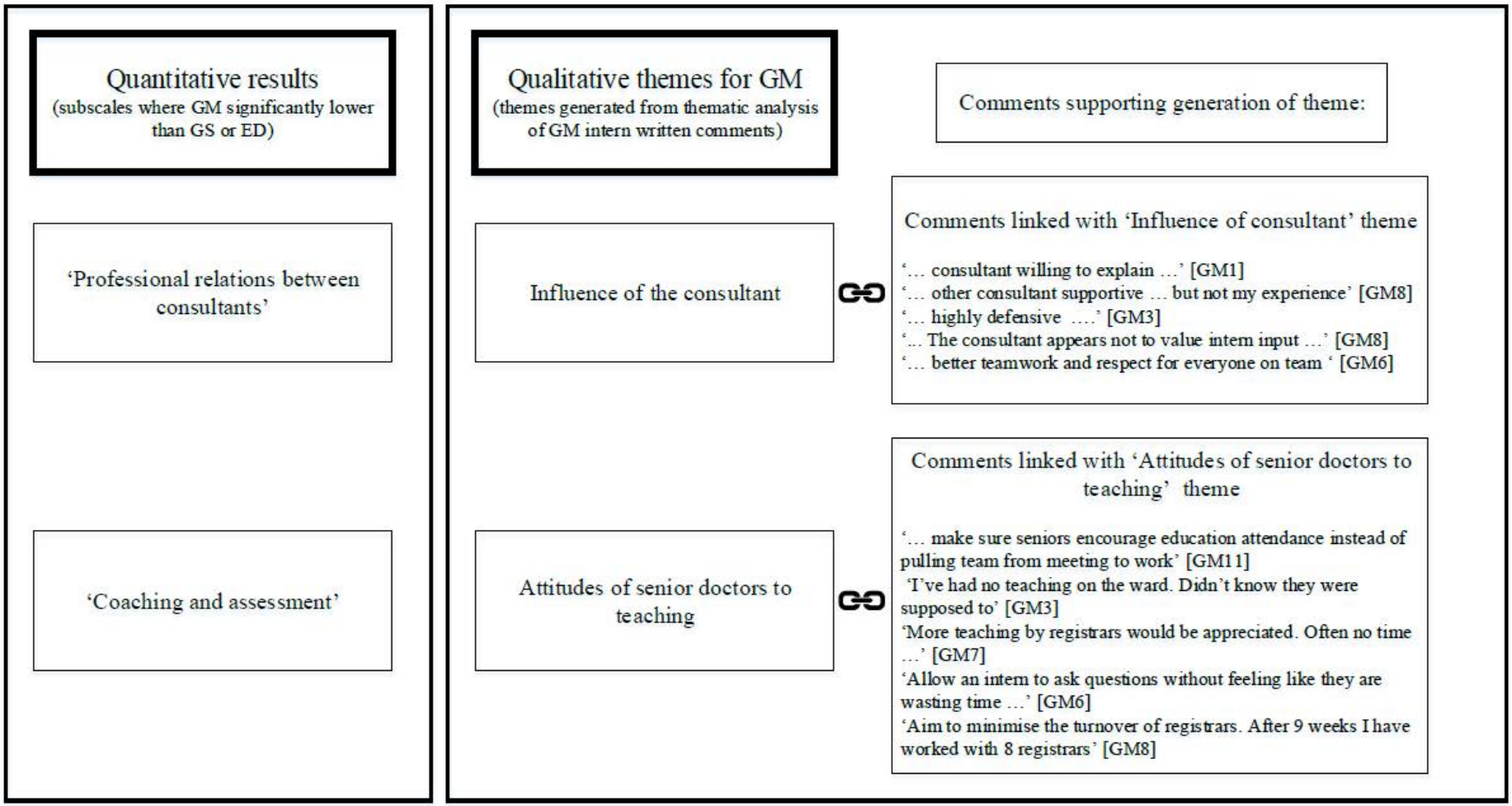

Figure 4.1 Summary of quantitative and qualitative results for General Medicine term.

Secondly, Figure 4.1 highlights that Consultant and Registrar teaching may be less than optimal at times. The D-RECT data shows that the *Coaching and Assessment* domain in General Medicine is lower than for General Surgery or the Emergency Department. The variable standard and at times, the willingness or otherwise of Registrars and Consultants to teach Interns is concerning. The combination of the two findings described above, provide evidence that the quality of the learning climate in General Medicine may not be consistently conducive to Intern learning.

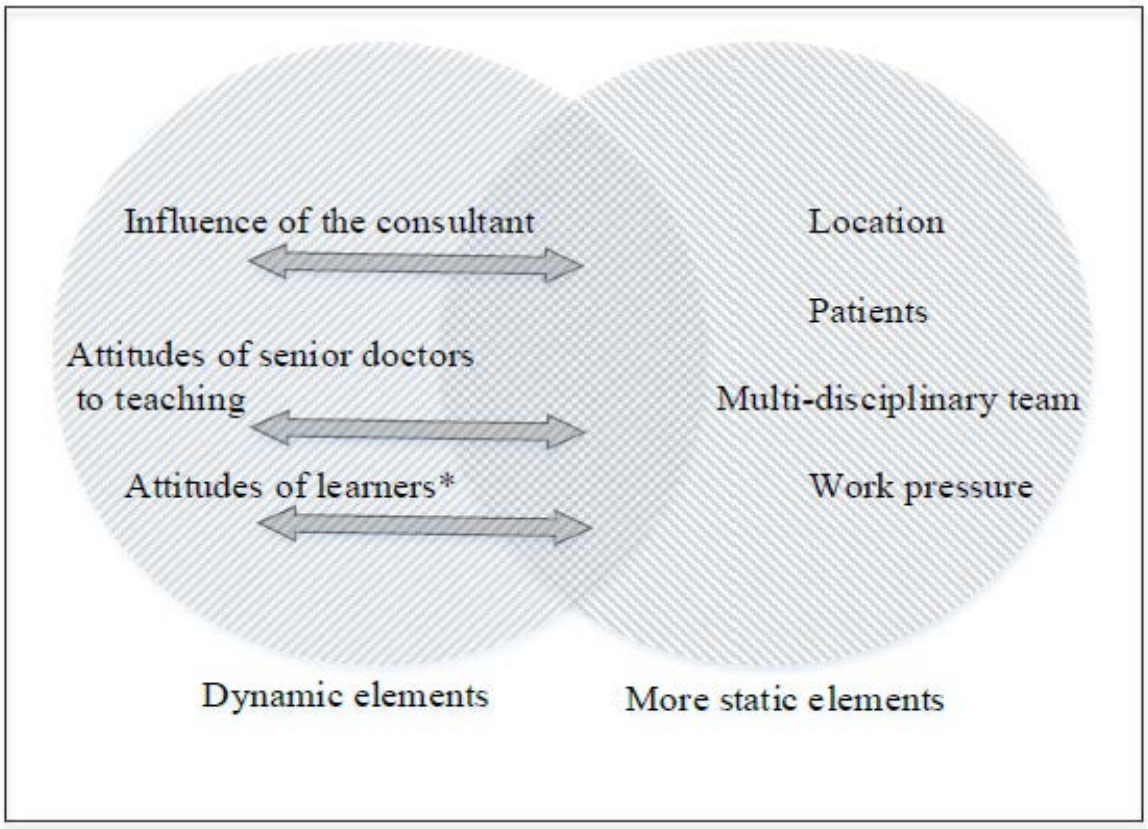

Figure 4.2 The learning climate is influenced by dynamic and more static elements

The General Medicine term appears to have two types of modifying elements that may affect the quality of the learning climate: dynamic and more static elements. Evidence for these two types of modifiers are provided by the reflections of the Interns working in the General Medicine teams at TTH. More static elements of the learning climate include the physical location of the wards, the nurses and allied health staff and the work pressure created by the volume of patients being cared for. It is reasonable to assume the patient case-mix over the course of the Intern term will be approximately equal between General Medicine teams. These more static elements appear to provide a passive background to the Intern learning climate. For

Interns working within the same wards, these more static elements were experienced similarly among Interns.

The dynamic elements, however, actively influence the quality of the Intern learning climate, and vary between units working within the same context. The dynamic element *Influence of the Consultant*, identified in Figures 4.1 and 4.2, provides evidence that the attitude of the Consultants and Registrars to teaching positively or negatively impacts upon the Intern learning climate. Figure 4.2 shows how the three dynamic elements may influence the more static elements. If the *Influence of the Consultant* and the *Attitude of the senior doctors to teaching* was positive, these dynamic factors moved to the right on Figure 4.2, and co-ordinate in a way that is conducive to learning. The element *Attitudes of learners** is discussed in more detail in the *Interns as learners* study in chapter 6.

If the Consultant and Registrars have a negative attitude toward Interns and Intern learning, then this appears to create a powerfully negative learning climate, without regard to the benefits of the more static elements of the learning climate. The final dynamic element, the *Interns as learners*, is explored in Chapter 6.

When the Intern terms are compared as ward and non-ward, C*oaching and Assessment* and the R*ole of the Educational Supervisor* were identified as being significantly different between the two groups. The non-ward group was composed of Emergency Department respondents (16/21) along with Interns in General Practice (5/21). The ward grouping (32 Interns) includes General Medicine (13/32) and General Surgery (7/32), along with the many smaller ward based units accommodating Interns. The non-ward grouping has a majority of Emergency Department Interns. The non-ward group reported significantly better scores in the subscales of *Coaching and Assessment* and *Role of the Educational Supervisor*. These results are consistent with the results when the three core terms of Emergency Department, General Medicine, General Surgery are compared with each other.

The Intern qualitative comments centred on the role, function and attitude of the Consultant. In the General Medicine term, Interns made robust comments about the detrimental impact of the attitude of some Consultants on their learning. The Intern learning climate in General

Medicine appears to have room to improve, and may in part be due to the way Interns are directed to do important clerical, non-clinical tasks (Sheehan 2012).

4.11 Summary

This study explored the educational learning climate of Intern doctors-in-training. The D-RECT instrument enabled quantitative measurement of the learning climate. Qualitative written comments were also gathered from the Interns. The qualitative information added depth to the numerical data and gave richer details about the Intern learning climate (Creswell & Plano 2007).

Developing clinical reasoning skills throughout a doctor's career is essential (Audétat et al. 2012). For these skills to be fostered it is essential that there is a conducive learning climate. Weise and Weise (2012) described the important role of the senior doctor as a coach:
'Great physician coaches have a powerful impact on learning' (Weise and Weise, 2010).

This process of coaching can be broken down into role modelling, motivation and feedback (Rencic 2011). A failure in any one of these areas will probably have a detrimental impact on Intern learning.

Synthesising the key findings of the qualitative and quantitative data it is evident that, although several factors within the learning climate are important, Consultants greatly influence the learning climate. When the Consultant is present, proactive and an encouraging lead clinician, the Intern learning climate is most likely to be conducive to learning. When the learning climate is conducive to learning, positive role modelling will help create the opportunity to further develop clinical reasoning skills (O'Sullivan 2015). If, however, the learning climate is less than optimal this will negatively influence the learning of doctors-in-training. This study indicates that the learning climate in General Medicine may need to be improved for more effective learning of clinical reasoning skills to take place.

Chapter 5: Consultants as role models

5.1 Introduction

In Chapter 4 the learning climate of Intern doctors-in-training was explored. The influence of Consultants on the learning climate of their Interns was a key finding from that study. This chapter explores the influence of Consultants further by investigating Consultants as role models.

Interns in their General Medicine term do much of their clinical learning under the supervision of Consultants. They also learn from Registrars and other medical staff, but the Consultants lead these teams. In addition to having a key role in setting the learning climate, the Consultant also helps to shape how clinical reasoning skills are learned.

Due to their seniority, expertise and influence over the learning of doctors-in-training, Consultants may be regarded as role models (Passi et al. 2013). The influence of Consultant role models is often subconscious, but critically important in the journey of doctors-in-training to becoming clinical reasoning experts (Houchens et al. 2017; Passi & Johnson 2016b). Much of the current research on the function of role models in learning can be traced back to Bandura's social learning theories (Section 1.9.2). Sternszuz et al. (2016) noted that, in order to adopt a role modelled behaviour, learners must observe it, create a mental representation of what they have observed and then trial it while self-monitoring their performance. The research of Passi et al. (2016) states that doctors-in-training study the behaviours of role models, and then make a judgement as to whether to adopt this behaviour or not (Passi & Johnson 2016a). Role models may also have an important function in teaching learners how not to conduct themselves (Cruess, Cruess & Steinert 2008; Passi & Johnson 2016a).

During their careers Consultants have seen and treated many patients. The literature indicates that Consultants generally make faster and better clinical decisions than their junior colleagues, but their clinical reasoning processes are often tacit and seldom discussed (Pinnock & Welch 2014; Sinclair 2010). The generally tacit nature of the clinical reasoning process makes learning clinical reasoning skills problematic (Section 1.12).

This study aimed to explore the function of General Medicine Consultants as role models in the development of clinical reasoning skills amongst Interns.

5.2 The research questions

The research questions for exploring situational factor 3 – *'Consultants as role models'* were:

- *What do Consultants understand clinical reasoning to be?*
- *How do Consultants understand they acquired their clinical reasoning skills?*
- *How do Consultants seek to foster clinical reasoning skills among doctors-in-training?*

5.3 Ethical considerations

Ethical approval was obtained for this investigation from the Human Research Ethics Committee of James Cook University (HREC/13/QTH0) and the Townsville Hospital (HREC/131QTHS/2680).

5.4 Methods

The method used for this descriptive qualitative study was based on a constructivist approach and used semi-structured interviews to collect data from the Physician Consultants. Audio recordings of the interviews were transcribed verbatim and then thematically analysed to answer the research questions.

5.4.1 Development of the semi-structured interview guide

The semi-structured interview guide was developed and piloted before the interviews of the four General Medicine Consultants took place. Three Consultant Paediatricians took part in the development and piloting phase of the semi-structured interview guide. Paediatricians, like general Physician Consultants, have gained their FRACP and treat a broad range of undifferentiated patients, normally admitted to their care from the Emergency Department.

The process of developing and piloting the semi-structured interview guide followed five stages. Based on the clinical reasoning literature, questions were developed by the researcher and then modified with input from C2, a Paediatrician aware of the aims and context of this

study, and familiar with the clinical reasoning literature. The second stage of development used this prototype semi-structured interview guide for interviewing C2. This interview was audio recorded and then transcribed verbatim, before being thematically analysed (Section 5.4.3). The third stage of development involved discussing the quality of data gathered and questioning whether the themes generated from this interview helped to answer the three research questions. The prototype semi-structured interview guide was further refined. Stage four of developing the semi-structured interview guide involved interviewing two additional Paediatricians unfamiliar with the context and background of this study. Audio recordings of their interviews were transcribed and thematically analysed. The data and themes generated from the three Paediatrician Consultant interviews were evaluated and discussed with C2 to determine if they would assist in answering the three research questions. The final stage of development involved making minor changes to the wording of the semi-structured interview guide.

Table 5.1 Semi-structured interview guide for Consultants

Semi-structured interview questions
a. What have been your observations about the different ways clinicians think when making a diagnosis?
b. Can you describe an occasion when you examined your own thinking when coming to a clinical diagnosis?
c. What made you question your thinking?
d. Did this occasion change your thinking on a global scale – or make you more aware of some of the pitfalls in future, similar, presentations? Describe
e. What makes you think about your thinking in the clinical diagnostic setting? – Describe please.
f. How would you describe the difference in the clinical reasoning skills of juniors and seniors?
g. Are there any aspects of these differences that could be taught?
h. How would you describe the relationship between clinical reasoning and medical errors?
i. Are there any errors you have become aware of that have changed your approach to clinical reasoning?
j. Is there anything that would make learning clinical reasoning skills easier?
k. What might make some people better at clinical reasoning than others?

The purpose of the semi-structured interview was to stimulate the Consultant thinking and responses, with the aim of answering the research questions. As part of developing the semi-structured interview guide the questions were mapped to the research questions, see Figure 5.1.

For the first research question, the Consultants were asked to explain what they understood clinical reasoning to be. The semi-structured interview guide questions were then mapped to the second and third research questions, as detailed in Figure 5.1.

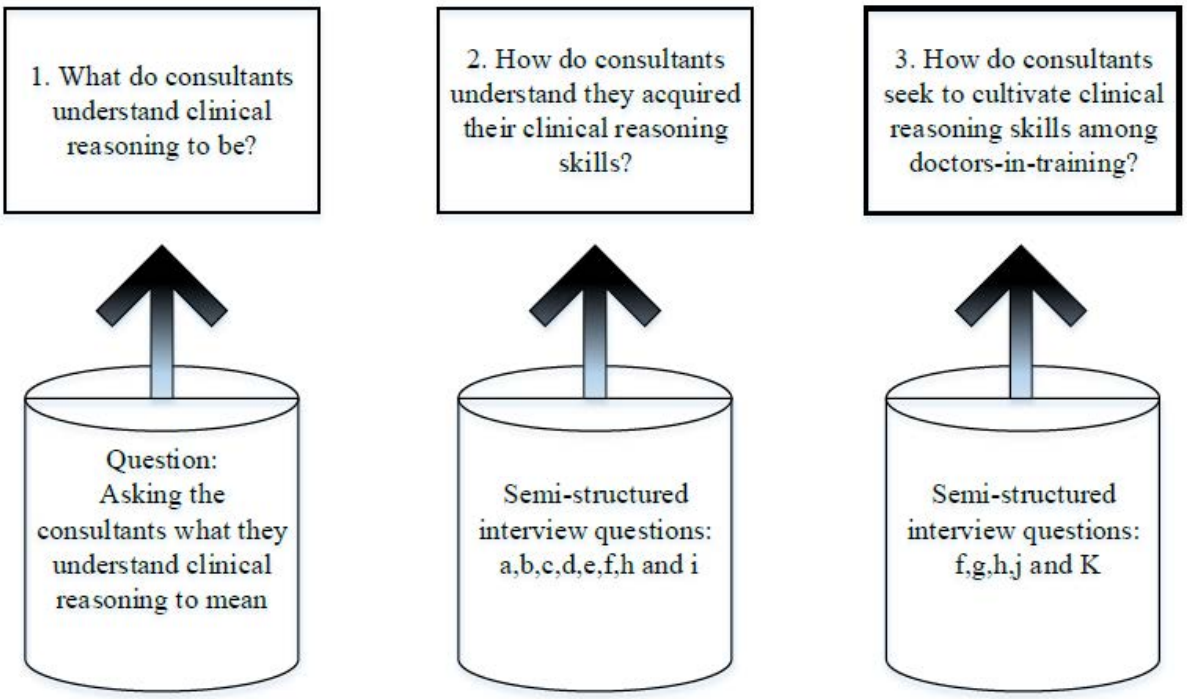

Figure 5.1 Link the between the interview guide and the research questions

5.4.2 Consultant interview protocol

The Consultant interviews took place in a quiet room in the library and away from the clinical work environment. Permission was sought and gained to audio record the interviews, so that both the researcher and interviewee could fully participate in the interview conversation. The researcher explained he would be asking a series of questions to ensure that the interview covered the same terrain for all interviewees. The researcher sought to establish a relaxed, open atmosphere and to encourage the interviewee to expand or deviate from questions as they wished. The interviews lasted from between 25 – 40 minutes.

After each of the interviews, the researcher made field notes of general observations and ideas emphasised by the Consultants interviewed. These notes were useful in the subsequent coding process utilised to generate the themes. The audio recordings of each interview were transcribed verbatim by a medical secretary, paid by the researcher and not connected with the interviewees. The researcher then verified these transcripts by listening to the audio file while reading the transcript. Any errors in the transcribed interview document were corrected and the audio and transcribed document securely stored under password protection, along with the field notes for each interview.

5.4.3 Thematic analysis of interview transcripts

By interviewing the Consultants, the researcher sought to determine how they conceptualised clinical reasoning, and to better understand how they seek to role model clinical reasoning skills to junior staff. Qualitatively analysing the interviews allowed an understanding of how their '…*world is interpreted, understood, experienced, produced and constituted'* (Mason 2018, p. 3).

Thematic analysis is a widely used method and is compatible with a constructivist approach, but is not wedded to any specific theoretical framework (Braun & Clarke 2006). By using thematic analysis, the researcher was able to identify, analyse and report patterns and themes within the data. Finding these patterns involved searching across the corpus of data to find repeated patterns of meaning (Braun & Clarke 2006). It was important to carefully observe the patterns within the data before attempting to understand its meaning and apply it to generate themes (Boyatzis 1998). Using thematic analysis enabled the researcher to generate themes and then to answer the research questions.

5.4.4 Process of thematic analysis

The process followed for the thematic analysis used the six stages described by Braun and Clarke (2006). The transcribed interviews were imported into the NVivo version 11 software package, which assisted in organising the interview data for the thematic analysis (NVivo 2016). This enabled the researcher to ensure that there were no inconsistencies in the transcripts, and enabled key ideas to be identified within the interview transcript for coding later. Braun and Clarke (2006) regarded active immersion in the data as vital to the search for meaning and patterns across the dataset. Reflective journal notes were also made, which were used to help in the process of coding the transcripts and identifying themes and sub-themes.

After familiarisation with the transcript and the production of journal notes for each of the interviews, the next step of thematic analysis was the coding of the transcripts. The initial codes identified an important aspect of the data and comprised '…*the most basic segment, or element, of the raw data or information that can be assessed in a meaningful way regarding the phenomenon'* (Boyatzis 1998, p. 63).

During the familiarisation stages, some initial codes and their rationales were identified and noted down. The transcript was then carefully read while listening to the audio file to identify sections of text that could be coded for meaning linked to the research questions. Interview sections that had similar meanings were coded to the same node (candidate theme). Periodically the coded sections were reviewed, and the names given to the nodes re-assessed. There was no attempt to try and restrict the number of nodes coded during this initial phase of coding. The process of coding organised the data into meaningful groups and was the first step in the process of discovering themes and patterns within the data (Crabtree & Miller 1992; Tuckett 2005). The coded, rich descriptions from the transcripts enabled the later development of meaningful themes. It was important to keep sufficient data surrounding each of the coded sections to avoid losing the contextual meaning from which they were extracted. Coded sections of the transcript that appeared contradictory to other interviewees were especially noted.

During the coding phase, the researcher was inductively searching for key ideas or salient comments made during the interview. The aim during the coding phase was to identify and group similar ideas that arose during the interview. Once all the interviews had been coded, the next phase was to identify the overarching candidate themes that link the codes. While generating the codes was an inductive process, developing the research themes from the candidate themes was a deductive progression. Some of the themes produced were sub-themes of larger concepts. The process of creating the themes was iterative and required revisiting the coded sections of each transcript. This was done to re-assess that the coding had been performed in a way consistent with the overall nature of the interview.

Once the candidate themes had been developed, they were reviewed to ensure that the coded sections linked together in such a way as to create meaningful internal consistency, while allowing for clear distinctions between themes (Braun & Clarke 2006). The second sub-process in reviewing the themes was to consider the validity of the individual theme in relation to the whole data set, being on guard against data that may have been incorrectly coded to a theme.

The fifth stage of the thematic analysis was the refining and (re)naming of the themes in order to ensure they were relevant and contributed to answering the research questions. Identifying the themes and the patterns within the interview transcripts was an active, reflexive process (Varpio et al. 2017).

In this study, in order to achieve the status of a theme, comment must have captured something important about the interview which was relevant to the research question and was representative of a patterned response or meaning, as suggested by Braun and Clarke (2006). The data coded to the themes was rich and descriptive and added depth to the comments assigned by a code.

The transcripts were coded inductively as ideas and constructs were identified, enabling salient and unexpected comments to be noted, as well as the more anticipated responses (Patton 2015). This inductive approach did not try to fit the data to an existing coding framework, but rather sought to identify patterns within the transcripts.

When the transcripts had been coded to candidate themes, they were deductively analysed to determine their internal consistency, the differences and similarities between the candidate themes, and their relevance to the research questions. The names assigned to the themes were carefully evaluated to ensure they succinctly and comprehensively accounted for the coded elements which comprised them.

The coded transcripts had their themes identified at a semantic (as opposed to latent) level (Boyatzis 1998). In Section 5.5 the themes are described and analysed, and the significance of their patterns given broader meaning within the context of this study.

5.4.5 Ensuring robustness of the thematic analysis

One of the researcher's academic supervisors (RE) selected several interview transcripts and independently coded and developed themes for comparison with those generated by the researcher. The researcher and supervisor met on several occasions to ensure the credibility and consistency of coding, as well as to reduce the risk of analytical bias (Patton 2015).

Developing clinical reasoning skills is a constructivist process, and each Consultant has developed these skills individually. The researcher sought to identify commonalities between each of the individuals. The word 'triangulation' carries the positivist notion of identifying latent truths, rather than actively grouping a variety of angles of approach. 'Crystallisation' is a more appropriate term to describe the role of supervisor RE in ensuring the rigour of the theme identification process (Richardson & St Pierre 2005).

In qualitative research involving interviews, the transcripts may be presented to the interviewees after the interview for their comment. This process is sometimes called member checking and is designed to enhance both the credibility of the data analysis and participant involvement (Varpio et al. 2017). Member checking, however, was not anticipated to change the overall nature of the themes and sub-themes identified. Encouraging interviewees to read the verbatim transcript of the interview with its pauses, 'ums' and unfinished sentences would not have added to the study and may have caused participants to feel unsettled. The researcher did not do this. The researcher identified themes and sub-themes while concurrently listening to the audio file and reading the verbatim transcript. The researcher developed meaning across the interviews, in conjunction with his knowledge of the clinical reasoning literature.

The intention when developing this study was for only the data from the four General Medicine Consultants to be included in the final analysis of the gathered information. However, the themes generated from the pilot phase of the study matched very closely with those from the General Physician interviews. The researcher, in consultation with his research supervisors, decided that it was reasonable to include the data from both Paediatric and General Physicians in the final analysis phase of this research study. The speciality of the Consultant Physician can be identified from Table 5.1. The researcher was satisfied that theoretical sufficiency had been reached; the themes and the sub-themes managed new data without the need for further modification (Dey 1999). In addition, the sample met the requirement for confidence that the data was robust enough for reliable analysis (Malterud, Siersma & Guassora 2016).

5.4.6 Participants and inclusion criteria

To explore Consultants as role models within General Medicine, the four Consultant General Physicians who worked at the Townsville Hospital were invited to be interviewed. All four General Medicine Consultants consented to participate in this study. Before the interview, it was explained to the Consultants the aim was to explore their understanding and experiences of clinical reasoning. Each of these Consultants had completed an undergraduate medical degree and years of further specialist training before gaining their Fellowship of the Royal Australasian College of Physicians (FRACP). The Consultants each worked nearly full time at the Townsville hospital and had practised there for a minimum of two years before the interviews. In addition, three Paediatric Consultants were interviewed during the pilot phase of

developing the semi-structured interview guide. The inclusion criterion for participants in this study was a Consultant Physician working at the Townsville Hospital. Demographic details of the paediatric and General Physician Consultants interviewed are included in Table 5.2.

Table 5.2 Demographic details for interviewed Consultants

Pseudonym	Age/ years	Gender	Years as a Consultant	Undergraduate training location	Fellowship training location	Specialty
C1	40 – 45	Male	11-21	Outside Australasia	Outside Australasia	Paediatrics
C2	51+	Male	21+	Outside Australasia	Outside Australasia	Paediatrics
C3	51 +	Female	21+	Australasia	Australasia	Paediatrics
C4	40 – 45	Female	11-21	Outside Australasia	Outside Australasia	General Medicine
C5	51 +	Male	21+	Outside Australasia	Outside Australasia	General Medicine
C6	46 – 50	Female	3-10	Outside Australasia	Australasia	General Medicine
C7	46 – 50	Male	21+	Australasia	Australasia	General Medicine

The Townsville Hospital is located in regional Queensland, and at times it struggles to attract medical doctors (Section 2.2). To encourage doctors to work in regional and remote areas, the Federal and State Governments have developed policies to encourage non-Australian trained doctors, including Consultants, to work in these underserviced areas. Table 5.1 shows that most of the Consultants in this study did neither their undergraduate nor their specialist training in Australasia.

5.5 Qualitative results and analysis

The process of thematic analysis described above was applied to all seven interview transcripts. Three themes were identified from these transcripts: '*Self as a learner*', '*Observations of the clinical reasoning process*' and '*Nurturing clinical reasoning skill development*'. These themes and sub-themes are described below (Table 5.3). The research questions were then revisited, and the findings from the interviews used to answer the research questions.

Table 5.3 Themes and sub-themes identified from Consultant interviews

Theme 1. *Self as a learner*
Clinicians' conceptualisation of clinical reasoning
Ingredients of clinical reasoning
Progression of a personalised approach
Mystery of the clinical reasoning process
Medicine as an apprenticeship
Theme 2. *Observations of the clinical reasoning process*
Development and variability of thinking style
Speed of novice compared to expert
Theme 3. *Nurturing clinical reasoning skill development*
Philosophical approach - develop yourself
Enablers and inhibitors of clinical reasoning development

5.5.1 Theme 1. 'Self as a learner'

'… my journey of learning clinical reasoning … was unguided. I mean, I – I didn't even know I was doing it and then it was really only in the last 10 or 15 years, particularly when I used to attend handover rounds with 15 registrars that I found I was thinking about things very differently to the way they were'. C2

This theme identified how Consultants reflected on their journey of acquiring clinical reasoning skills. It was clear that the process of gaining clinical reasoning skills had been a personal, tacit and un-guided progression over a prolonged period, and that it had been influenced by many senior doctors and clinical experiences. The way this influence is described by C2 (above) gives weight to the notion that more senior medical staff have acted as mentors to C2. The interview process unpacked the sub-themes of the *'Self as a learner'*.

The five sub-themes are

1. *'Clinician's conceptualisation of clinical reasoning'*,
2. *'Ingredients of clinical reasoning'*,
3. *'Progression of personalised approach'*,
4. '*Mystery of the clinical reasoning process'*, and
5. '*Medicine as an apprenticeship'*.

The essence of this theme was that learning clinical reasoning skills for these Consultants had been a protracted and subconscious journey.

Sub-theme 1. *'Clinician's conceptualisation of clinical reasoning'*:

The Consultant's explanation of what he/she understood clinical reasoning to be included the notion that it was a 'challenge' and a 'puzzle' and that it was:

'…about how a clinician comes across a diagnostic and therapeutic problems and how they use their experience and knowledge to come up with an answer' [C4].

Their responses showed that the Consultants were unfamiliar with the term clinical reasoning as described in the literature, but they stated that knowledge and experience were necessary to solve clinical problems. For all except one of the Consultants, the interview was the first time

they had talked at length about clinical reasoning. [C3] said that he/she had never heard the term clinical reasoning until quite recently. The term clinical reasoning may not have been familiar to the Consultant participants, but they each had a tangible understanding that knowledge and experience were necessary to diagnose and manage patients, and that these skills were an integral part of their role as a clinician. Their lack of familiarity with such a term gave credence to the idea that clinical reasoning had a low profile within the busy clinical environment.

Sub-theme 2. *'Ingredients of clinical reasoning'*

The Consultants identified five ingredients they regarded as important for clinical reasoning namely: 'knowledge', 'experience', 'information filtering', 'metacognition and feedback' and 'gut reaction/ intuition'. These ingredients are discussed below. The researcher's field notes from most of the Consultants interviewed emphasised that knowledge and experience were regarded as the most important of the ingredients.

Knowledge:

The Consultants regarded clinical reasoning as having two key ingredients: knowledge and experience. However, they struggled to explain in detail why each was necessary to the development of clinical reasoning expertise. They conveyed an assumption that to be more proficient, one needed more clinical knowledge, and to have seen many patient presentations over time.

'Clinical reasoning is very knowledge-based …' C1.

'You need to have a certain amount of knowledge base and to keep expanding it. There's no limit of that knowledge' DM2

'… it's knowledge and it's not just knowledge, it's the relevant knowledge' C2

The literature discussed the need for clinical knowledge to be organised so that it can be mobilised for clinical use (Charlin et al. 2012). The Consultants did not discuss how this knowledge needed to be transformed for use within the clinical context, as discussed earlier in Section 1.10. Understanding this transformation process with the aim of being able to explain and teach it is considered, in the literature, to be more important than the popular emphasis on the need to gain more knowledge (Custers, Regehr & Norman 1996; Cutrer, Sullivan &

Fleming 2013). The Consultants interviewed in this study were aware of the need for doctors-in-training to continue to increase their clinical knowledge. However, they did not explain how this knowledge could be transformed and made available for use in the clinical setting.

Experience:

The importance of clinical experience in developing clinical reasoning skills was frequently mentioned by all Consultants during their interviews.

'... the doctor-in-training who asks many, many things maybe they don't have the cognitive experience to know what to do with the responses to all of those things' C3

Consultant C3 states that doctors-in-training may gather large amounts of patient information but struggle to discern which elements of it are useful or not. In helping to develop clinical reasoning skills, the function of experience, like knowledge, was not explained by the Consultants. There was an implicit assumption that seeing more patients enabled doctors to advance their clinical reasoning skill development. This simple explanation contrasts with that in the literature, in which authors discuss the ways that clinical knowledge is encapsulated to form complex, but cognitively mobile illness scripts, which improve decision making and may make it appear less effortful (Dreyfus & Dreyfus 1980; Schmidt & Rikers 2007; Sweller 1994). Illness scripts may be then modified, expanded and refined (Section 1.10.4).

Information filtering:

All the Consultants referred to the need for seeking and using 'relevant' knowledge to make clinical decisions. They spoke of the need to 'filter' the information gathered from patient histories, imaging scans and laboratory results. The idea of filtering information was described by DM2:

'... you activate your filter to filter off all the noise from the signals ... You don't take everything on the face value, and you try to fit in – into that basic story where does that fit.' DM2

The Consultants appeared to use the analogy of a filter as a way of highlighting the need to separate the important from the unimportant information needed for making clinical decisions. This idea built on C3's previous statement about students gathering a large amount of information but being unable to make sense of it. Students may struggle for two reasons: firstly, they cannot sift the information to identify the essential information, and secondly, they may

not have enough sufficiently developed illness scripts to be able to extract meaning from the data. In the Consultant interviews, knowledge and experience appear inextricably intertwined:

'... experience and knowledge both have to marry each other'. DM2

The tacit development of an information filter is expected of students and doctors-in-training by Consultants, as stated below:

'[It] *really irritates you when someone's presenting a case ... and two or three things that I want to know ... and I don't hear them ... and it's difficult for me to listen to what else they are presenting until I get those three questions…'* C2

Consultant C2 states their frustration at being provided with large amounts of patient information, much of which they regard as unimportant in identifying the diagnosis or management plan. This consultant wants the presenting doctor to prioritise and disseminate important information first.

It appears only information regarded as important was sought and then used in decision making by Consultants. The development of this information filter was spoken of as evolving over time as the doctor gained more experience. This idea of a filter, described by C5, implies both direction and momentum in the way information is sought and then synthesised. Consultants are actively testing early diagnostic hypotheses in a dynamic and systematic manner. They are not mindlessly gathering as much information as possible. Instead, the Consultants spoke of intentionally seeking specific data to test and refine their differential diagnoses. Consultants may have a target diagnosis in mind, but they are aware of the need to be vigilant and avoid errors in filtering and synthesising the information gathered:

'...I think you've just got to be pretty bloody careful out there and mindful…You've just got to go ahead and be as aware as you possibly can of everything around you and take nothing for granted.' C2

Metacognition and feedback:

Learning (tacitly), how to think about their thinking, and the feedback received from Consultants during their training, were cited as important factors in developing the Consultant's clinical reasoning skills.

'Well, clinical reasoning skills are the more you do it, the better you're at it, and I think that certainly people of my generation learnt clinical reasoning by trial and error, and I don't think they knew what they were learning. They didn't think about their thinking. No one – no one has ever suggested, you know, I think about my thinking. I was also told that, you know, you were wrong to think of that or you were right to think of that, but the actual process of thinking and the intricacies involved – I don't think I knew about them until about 2 or 3 years ago.' C2.

This comment indicates that improving clinical reasoning skills requires metacognitive skills and is further emphasised by the comment from C2:

'No one has ever suggested, you know, I think about my thinking'. C2

This statement by C2 indicates that he/she now regards thinking about thinking as important, but it was never mentioned during his/her own training. Within the literature, there is a considerable body of evidence promoting the importance of metacognitive awareness and its role in developing expertise (Kuhn 2000). Kuhn stated that as metacognitive skills develop they become more explicit, powerful and effective and operate more under conscious control (Colbert et al. 2015; Kuhn 2000). It appears that Consultant C2 is indicating that by developing metacognitive skills they are now able to better regulate their thinking and decision making.

The second factor C2 mentions is the way they were given feedback by their senior clinician supervisors:

'I was also told that, you know, you were wrong to think of that or you were right to think of that, but the actual process of thinking and the intricacies involved – I don't think I knew about them until about two or three years ago'

This binary way of thinking: you were either right or wrong, did not encourage this doctor to think very deeply about the way he/she synthesised information to arrive at a diagnosis or management plan. If he/she were 'right' – then the Consultant was likely to have stopped thinking about the clinical decision any further, as described earlier by Croskerry (2009). If he/she were 'wrong' however, C2 implied that the onus was exclusively on the doctor-in-training to try and work out the cause of the error. To do this required the ability to think about their thinking (metacognition), which was not explicitly encouraged. If the doctor-in-training

did not later think about his/her thinking after having been 'wrong', then it is likely they would not learn a great deal from this event.

One of the respondents (C1) said:

'I am naturally quite reflective based on my internal monologue, so I do often reflect back on what's gone on and how I've done things and where I know I've cocked up'.

This Consultant discussed his/her metacognitive style as being a personality attribute and explained how this helps him/her to reflect on past successes and failures. From these comments, it was implied that he/she regarded metacognition as an important instructive process, but one that was rarely articulated. The implication is that during his/her training the Consultant worked out for him/her- self the importance of metacognition, and then developed it as a tool to refine his/her clinical reasoning skills.

Gut reaction/ intuition*:*

Several of the Consultants talked of 'trusting my gut feeling' – which they explained as trusting their intuition. When the interviewer explored this idea further the Consultants rationalised this type of intuitive decision making as being based on the sum of their knowledge and experience:

'I think that even though I've got my gut feeling, it's not based on gut, it's based on my experience' C4

'If it's not matching your intuition, then you go and start doing deduction again, most of the doctors-in-training I noticed they work more in deduction style'. C6

'If I take a patient with multiple problems going on, my overall analysis sometimes says that this is a very simple problem because I've seen it a million times before, and then I realise that it's simple for me because I've seen it many times and I need to make it simple for the junior who hasn't seen it before.' C4

'…as people go through their working life they realise that not every patient fits that perfect textbook diagnosis.' C1

During the interviews, the Consultants explained they were much more reliant on intuitive thinking than doctors-in-training. The literature identified intuitive thinking as being a type of

pattern recognition (Section 1.10.5). The Consultants subconsciously assimilate new knowledge and experience, which results in further refinement and elaboration of their illness scripts. The Consultants also displayed a heightened awareness of the need to monitor their thinking to avoid errors. Having seen many similar patient presentations over time, Consultants are mindful of the various ways in which a condition may manifest. This approach avoids anchoring themselves to a fixed path of thinking and enables them to generate a larger number of possible differential diagnoses.

The concepts identified in this sub-theme of 'Ingredients of clinical reasoning' include many of the items described in Section 1.2. It was noteworthy that although the Consultants were aware of many of these concepts from their own experience before the interviews most of the Consultants had not consciously thought about their clinical reasoning processes.

Sub-theme 3. *'Progression of a personalised approach'*

Many of the responses coded to this sub-theme were expressed in response to the first three questions in the semi-structured interview. The questions asked the Consultants to reflect on their own clinical reasoning skills and those of their colleagues. All the Consultants interviewed expressed the idea that, over the course of their careers, their approach to solving clinical problems had changed, but most had not reflected very much on this. C2, who was knowledgeable about the clinical reasoning literature, said:

'*…only in the last 10 or 15 years… I found I was thinking about things very differently to the way they* [doctors-in-training] *were*'.

This un-noticed development in thinking over time, was a commonly expressed sentiment:

'... before, I think I did things by my gut instinct without realising' [C4]

[C1] talked of their *'internal monologue'* as they reflected on *'how I've done things and where I know I've cocked up'*.

The probe and prompt process of the semi-structured interview process generated evidence that cognitive and metacognitive reflection are seldom explicitly discussed or taught to junior medical staff. This self-feedback or metacognitive monitoring of performance is important, but

seemed to have been given very little prominence during their training. The Consultants experienced personal, tacit self-reflection as culturally normal. This finding led to the Consultants reflecting that their own journey of clinical reasoning development had been a private and personal one, rarely brought into the open or discussed with colleagues or peers.

'I build the middle path. That's my own way of doing it'. C5

The above quote by C5 succinctly exemplifies the notion of Consultants building their own individual style of thinking.

All the Consultants described that developing clinical reasoning skills had been an unguided process, and one in which they had had to build their own pathway to solving clinical problems:

'the way experts worked were a complete and utter mystery to me as to how they got the diagnosis…'. C1

'Unguided process of learning'. C1

The Consultants described the learning process as hidden and 'unguided' and the way experts worked and thought while they were training as a 'mystery'. It was only now as Consultants that they had become aware that they now think differently from doctors-in-training.

Sub-theme 4. *'Mystery of the clinical reasoning process'*

Solving clinical problems is at the core of medical practice, and Consultants are at the forefront of role modelling this to doctors-in-training. From the interviews with Consultants it was evident that they have very little understanding of how they solve the clinical problems and fulfil this role model function:

'A lot of people out there are excellent diagnosticians …. but it's all a mystery to them and they don't know how they do it … I don't exactly know how it works' [C2].

To further compound this problem, there was a realisation that the clinical reasoning process is fast and generally subconscious, making it very difficult to explain to doctors-in-training. The comments made by those interviewed are sentiments that have often been reported in the literature (Irby 2014; Montgomery 2005). The implications of this are profound and problematic. One of the Consultants interviewed, C2, was knowledgeable about the clinical

reasoning literature. The remaining Consultants had not come across this literature before. Most of the Consultants only had their own experience and reflections to draw upon in helping to make sense of how they problem solve.

Sub-theme 5. *'Medicine as an apprenticeship'*

All the Consultants interviewed stated that they felt experience and knowledge were essential for developing clinical reasoning expertise. They also described the influence that senior clinicians had on their learning.

'The exam system doesn't set you up to do the job … I'm a huge believer in you do have to do some time. I think medicine is actually an apprenticeship, which is not very fashionable in certain parts of the world currently – in terms of looking at that as how you train doctors'. C1

The notion of learning by apprenticeship has long been established in many trade-based professions, and recently has been re-emphasised in the health literature (Lyons et al. 2017). Implied within this description is the idea that learning takes place under the tutelage of a more experienced clinician, who gives feedback and correction when necessary, and that over time and with experience, novices develop expertise themselves. It is interesting to note that C1 anticipates that using the term 'apprenticeship' may be met by opposition within the medical community. They felt this opposition to using the term 'apprenticeship' may be due to the term being used more commonly within the context of learning a trade skill, and not medicine. The concept of learning clinical reasoning skills by an apprenticeship model is detailed later in Chapter 7

5.5.2 Theme 2. 'Observations of the clinical reasoning process'

The focus of this theme were the Consultant reflections of their clinical reasoning processes and that of their doctors-in-training. The two sub-themes generated were:

1. *'Development and variability of thinking style'*
2. *'Speed of novice compared to expert'*

Sub-theme 1. *'Development and variability of thinking style'*

'Some people work quite differently from me' C6

The Consultants described their learning of clinical reasoning skills as being a tacit process which was not discussed with either their peers or Consultants during their training. The notion that during their training they regarded their Consultants as 'geniuses' and the way that they thought as being a 'mystery', has already been noted.

All the Consultants indicated that there was considerable variation in the way that individuals process and solve clinical problems. It was implied that doctors-in-training would also develop a personalised approach to clinical reasoning, but it was for them to discover what worked best, just as they had done during their own training.

'There are many ways to skin a cat …' C6

'I modelled myself on my immediate peers and on registrars and Consultants'. C5

The Consultants were likely to model clinical reasoning to their junior staff in a way that matched their own preferred learning and reasoning style. The unspoken understanding was that their junior staff would then build their own reasoning pathway as they progressed during their training.

Sub-theme 2. '*Speed and inflexibility of novice compared to expert*'

The Consultants described the way doctors-in-training often appear to be in a rush to make a diagnosis and then to anchor to it, even if evidence then becomes available which might challenge this diagnosis:

'The young people tend to want to go for diagnosis straight away – feel under pressure to find the diagnosis'. C3

'Sometimes they're unwilling to move sideways. You know, once they've decided this is what fits this pretty picture, they don't want to move laterally and say it could be something else'. C4

'Some people are more rigid, and they decide on a path and go for it. And I think there's something probably intemperate about that … have a concrete way of looking at stuff, they struggle more.' C1

'You're most confident when you know the least, you know. Your confidence actually begins to wane with time because you realise that nothing is as certain as you think it is.' C4

'For complex problems, I tend to want to feel out all the different possibilities before I come to the exact diagnosis or a set of differentials. Common things are common, but you need to make sure you've excluded – I guess the red flags?' C3

[Interviewer] 'So what makes you as a Consultant more willing to be flexible?'

'.... I've been burned'. C4

The doctor-in-training may regard making a diagnosis as a challenge, and a quick response indicates a superior ability to synthesise information efficiently and effectively. Doctors-in-training may also see fewer diagnostic possibilities, as their clinical knowledge is not yet organised in a way that enables them to suggest multiple, competing diagnostic possibilities, particularly with unusual case presentations. Seeing fewer possibilities, feeling the need to arrive at the diagnosis quickly and then defend it, may cause clinical reasoning errors for doctors-in-training. It may also make them appear impetuous. By contrast, Consultants can generate many viable differential diagnoses but are cautious about committing themselves to a single diagnosis prematurely (Section 1.11). Consultants may have been incorrect in the past, and they understand the importance of carefully monitoring and regulating their cognition, and the need to re-examine their diagnoses (called safety-netting) in case further information becomes available (Section 3.5).

5.5.3 Theme 3. 'Nurturing clinical reasoning skill development'

This theme comprises the comments made by the Consultants as to how they seek to nurture clinical reasoning skill development among their doctors-in-training. The sub-themes were:

1. *'Philosophical approach - develop yourself'*
2. *'Enablers and inhibitors of clinical reasoning development'*

Sub-theme 1. '*Philosophical approach – develop yourself*'

Three factors appear to influence how Consultants may foster clinical reasoning skills in their doctors-in-training. Firstly, their own experience has taught them about the need to develop a personal clinical problem-solving style. Developing their own personalised style has been a

subconscious process, undertaken without externalising the process in conversation with their peers or senior colleagues. Secondly, Consultants readily attributed acquiring clinical reasoning skills to gaining more knowledge and experience. This emphasis on the importance of gaining knowledge may lead Consultants to pass on information to doctors-in-training, believing they are helping the trainees develop their clinical reasoning skills. More important than the knowledge alone is how it is organised to solve clinical problems (Section 1.10). The third factor likely to influence how the Consultants mentor, is the learning culture that they experienced during their undergraduate and postgraduate training. Consultants may seek to replicate their own training culture or may decide that they wish to create a very different learning climate to the one role modelled to them as they work with their own teams. Two of the Consultants noted the very hierarchical structure of the teams in which they had worked during their early training in the Indian sub-continent.

'...hierarchy-wise as a junior level back at home [Indian sub-continent] – your Consultant never noticed you …. yeah, we were all scared. We were not going to ask him any questions.' C6

The same Consultant observed of his/her postgraduate training in Australasia:

'[In Australasia] the communication is open – open among each other. Everybody's putting in their two coins, including the Intern'. C6

This Consultant explained the benefits of open communication in terms of encouraging each member of the team to contribute, within an environment which is positive and non-judgmental. The literature has supported the view that this non-judgmental type of working environment is conducive to learning clinical reasoning skills (Section 4.11). The country the Consultants trained in is likely to influence how they learned, and possibly foster clinical reasoning skill development.

How Consultants viewed the learning process may have a significant impact on the way they seek to cultivate clinical reasoning skills among their doctors-in-training:

'I don't spoon feed them'. C5

'Mostly I tell them that medicine is a practice that comes over time so the more you do, the more you see that better the pattern because it's not only signs'. C6

'I think that they should get it [understanding] by watching and getting what I'm doing'. C1

'You cannot do without knowledge, but beyond that is only attitude. How you learn from the seniors – what to take from each of your Consultants'. C5

The Consultants' predominant philosophical approach was that doctors-in-training learn clinical reasoning skills on their own by observation, by experience and by acquiring knowledge. The Consultant C5 described doctors-in-training as needing to have initiative, motivation, and the right attitude if they are to gain the knowledge required to become a clinical expert. In other words, by interacting and watching the Consultant go about his/her work, the doctor-in-training will slowly become better at clinical reasoning. These comments indicate a culture of learning which promotes the notion that each doctor-in-training must forge his/her own pathway to expertise. These attitudes align with the experiences described earlier of how the Consultants themselves learned as doctors-in-training. It also explains why, as doctors-in-training, they regarded their Consultants as 'geniuses' and the way they thought a 'mystery'. The implied attitude was that the doctor-in-training must develop their own route to expertise. Most of the Consultants did not suggest how they could additionally help foster clinical reasoning skills among their doctors-in-training.

These philosophical approaches were in stark contrast to those of one of the Consultants, including (C2) who had an interest in and familiarity with the clinical reasoning literature:

'I think that it would be helpful to get them to think about their own thinking - they should learn about cognition'. C2

'Unless you're actually addressing teaching clinical reasoning, you're going to keep on getting these errors, no matter what system you've got in place. 'I think trying to say that we don't have any evidence for the best way of teaching clinical reasoning and therefore not doing it is not good enough - waiting around until we've got the perfect way to teach clinical reasoning, is not going to work.'. C2

This Consultant advocated the approach of teaching aspects of clinical reasoning which familiarises the doctor-in-training with an understanding of how expertise develops. This instructive style contrasts with the passive approach of the majority of Consultants interviewed.

C2 felt that helping doctors-in-training to understand how their thinking develops would be beneficial in assisting them to understand and refine their own reasoning skills.

Within this group of Consultants there were two contrasting viewpoints. Most Consultants felt that gaining clinical reasoning skills was a journey each doctor-in-training must embark upon on his/her own. There was little a Consultant could do to help. In contrast, C2 felt there was a great deal that could be done to illuminate the unfolding learning pathway for the doctor-in-training. He/she felt that helping the doctor-in-training to understand the learning process would facilitate insight and foster metacognitive skills.

Sub-theme 2. *'Enablers and inhibitors of clinical reasoning development'*

Thematically analysing the Consultant interviews identified several factors they regarded as positively influencing their own development of clinical reasoning skills, namely: 'Self-aware', 'Asking the right question', 'Attention to detail', 'Striving to continually improve' and 'Sensitivity to the clinical picture'. The Consultants felt that an absence of these factors would manifest as barriers to the clinical learner. An additional factor was identified: 'Inhibitors of clinical reasoning skill development.

Self-aware:

In the interviews, the Consultants explained the concepts of being 'self-aware' and 'self-critical' as being necessary for monitoring their thinking:

'... it's a thing about having some self-awareness'. C1

The Consultants described the need to be metacognitively aware when making clinical decisions. These comments are supported by the literature, which emphasises the association between metacognitive awareness and expertise. The key assumption underpinning these statements is that failing to be self-aware or self-critical in the past has led these Consultants to make clinical reasoning errors. These experiences were painfully memorable and taught the Consultants about the need to be cautious and reflective in decision making. Consultant C2 described the awareness needed as being the same as that of one navigating through the jungle.

'I think you've got to be self-critical really ... I think you've just got to be pretty bloody careful out there and mindful ...of what you're doing and making sure that you don't – I mean it's

almost like … walking in the jungle with a whole lot of wild animals around you. You can't think about everything. Whether there's a tiger behind that tree or not … You've just got to go ahead and be as aware as you possibly can of everything around you and take nothing for granted'. C2

Asking the right question:

All the Consultants underlined the importance of the doctors-in-training continually expanding their knowledge base. Understanding the significance and links with other information within the clinical context was an important application of this knowledge, as was described by C5:

'So here is the answer to the direct question, but there may be other factors that you're not aware of that hang off that question you know, for example, I've got this patient with staph aureus in the urine what do I do about that? Well in fact the staph. aureus in the urine … will be staph. aureus from the blood stream. So, have you thought about this, this and this?' C5

If the doctor-in-training does not understand that the cause of the bacterial infection is from the blood, he/she may only seek to treat the urine infection. By incorrectly targeting the source of infection, the patient could rapidly develop fatal septicemia. By knowing the pathophysiology of the *Staphylococcus aureus* infection in the urine, the doctor-in-training can ask the more insightful question of how to treat the blood-borne infection. Treating the blood infection will also kill the bacteria in the urine and the patient will likely recover.

In this example, the Consultant intuitively knew that if *S. aureus* was found in the urine, it must have originated from the blood and be treated systemically. This type of rapid, intuitive response was possible because the Consultant had a wide range of well-developed illness scripts enabling them to quickly assimilate new information and then rapidly decide the best course of action (Charlin et al. 2007).

The underlying correlation between cause and effect needs to be considered very carefully. The Consultant is implying that one must be vigilant and reflective so that the right question is asked, which then can lead to the correct diagnosis or management plan. If the clinical problem is not correctly identified, then it follows that a proposed course of action will likely be incorrect.

Attention to detail:

Consultants regarded being vigilant and attentive to detail as an important attribute in helping to develop clinical reasoning skills, as well as in avoiding poor patient outcomes. This sentiment was conveyed by all the Consultants in the tone and word choice they used throughout the interviews, as described below:

' .... patients can get sick very quickly by not paying attention to detail — I guess having a bit of a laissez-faire attitude'. C3

Attention to detail is an enabler of clinical reasoning development and fits well with the other sub-themes that document the development of clinical reasoning skills. Failing to be vigilant in managing details may lead to the faulty synthesis of the information needed for decision making. The Consultants implied that by not paying attention to detail the care of the patient would be compromised, as important clinical tasks may not be adequately performed.

Striving to continually improve:

The Consultants agreed that the development of expertise requires an attitude of continually striving to improve. Commenting on a doctor-in-training who appeared to fail to progress as anticipated, C5 said:

'*I think they stopped maturing themselves…. they are not trying to close the loop'*. C5

This notion of continually striving to improve aligns with the literature and the role of deliberate practice in the development of expertise (Ericsson 2004). The forward momentum developed by actively striving to improve enables progression through the stages of acquiring expertise (Dreyfus & Dreyfus 1980). Those lacking this drive and inner determination are inhibited in their progression along the path to developing clinical reasoning expertise.

Sensitivity to the clinical picture:

The Consultants described the concept of the patient's imaging results, clinical history and laboratory tests combining to paint the clinical picture of the patient. Each component of the clinical picture provides a different perspective but is supportive of the same diagnosis or management plan for the patient. The Consultants used different descriptions to express the

idea of moving along a decision pathway, but failing to be sensitive to the overall trajectory of the evidence:

'...sometimes you recognise that you or someone else has actually followed something with their blinders on'. C4

'[If] it's not matching your intuition then you start doing deduction again ... I start as intuitive but as soon as I figure that no, it's something else, I just discard it .... When the pattern is not matching, I become more careful – you have to do it more slowly and consciously '. C6

'So even though they've asked maybe all the right questions and got the answers, they haven't been able to synthesise that together to come to the ... (correct diagnosis)'. C3

Reflecting what had helped their own development C1 stated:

'I think I'm relatively lucky in knowing my own limitations all the way through, and therefore I have no problem going to someone else and saying, 'I don't know' - 'What do you know? You're better at this than me in a – in a certain area.' I would seek help'.

Failing to be sensitive to the unfolding clinical picture and failing to identify any inconsistencies as they arose was considered likely to result in judgemental errors. Learning to be aware of subtle inconsistencies, while balancing these with the individuality of each patient presentation was regarded as a crucial skill, but difficult to learn. By deliberately practising, doctors-in-training can learn to be vigilant about each clinical detail and learn to consciously synthesise information linked with the unfolding clinical scenario (Ericsson 2004).

Inhibitors of clinical reasoning skill development:

In addition to the enablers of learning, the Consultants highlighted a dependence on modern technology as a potential inhibitor to making clinical decisions:

'The reliance on very careful history taking to get to the diagnosis has been somewhat superseded by clear tests like the CT [Computed Tomography scan]*'.* C5

'I think we are quite test-dependent. We're lazy– and you can do better if you take a good history rather than doing a blood test'. C6

Underlying these comments was the reality that, within the hospital context, it is relatively easy to order a wide variety of laboratory and imaging services. As well as availability, additional data were considered desirable to assist in making a diagnosis. The Consultant C5, described the CT scan result as 'clear' – implying that the radiologist interpreted scan result will yield the undisputable truth. Each type of medical diagnostic test and scan has its own specificity and sensitivity limit. No test is completely accurate all the time. Although useful, it is important that all the aspects of the clinical picture align to tell a consistent story, rather than relying on a single type of information. The Consultants implied that becoming reliant on these results was easy and the results are widely regarded as unequivocal. However, diagnosing or managing a patient from a test or scan result without a full understanding of the patient's clinical picture may be problematic. A scan or test may be ordered, not necessarily to confirm a diagnosis, but rather to identify the cause of the symptoms. Ordering scans or tests with the expectation that the result will illuminate a diagnostic or management pathway may lead to a simplistic over-dependence on this technology. Adopting this strategy may be appealing, but Consultant C6 warned against focusing too much importance on laboratory results at the expense of a whole patient perspective:

'We need to treat the patient, not the numbers' C6

Modern technology may be useful in helping to confirm a diagnosis or management plan, but using it to search for solutions may lead to errors. As well as being expensive, the over-reliance on diagnostic tests may diminish the necessity to think through a clinical puzzle and therefore inhibit the development of clinical reasoning skills.

5.6 Discussion

The themes and sub-themes which were generated from thematic analysis of the interview transcripts were used to answer the research questions posed in Section 5.2. These answers increase our understanding of how Physician Consultants function as role models. The discussion below is organised to address the research questions posed at the start of this study.

Question 1: ***What do Consultants understand clinical reasoning to be?***

The Consultants generally described clinical reasoning as a puzzle and a challenge that involved using their knowledge and experience to solve a diagnostic or patient management

problem. Being able to seek out relevant information, and then to synthesis the information to make a diagnostic decision was recognised as a critical part of their role as Consultant Physicians.

Question 2: ***How do Consultants understand they acquired clinical reasoning skills?***

The Consultants described their acquisition of clinical reasoning skills as having been an unguided and subconscious process. During the early stages of their clinical training, they regarded the way their Consultants made clinical decisions as being a complete mystery; as if these Consultants were geniuses. It became evident through the interview process, that transitioning from novice to expert was neither considered nor discussed with them during their training. The Consultants described increasing one's knowledge and experience as being essential to their development of clinical reasoning skills, but they did not give a convincing explanation of how this had taken place. They suggested that the observation of more senior colleagues' decision making and the feedback they had received had shaped their thinking and approach to clinical decision making. By inference, they understood they were now in a position in which those junior to them would be looking to them as role models. The Consultants explained that over time they had learned to filter patient information and discern its relative clinical importance. They described learning this process of discernment subconsciously, however, it was recognised as essential to the way they sought and synthesised information. Some of the Consultants disclosed that they had only recently become aware of the development that had happened in their own clinical reasoning. One of the Consultants described the process as being akin to an apprenticeship, and that they were now more reliant on their own intuition than they had been earlier in their training.

It is evident that Consultants' journey to developing clinical reasoning expertise was a significant but incremental and subconscious process. Only recently had they reflected that their years of clinical training had not just equipped them with more knowledge and experience but had changed the process by which they conceptualised and solve clinical problems. The Consultants indicated that their journey to developing expertise had been travelled without them being consciously aware of progressing through developmental stages.

The insights of the Consultants mesh with the literature. A consistent theme within the literature is that learning clinical reasoning was generally a subconscious, tacit process (Section 1.12).

The problem was that such a hidden process being it that it was often concealed from the conscious observation of the learner, and not reflected upon by the Consultant. Most of the Consultants interviewed stated that in the past they had not thought about clinical reasoning. The interviews appeared to have prompted some of the Consultants to reflect, for the first time, on their own experience of learning clinical reasoning skills. Given the importance of developing clinical reasoning skills, it is of great concern that learning these skills seems to be left passively to chance.

Question 3: ***How do Consultants seek to foster clinical reasoning skills among doctors-in-training?***

Gaining more knowledge and experience was the approach most Consultants advocated for the development of clinical reasoning skills. The clinical reasoning literature, however, makes it clear that additional skills need to be fostered if clinical knowledge and experience are to be transformed into improved clinical reasoning skill levels. These additional skills include cognitive flexibility, metacognitive skills and the characteristics of the adaptive expert (Spiro et al. 1988, Croskerry 2000; Cutrer et al. 2017; Lajolie & Gaube 2018). Most Consultants expected doctors-in-training to be self-motivated adult learners learning by participation and observation. The majority of Consultants espoused the view that doctors-in-training needed to make their own path to develop clinical reasoning skills, and it was a personal process undertaken without explicit guidance. No Consultant comments indicated that they had reflected on how knowledge and experience work together to help the doctor-in-training develop expertise. Consultant C2 had a different view from most Consultants. He made it clear that seeking to educate doctors-in-training about some of the key findings in the clinical reasoning literature, as well as encouraging them to regularly discuss the process of decision making explicitly, would be beneficial to trainees. These ideas are represented in Figure 5.2 below.

It was evident that the development of clinical reasoning skills by most Consultants is largely a subconscious process. The Consultants identified characteristics they regarded as necessary to the development of expertise, see Figure 5.2. The gap between the doctor-in-training learning path and what Consultants think they should learn is indicated in Figure 5.2 by a ‘star’.

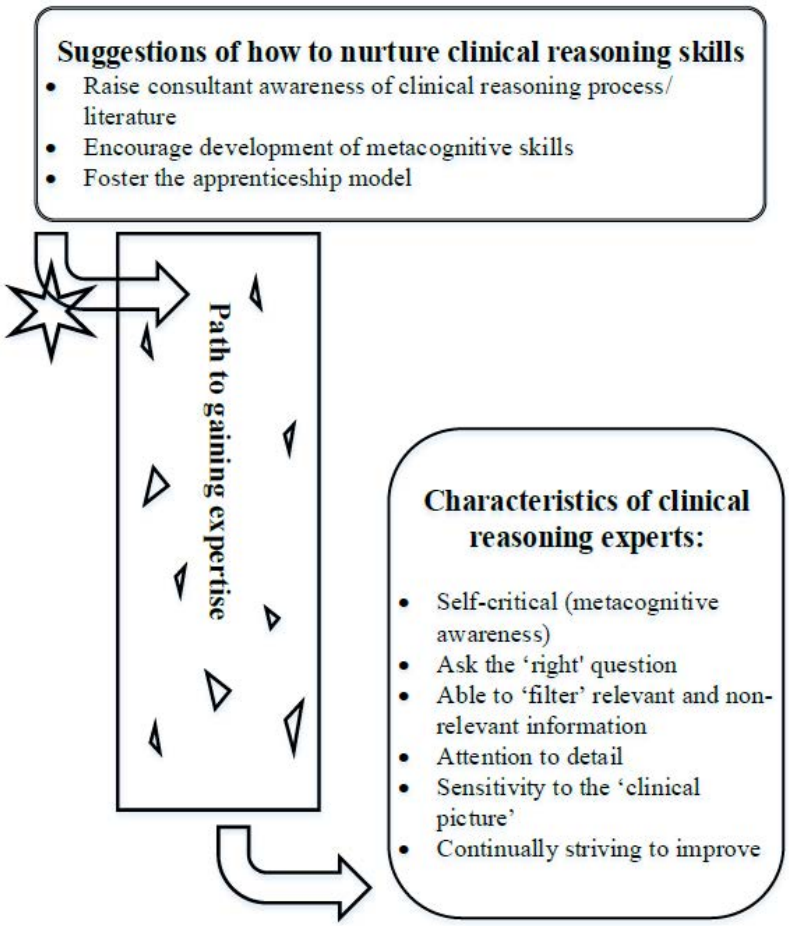

Figure 5.2 Summary of Consultant interviews

The Consultants identified several attributes they felt important and that should be cultivated, including the need to be self-critical, which links closely to metacognitive awareness and the need to monitor and regulate one's thinking. Although they note that being self-critical is important in developing and refining clinical reasoning skills, the Consultants did not indicate that they currently encourage their junior staff to develop metacognitive skills. It is noteworthy that during the Consultants' own training they also did not receive encouragement to develop metacognitive skills. The Consultants understood that these metacognitive skills were necessary, but felt that it was normal to develop these skills without any explicit guidance. The literature, however provides evidence that fostering metacognitive skills is necessary and important (Section 3.3). Actively paying attention to detail, asking the right questions and being sensitive to the patient's unfolding clinical picture were other associated factors identified by the Consultants.

It was evident during the interviews that the Consultants did not regard themselves as role models, but instead simply as more knowledgeable and experienced clinicians. The views of these Consultants contrast with the literature which identifies Consultants as vital role models to clinical learning (Passi et al. 2013; Houchens et al. 2017; Passi & Johnson 2016b). The interview data makes it clear that in the past the Consultants had not reflected on their own learning journey, which may account for them failing to self-identify as role models to their junior staff. The interviews also provided evidence that during the Consultant's own training there was no explicit awareness that their clinical supervisors were acting as role models to them. By failing to identify with their function as role models the Consultants may be adversely influencing the learning of their doctors-in-training. Two of the Consultants, C2 and C1 (both Paediatricians), gave suggestions as to how clinical reasoning skills could be better cultivated in doctors-in-training, including fostering the apprenticeship model of learning. Most Consultants, however, offered no suggestions on how they could intentionally foster clinical reasoning skill development.

The findings from this study identified an important gap between what the Consultants subconsciously know about clinical reasoning, and their current awareness and capacity to act as teachers and role models to doctors-in-training. This study has provided evidence that Consultants do not regard themselves as role models for learning, but are aware of many of the attributes cited in the literature as necessary to cultivate clinical expertise. Helping the Consultants to self-identify as clinical role models would appear to be beneficial. Providing the necessary support and training to Consultants to act as role models may assist doctors-in-training to learn the skills the Consultants identified as necessary for clinical reasoning expertise. A framework to support more effective learning of these skills is proposed in Chapter 7.

There were several strengths and limitations with *the Consultants as Role Models* study. A limitation of this study was that it took place in one hospital with a total of four Physicians working in the General Medicine unit. Most of the Consultant Physicians interviewed had done their undergraduate and postgraduate training outside of Australasia, which is common for doctors practising in regional and remote areas (Section 2.2.1). These non-Australasian trained Physicians brought expectations and experiences to their practise which may be different from those educated and trained in Australasia. A strength of this study was that the whole

population of General Physicians at TTH consented to participate and were interviewed for this study, in addition to the three Paediatric Consultants. Sampling the whole population of General Physicians gave confidence that data saturation for the interview responses had been reached. All Interns at TTH and many medical students and doctors-in-training from JCU experience learning in the General Medicine Unit under the supervision of the General Physicians interviewed.

The researcher worked in the Medical Education Unit at the Townsville Hospital while this study was undertaken. His role enabled him to develop a good working relationship with the General Medicine and Paediatric Consultants before inviting them to participate in this study. The researcher acknowledges that his role and previous rapport with the Physician Consultants may have influenced the interviews, and the subsequent thematic analysis of the transcripts. It is also likely that his previous acquaintance with the Consultants and work role gave legitimate permission to ask more probing interview questions.

5.7 Summary

Doctors-in-training in General Medicine work at the Townsville Hospital within Consultant-led teams. The Consultants are regarded as clinical experts, both leading and modelling thinking and learning their doctors-in-training, but do not regard themselves as role models. Three themes were generated from the Consultant interviews: *Self as a learner*, *Observations of the clinical reasoning process* and *Nurturing clinical reasoning skill development*.

Although the Consultants identified factors they regarded as important to their own clinical reasoning development, they provided few suggestions as to how they could actively foster these skills in their doctors-in-training. Consultants primarily conceptualised clinical reasoning expertise as the sum of a clinician's accumulated knowledge and experience. The Consultants' understanding of the clinical reasoning process, and how it can be fostered appear simplistic when compared to the literature (Sections 1.9 to 1.13). The study also provided evidence that the Consultants did not regard themselves as clinical role models.

It may be beneficial to increase the understanding among Consultants of how clinical reasoning skills are learned and explicitly fostered, as well as helping them to understand their function as role models. A faculty education initiative which aimed to educate and equip Consultants to

cultivate these skills among doctors-in-training may reduce the frequency of clinical reasoning errors, and improve patient health outcomes. A proposed learning framework to support Consultants as role models for developing clinical reasoning skills is discussed in Chapter 7 - Synthesis and Proposed Framework.

Chapter 6: Interns as learners

6.1 Introduction

Chapters 3-5 explored the influence of metacognitive awareness, the learning climate, and the function of Consultants as role models in the development of clinical reasoning skills in doctors-in-training. The General Medicine term is a key focus of this whole program of research. This chapter explores how Intern doctors-in-training understand their development of clinical reasoning skills during their General Medicine term.

In earlier chapters the structure and composition of the Intern year and the characteristics of internship at the Townsville Hospital were discussed (Section 2.2.2). Interns at the Townsville Hospital have completed their undergraduate studies in a variety of medical schools throughout Australia, with many from James Cook University. Their varied backgrounds mean these Interns are likely to have had differing experiences of learning clinical reasoning skills.

This study required the Interns to reflect on the development of their own clinical reasoning skills, even though it is unlikely to be at the forefront of their minds on a day-to-day basis. There are a number of methods which may be used to explore the views and learning experiences of doctors-in-training, though not all were practical for use in this study. For example, interviewing the Interns, without previous mention of clinical reasoning skill development, was thought unlikely to yield meaningful, in-depth reflections. Within the current research, video recording of Interns during their working day, for a 10-week term, and then asking them to reflect on their learning, was thought impractical and possibly unethical, as it may have compromised patient confidentiality.

Instead, a short PowerPoint presentation about clinical reasoning was developed to provide the stimulus for the Interns to meaningfully reflect on their learning of clinical reasoning skills at the end of their General Medicine term. The Intern PowerPoint presentation explored the importance and relevance of clinical reasoning skill development (Appendix 3). The rationale and development of this presentation are discussed in Section 6.4.1. A stimulated recall method was used for the 27 Intern interviews (Lyle 2003).

6.2 The research question

The research question for this study was: *'How do interns in medicine experience learning clinical reasoning skills'*

6.3 Ethical considerations

Ethical approval was granted by Queensland Health Human Research Ethics Committee (HREC/14/QTHS/ 178), and subsequently approved by James Cook University Human Ethics Research Committee (H6087).

6.4 Methods

The Sections below describe the rationale, development and protocol for the Intern PowerPoint Presentation offered to volunteer Interns at the start of their General Medicine term. At the end of each General Medicine term consenting Interns participated in a stimulated recall interview. A paper copy of the Intern PowerPoint presentation was used by the interviewer to stimulate Intern recall of their experiences in learning clinical reasoning skills during the previous ten-week term (Appendix 3). In Section 6.4.3 the stimulated recall method is discussed along with the process for thematically analysing the 27 Intern interviews.

6.4.1 Rationale and development of the Intern presentation

The Intern PowerPoint presentation sought to emphasise the importance of developing clinical reasoning skills by highlighting concepts and using vocabulary explored in the literature, as discussed in Chapter 1. The structure of the presentation was designed to provide a framework of topics for reflection by the Interns when they were later interviewed. The design and content of the presentation were discussed and modified in consultation with an experienced medical Consultant aware of the context and aims of this research. Activating the Interns' prior knowledge on this topic was regarded as important, as the researcher was concerned that without it the Interns may have been ill-equipped to reflect meaningfully on their learning.

The first slide of the presentation aimed to engage Interns by introducing the idea that they may be effective at gathering substantial amounts of patient information but may struggle to know

how to use it to generate a clinical diagnosis or management plan. The definition of clinical reasoning used in the presentation is the same as that used in Section 1.2:

Clinical reasoning is the ability to *'sort through a cluster of features presented by a patient and accurately assign a diagnostic label, with the development of an appropriate treatment strategy being the end goal* (Eva 2005, p.98).

The next PowerPoint slides explained the consequence of clinical reasoning failures in terms of the cost to the patient and healthcare provider, both financially and through increased patient morbidity and mortality. The literature used for these slides drew upon Section 1.11. Figure 6.1 shows that the focus of the presentation is the clinical reasoning process. The three main components of this process are knowledge and experience, data gathering and analysis and synthesis of information. The presentation was designed to provide vantage points from which Interns could reflect upon their own learning and decision-making processes.

The Intern presentation explored learning as an experiential process - more than simply gathering knowledge and gaining experience (Sections 1.9.3 and 1.10.4). The idea of meaning being constructed by the linking of new knowledge to existing knowledge to generate encapsulated knowledge was also explored in the presentation (drawing from Section 1.10.3). The researcher regarded it as important for the Interns to be aware that although knowledge and experience are important, it is how this knowledge is stored and made available for retrieval that makes it useful for clinical decision making. The Intern presentation also used a case study to demonstrate how clinical information may be used to trigger the recall of simple illness scripts (Section 1.10.4). The example used in the presentation was of a young female patient complaining of abdominal pain. The Interns were provided with some clinical information and asked to suggest and justify a differential diagnosis based on the information.

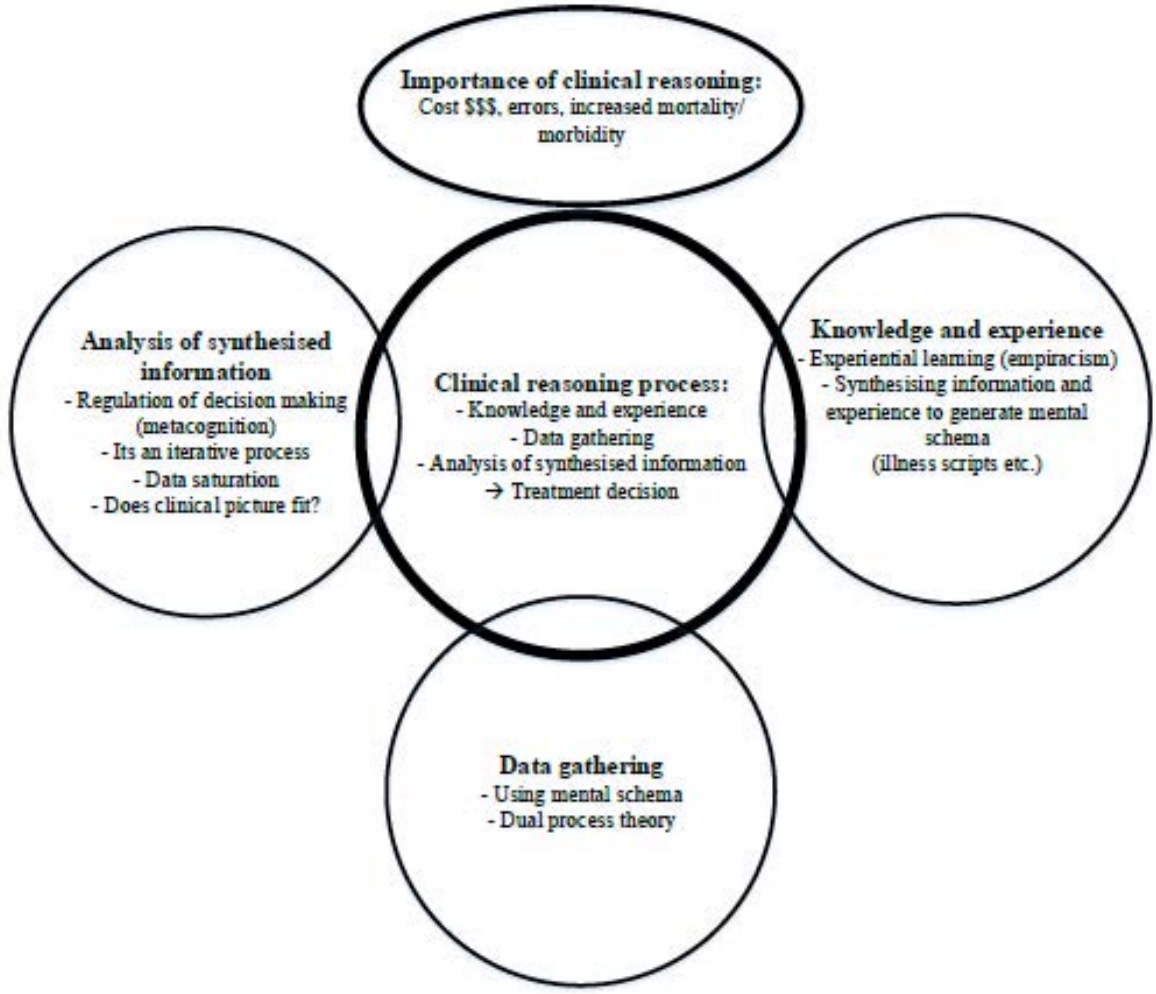

Figure 6.1 Components of the Intern Presentation

The second Section of the Intern presentation explored how patient data can be gathered. As students, doctors-in-training are taught to gather information by asking a series of questions related to the patient's presenting complaint, along with using laboratory and imaging information (Murtagh 2011). The literature indicates that the information gathered from the patient then subconsciously triggers the recall of pre-existing illness scripts, relevant to a possible differential diagnosis. Several authors explain the recall of illness scripts as being by an intuitive (Type 1) or hypothetico-deductive analytical process (Type 2 thinking). The Intern presentation briefly discussed this dual process theory of decision making (Section 1.10.5).

The final section of the Intern presentation explained that clinical reasoning is an iterative process of gathering, analysing and synthesising information until sufficient data enables the clinician to generate a defensible diagnosis. The ability of clinicians to reflect upon and monitor

their own decision making (metacognition) was discussed and explained earlier (Section 3.3). The presentation aimed to provide the Interns with an understanding of several key concepts which would assist them when reflecting on their own experience during the interviews at the end of the term.

6.4.2 Protocol for the Intern presentation

All Interns starting their General Medicine term were invited by an email from the researcher to attend the clinical reasoning presentation (Section 6.4.1 and Appendix 3). Before the start of the presentation, the Interns were made aware that their attendance was voluntary. Consenting Interns were contacted at the end of the term requesting an interview. Not all the Interns who signed the consent form were available for interview ten weeks later. Of the Interns invited for interview 25/70 failed to respond to the email invitation and 14/70 cited lack of time to attend due to workload pressures.

On each of the five occasions that the presentation was given, there were between 12-15 Interns present, along with a member of staff from the hospital Medical Education unit. The presentation took place in a quiet teaching room away from the clinical work environment and lasted 30 – 40 minutes. The Interns were not disturbed by phone calls during this time. The researcher who created and delivered the Intern presentations was an experienced educator, familiar with creating a safe and interactive learning environment for the Interns. He intentionally encouraged the Interns to ask questions during and after the presentation. A member of staff from the Medical Education unit confirmed, on all occasions, that there was a relaxed atmosphere in which interaction between the audience and presenter was encouraged.

6.4.3 Intern interviews – using stimulated recall

The literature makes clear that learning and the construction of meaning is a personal process, so individual Intern interviews were used instead of focus groups or written feedback. Stimulated recall is an introspective research methodology which enables the cognitive processes and memories of a subject to be recalled (Lyle 2003). Often in stimulated recall research, a subject is video recorded during a procedure or event, and then later asked to narrate the video recording, perhaps with additional prompting from the interviewer-researcher (Chen, Williams & Smink 2015). The narration/interview may be audio recorded, transcribed

verbatim, and then thematically analysed. Using the stimulus of the video recording, for example, a surgeon may recall individual aspects of the procedure, giving a much more detailed analysis of his/her thinking processes than would be obtained from a post-event think-aloud process.

Stimulated recall does not need to be confined to video recording an event before inviting the participant to discuss it. Stimulated recall has been modified within the medical education research context to include paper-based patient charts to explore a clinician's rationale for diagnostic, investigative and treatment decisions (Jennett & Affleck 1998; Maatsch et al. 1983). Chart stimulated recall has been used to evaluate clinical judgement by the American Board of Emergency Medicine and is regarded as having a high degree of face validity and acceptable psychometric measures of reliability (Solomon et al. 1990). A more recent study by the American Board of Emergency Medicine confirmed its use as producing both valid and reliable results as part of their enhanced oral examination process (Kowalenko et al. 2016). Chart stimulated recall has also been used as an assessment instrument as part of the UK National Health Service Foundation Program for junior doctors (Norcini & Burch 2007).

In this study, the researcher used a paper copy of the Intern PowerPoint presentation to stimulate recall of Intern experiences of learning during the previous term. The semi-structured interview followed the sequence of PowerPoint slides. The interviewer asked the interviewee to comment on each slide. The research question for this study was not directly mentioned to the interviewee, as recommended by (Lyle 2003). This avoided the possibility of the Intern stating what they thought the researcher might wish to hear. Lyle (2003) reported the need for the interviewer to develop a relaxed and non-judgemental rapport with the interviewee at the start of the interview to help facilitate candid reflections. The interviews took place in a quiet, comfortable room within the hospital library, which was familiar to the Interns. After informed consent the researcher highlighted the importance of ensuring patient confidentiality.

6.4.4 Transcription and thematic analysis

The Intern interviews were audio recorded and then transcribed verbatim by a paid assistant. The researcher checked the transcribed interviews for errors and corrected these by listening to the audio recording while checking the transcribed interview. The method used for thematically analysing the interview transcripts is described in Section 5.4.4.

6.4.5 Participant inclusion criteria

All Interns in the cohort were invited to participate over the course of the year. The participants in this study were 67% female, compared to 56% for the whole Intern cohort. There were 27 Interns interviewed from the cohort (N=27/70). The age for all interviewed participants in this study was between 21-25 years old, with the mean age for the cohort being 24.5 years old (SD=0.7). No Interns over the age of 25 years (N=0/8) chose to participate in this study.

Table 6.1 Participant demographic data

Term no.	Participant ID	Gender	Age years
Term 1	A1, D1, M1, T1	2M:2F	21-25
Term 2	C2, J2, M2	3F	21-25
Term 3	D3, E3, G3, Gi3, S3, Si, Z3	4M:3F	21-25
Term 4	A4, A14, E4, Ja4, J4, K4, Z4	2M:5F	21-25
Term 5	B5, C5, J5, Z5, M5, R5	1M:5F	21-25
	27 Participants	9M:18F	21-25

The structure of the Intern year was discussed in Section 2.2.2. At the beginning of each term, all Interns starting their General Medicine term were invited to participate in the study. Interns were provided with an information sheet about the study, and their written consent was obtained.

6.5 Results and analysis

The thematic analysis of the interviews produced three themes, each of which had several sub-themes. These are tabulated in Table 6.2 and explained further in subsequent sections. The meaning of these results will be explored in the Section 6.7 of this chapter.

Table 6.2 Themes and sub-themes from Intern interviews

Theme	Sub-theme
1. Characteristics of clinical reasoning experts	1. Knowledge and experience
	2. Discernment
	3. Proactive
	4. Cognitive flexibility
	5. Tolerance of uncertainty
2. Influences of colleagues	6. Supportive attitude
	7. Explain their thinking
	8. Negative role modelling
	9. Mimicking
	10. Patient handover
3. Influences of external factors	11. Rostering and workload
	12. Affect bias
	13. Electronic medical records
	14. Imaging reports

6.5.1 Theme 1. 'Characteristics of clinical reasoning experts'

The interviewed Interns stated that they are dissimilar to clinical reasoning experts. The sub-themes below identify how the Interns perceive these differences, along with the evidence they provide to support their observations. The theme *Characteristics of clinical reasoning experts* comprised the sub-themes of*: 'Knowledge and experience', 'Discernment', 'Proactivity', 'Cognitive flexibility'* and *'Tolerance of uncertainty' w*hich are discussed below**.**

Sub-theme 1. *'Knowledge and experience'*

For many of the Interns interviewed, acquiring more knowledge was strongly associated with gaining clinical reasoning expertise:

*'... well they've got more knowledge so they're able to think of things that I never would'.*C5

Acquiring more clinical knowledge as a means to gaining clinical mastery appears to be emphasised at medical school and throughout postgraduate medicine study. Alongside

knowledge, the Interns frequently stated that experience is a vital ingredient for developing expertise. By identifying their superior knowledge and greater experience, most Interns felt they had explained why their Consultants were better at clinical reasoning. Intern R5 repeated the understanding of their Consultant, regarding the role experience plays in developing clinical reasoning expertise:

'... one of the Consultants once told us that we as Consultants are no better than you – in the sense that we have just seen a lot more, more often than you have'. R5

The Interns felt that having more knowledge and experience had enabled the Consultants to develop pattern recognition which improved their clinical decision making. Developing a greater focus on the way doctors-in-training present and seek information was often stated as being an important developmental process. Being more focused required the Intern to identify and pay attention to the salient aspects of the unfolding clinical history:

'... When I call the Registrar now I start with the reason I'm calling: 'Can you come and review the patient?' then they'll want to know a bit more, so I start with what the task for the person I'm calling is, that way they can orientate their questions'. M1

The Intern M1 stated that earlier in the first term they had tended to ask more broad questions of their Registrar and Consultant. This less focused approach seems not to have elicited the required help, requiring the Intern to develop a more sophisticated method of gaining assistance from the Registrar. The Intern indicated they now plan what help they will require and have the necessary patient information available before asking the Registrar simple, focused questions requiring specific action. The Interns expressed this need for brevity and focus as being of general importance in the way they talked to colleagues as well as in the written patient notes.

'... in the beginning, I'd be very – very extensive. Just verbose almost like as if I was saying it. I've noticed that when Consultants or regs wrote notes, they would get everything I tried to say across in much shorter notes' R5

Sub-theme 2. '*Discernment*'

The Interns cited that the Consultants sought specific clinical information about a patient and could synthesise this information to generate a diagnosis or management plan much faster than the Interns:

'I find that they are very specific with what they look for'. A1

'And I think all those thought processes for us though are just a lot slower and take a lot more steps'. M2

'... they will usually be able to ask it a lot quicker. Like they'll ask probably less questions'. A4.

The Interns recognised their own loquaciousness in contrast to that of their Consultants:

'... I'd ask the Consultant what's his clinical impression of the patient and he'd have a lovely sentence which kind of highlighted the two main things and why they were linked ... in a really effortless sort of way ...' M2

The processes of defining, refining and filtering or discerning important from less important clinical data were regarded as a vital component in developing expertise. The Interns readily observed these characteristics in both the Consultants and, to a lesser extent, in Registrars. Although they recognised this trait, none of the Interns stated they had discussed it with their senior medical colleagues; they had simply noticed the phenomenon and sought to copy it.

Sub-theme 3. '*Proactivity*'

The Interns identified that Consultants proactively assimilate clinically useful information, and taking responsibility for the patient stimulates this process:

'... one of the Consultants, Dr X, he said, don't treat these patients as if they're my patients. Treat them as if they were <u>yours</u> because then you'll actually care about what happens to them ...' R5

The Consultant thought that taking more responsibility and ownership for the patient would help the Intern raise their level of thinking and learning. Interns emphasised the need to initiate and maximise each opportunity for learning as they felt it was not going to occur if they were

passive. The two Interns quoted below highlight the need for theoretical information to be turned into a useful form within the clinical context.

'... you can learn as much as you want at medical school but, like until you actually see patients and put it into practice you don't understand it really but – it's like an internship is such a huge experiential learning'. C2

'... theory is there but then until you like organise theory in practical use, it's never going to be useful to you.'. R5

The Interns interviewed stated that Consultant clinical reasoning was different and superior to theirs. It involved being able to efficiently and effectively use their medical knowledge within the clinical setting. The Interns were not able to identify how theoretical knowledge was transformed through experience into a form that was more accessible and available for clinical use.

Many of the Interns described working on the Acute Adult Admitting team as a time when they had learned the most. During this time the Intern was the first doctor to have contact with the patient in the Emergency Department. The Interns have about one hour to take a patient history and then order some basic laboratory tests or imaging. In taking the initial history from the patient, the Intern determined which questions to ask, and from these answers construct a coherent clinical picture to explain their findings and identify a working diagnosis. Once completed, the Intern presents the patient to the Consultant, along with their diagnosis and a suggested management plan.

The responses from several of the experienced Interns indicated that evaluating the relevance of clinical data was sometimes beyond their level of expertise:

'... they're hazy edges that an expert – like people like myself wouldn't think about because they wouldn't notice it, or they wouldn't think to think about it'. R5

'No, it's just a question mark that just hangs above it and if I can't make sense of it then that's when I just let the Consultant know'. K4

'[Consultant] Might place more importance on it or think a bit more about what's actually going on rather than trying to brush it off'. J5

One Intern stated that if some clinical data could not easily be integrated into the clinical picture, their Registrar would tend to ignore it. Ignoring patient data that does not conform to the dominant, unfolding differential diagnosis or management plan may lead to clinical reasoning errors in some situations.

'... if the Registrar doesn't know what to do it's usually dropped off…they will just leave it'. G3

Sub-theme 4. *'Cognitive flexibility'*

In addition to specificity and being concise, the Interns identified agility of thinking, or cognitive flexibility, as being an important trait of Consultants. Many of the Interns highlighted the sensitivity of Consultants to the way they interpreted the evolving clinical status of their patients. The Interns contrasted this with their own inflexibility and hesitancy in being prepared to alter a current management plan or diagnosis:

'... then if something unexpected comes up, I've learnt that you can't just keep going on that same path, you have to try and change what you were thinking which is really hard to do; especially on a ward round when you've known a patient for two weeks - so then there's a new problem. It's about trying to start again really and then that may take you a different way then … it's definitely easier for the seniors' E4

Sub-theme 5. *'Tolerance of uncertainty'*

Along with a greater capacity for quickly gathering and synthesising relevant clinical information, Consultants were also described as being able to make decisions based on incomplete clinical information by displaying a tolerance of uncertainty.

'... part of it is – is becoming very good at recognising patterns that you've seen very many times before, but I think even, you know, the majority of the bosses here will also have a system for creating a good differential based on incomplete information. The Consultant is making these thought processes opaquely though'. Z3

This Intern implied that the intuitive and subconscious processes at work in the mind of the Consultant to initially generate, and then later apply pattern recognition to a new presenting patient, probably cannot be taught or even understood. Maybe for these reasons Interns are

content to attribute the term 'experience' as the rationale for the superior clinical reasoning skills of Consultants. The doctor-in-training appears to regard the precise role of experience in the cognitive development of the Consultant as unknowable.

The Interns often mentioned pattern recognition as a way of explaining the speed and perceived accuracy of the Consultant in arriving at a diagnosis or management plan. The Interns linked the development of this type of pattern recognition to the Consultants' expansive clinical knowledge and experience. The ability to make clinical decisions with incomplete information was simply described as being an opaque process. The Intern had no explanation for how the Consultant was able to make these decisions. One Intern summed up the common sentiment that there was an unexplainable link between experience and pattern recognition:

'...like it just sort of comes to them, a pattern, it's a *learned pattern recognition through experience that they don't really need to think about. I don't think you can be taught, it's what we gain from experience'. Z4*

'... I guess, for me I think it's all about experience and then developing that pattern recognition of certain things. I don't think you can be taught it all as much as what we gain from experience'. Z5

The Intern Z5 in the latter part of their quote hinted that developing clinical reasoning expertise cannot be taught, but it can be learned. This notion seemed to underpin many of the Intern ideas about clinical reasoning which appear to inhibit further reflection on how a doctors-in-training could further develop their clinical reasoning skills.

6.5.2 Theme 2. 'Influence of colleagues on learning'

In analysing the Intern interview transcripts, there were several ways that colleagues, including Consultants, influenced Intern learning of clinical reasoning skills. The sub-themes included: *'Supportive attitude', 'Explain their thinking', 'Negative role modelling', 'Mimicking'* and *'Patient handover'.*

Sub-theme 1. *'Supportive attitude'*

Interns sometimes felt that the attitudes of their Consultants were unsupportive of learning. Comments from the Interns ranged from a feeling that if they did ask a question, they would

be made to feel they were making a nuisance of themselves, through to a feeling of there being a disparity between what the Consultant might say and then actually be prepared to do.

'I felt like I was bothering them needlessly, I was very much made to feel like I was a nuisance. So, it wasn't supportive – they explained why they weren't worried, but it was done very abruptly, very shortly and very much like they needed to be somewhere else and I was wasting time.' S4

'I have a Consultant who said to me at the start if you ever have any questions about what I ask you to do, feel free to ask. So, they did say that - however, in the same way they probably were not the most approachable person. I didn't feel like if I did ask they would be very receptive' A4

Sensing this attitude from the Consultant, the Intern would ask another medical colleague for an explanation to avoid missing an important aspect of the management plan. In the quote above the term four Intern reported that if he/she did ask a question, their Consultant might have regarded it as a challenge to his/her knowledge or authority, not a way of helping shape the Intern thinking processes.

The learning experiences of the 27 Interns interviewed appeared to have been greatly dependent upon the way the Intern sensed and responded to the personality of their Consultant. The Interns regarded some of the Consultants as amenable to helping them, whereas other Consultants were thought much less approachable.

'And so, no matter if you got the question right, you would come away feeling very beat down and stupid from that'. D1

The Intern who made the statement above was in term one, so the attitude shown by this Consultant was likely to have made a significant impression on them and may possibly have made them warier of seeking advice from that Consultant in the future.

Sub-theme 2. *'Explain their thinking'*

From the Intern's comments it seemed that one of the most beneficial ways a Consultant could help Interns improve their clinical reasoning was to help them understand how they had arrived at a clinical decision:

'The best Consultants are the ones who have good clinical reasoning and who justify everything that they do'. A4

The Intern interviews identified at least two situations that may lead a Consultant to avoid verbally explaining their thinking:

'I don't know, coming from me it would have been taken more as a challenge. So, I often didn't ask, and the few times I did ask, the reasons I got didn't make sense. Like - they wouldn't have gone along with any clinical guidelines'. A4

In this comment, the Intern is showing a high level of critical thinking. The Intern expects Consultant advice to be consistent with both clinical guidelines and the patient history. If a different treatment plan was adopted, the Intern would expect there to be a clear, coherent supporting rationale. Intern A4 stated that their Consultant sometimes made illogical clinical decisions that didn't align with clinical guidelines and that they may fail to provide a rationale for their decisions. The apparent frustration the Intern feels towards their Consultant may mean he/she does not have high regard for the clinical skills of their Consultant. A lack of respect for their Consultant is likely to affect their learning detrimentally.

'A lot of it's going on in their head, but they don't communicate it to the Intern. You're sort of there with the notes you know; I don't know what's going on … I'll just say straight-out well that was just way over my head, can you, like tell me what I need to write here?'. K4

Intern K4 expressed frustration and pragmatism in the statement above. They had resigned themselves to not being able to gain a pertinent explanation for the Consultant decision. Instead, they were now simply ready to perform their duty as a recorder of information, rather than to try and understand the clinical rationale for the patient management plan.

'… if the person who is trying to mentor you or teach you cannot actually give you a rationale why they're doing something – not just that they aren't really good at communicating or aren't very proactive in teaching … that's when you get a poor learning experience.'. M5

There are several reasons a Consultant may not discuss his/her rationale. For example, the Consultant may be time poor, not enjoy teaching or be either unable or unwilling to explain his/her clinical reasoning rationale.

'...alot of them think in their head you know - it's like a duck. The feet are paddling under the water, but you can't really see what's happening ... they're just gliding, but underneath their legs are sort of whirring around.' S4

This statement conveyed several connected metaphors. Firstly, one cannot tell how the duck is moving along, but it is gliding gracefully and in a specific direction. In the same way, the Consultant who does not explain his/her thinking does not help the Intern to understand their clinical rationale for action, but the Intern is aware that there is both direction and momentum to their Consultant's thinking. Secondly, the Consultant appears to think fast and without effort, as there is little visible deliberation or exertion to observe. The cognitive demand on the Consultant to identify a diagnosis or management plan may appear minimal. This powerful metaphor represents how unhelpful it is for Intern learning if the Consultant does not explain his/her rationale for clinical action. The Intern can identify the expertise of the Consultant but is not helped to understand how the Consultant has synthesised the clinical data to generate a clinical decision. Intern frustration with being unable to understand the Consultant's thinking was identified in some of the comments made:

'.. if you then understand the reasoning behind that, that's a good experience to learn from' A4.

'...sometimes you just get sent to get a consult and you haven't even seen the patient - you don't even know what questions you could be asked. It is just very poor communication ...'. G3

The willingness and ability of the Consultant to explain his/her thinking appeared to be linked with Intern respect and confidence in their senior colleagues. The comment made by Intern G3 conveys a sense of frustration as he/she is requested to arrange a patient consult with another specialty, but without understanding the clinical rationale behind this request. Intern G3 describes this as poor communication but implies that the lack of understanding behind the request for a consultation is likely to make the task of arranging it more problematic, which

may compromise patient care. Frustration was a common sentiment for occasions when there was no understandable explanation given to the Intern.

Sub-theme 3. *'Negative role modelling'*

The Interns described several examples of negative role modelling – experiences they felt were instructive in how not to conduct themselves in their future medical careers. As part of their job, Interns are often required to approach the radiology department and request imaging scans for their patients. Intern J5 described an occasion when he/she was asked by the Consultant to obtain a specialised High-Resolution Computed Tomography (HRCT) scan for a patient:

'... the team thought that we needed a HRCT scan ... I took it down. Rather than just going through it with me and like why, when it – would be appropriate and when it wouldn't be appropriate I was kind of just told no, we don't do that.

I'll take it on myself when I'm teaching as an example of what not to do ...'. J5

Intern J5 reflected that this incident made him/her evaluate the experience and resolve not to emulate that type of behaviour. Another term five Intern, Z5, identified an example of poor communication between a Consultant and a patient as being an important lesson to them as to how not to behave:

'I know they [Consultants] *are busy people but they just have like zero communication skills. So, that's definitely one thing where I've always been, like I'm never going to be like that because the patient is sort of left just going: 'What?' Like some of them don't even know they needed surgery even though they're in the surgical clinics and they'll* [the Consultant] *just walk in and be like, we're taking your gall bladder out and you're like, 'thanks again, I'll fix all this up for you'. So, that's something I would not choose to do'.* Z5

These examples of negative role modelling, although regarded by the Interns as poor practice, were instructive when Interns metacognitively reflected on the incidents, and how they might influence their future practice. In the example of Z5, the Intern now had the more cognitively complex and sensitive task of re-explaining the Consultant comments to the patient, who may be confused and upset. Explaining the Consultant remarks to the patient was likely to have been a valuable learning experience, as the Intern needed to talk to the patient in an empathetic and informed manner, while answering any questions in a clear and understandable way.

Another frequently mentioned example of negative role modelling centred on the ordering of patient laboratory tests and imaging services.

'Some tests are misunderstood and so they're ordered inappropriately or too frequently'. D3

'Sometimes I'll order bloods that I don't think are appropriate, but I know that the Consultant will want, and they'll be annoyed if they're not there'. A4

'I think there's still a lot of shotgun investigations done here where you have a presentation and there's a very small hint – I think particularly in the rheumatoid or autoimmune side of patients with myalgias getting full work up who then come back to have the flu but have now had rheumatoid factor, and DCCPs, anti DSDNA, C3, C4 – yeah, and the fact that you can almost rattle it off because you've written it up so many times … I haven't seen any of them come back positive really this year'. Z3

'We do so many blood tests on people and you're bound to find, you know, electrolyte disturbances and stuff that doesn't really matter'. M5

The above quotations suggest that the Interns disapproved of the over-ordering of laboratory tests without regard for the possible utility of the result. The Interns also noted that the tests ordered may vary depending on who orders the test. It is evident from the above Intern comments that they have reflected on what they regard as poor practice and have decided to practice in a different, less wasteful and more intentionally focused way.

Sub-theme 4. *'Mimicking'*

Several of the Interns interviewed in the first two terms of the year mentioned the concept of seeking to copy or mimic the way in which their Consultant or Registrar spoke and behaved:

'… I think I mimic them more than anything. So, if I hear the way that they describe a patient, that's kind of how I'll interpret it because that's their …professional, more senior opinion of this patient.

'So instead of saying, 'Oh this is a gentleman who is withdrawing from Benzos – who was previously Benzo dependent' - I said that he was 'a gentleman who was admitted for poly – secondary to polypharmacy'. T1

The Intern T1 appeared to mimic the language of their Consultant and Registrar with the aim of being accepted into the team. This assimilation process required Interns to observe and copy the language of their clinical team. Interns are some of the most junior members of the medical team.

Sub-theme 5. *'Patient handover'*

Patient handover to a new team of doctors was frequently cited as a cause of potential cognitive bias:

'I think a lot of biases are based on handover as well … it can lead to a bias because if you don't look at the overall picture, you're like oh this patient is like this all the time. You kind of get the tendency to be a bit biased because of what the person previously has said the patients are like'. B5

The thinking trajectory of the earlier team is described as having a very strong influence on the subsequent management of the patient. This may be the optimal path of treatment for the patient, but the Interns also indicated that it may dissuade the new team of doctors from re-assessing the current management plan, and lead to premature closure.

6.5.3 Theme 3. 'Influence of external factors'

This theme covers additional elements which influence Intern learning, including organisational factors not directly linked to clinical colleagues. The factors identified from the Intern interviews include 'R*ostering and workload', 'Affect bias', 'Electronic medical records' and 'Imaging reports'.*

Sub-theme 1. *'Rostering and workload'*

For some Interns, the core General Medicine term may involve several weeks working as part of the Acute Adult Admissions team (AAA). Being seconded away from their General Medicine unit to the AAA part-way through the ten-week term was often regarded as disruptive to learning:

'… if you have six or seven weeks with the same team, that's fantastic … but switching teams you lose the team atmosphere … I would have liked more of the admitting weeks to be honest

with you. I think that's really good – that's what I liked about medicine. That's where you learn because – it's your responsibility and you don't want to drop the ball for the home team'. G3

The perceived disruption of changing teams seemed to be regarded as more than simply having to do a different type of work. The camaraderie of working alongside the same individuals seemed to add stability to Intern learning. In addition, working with the same team for longer may have afforded the Intern a greater level of acceptance, including being given more responsibility. One of the term two Interns expressed a more general frustration at being moved to different teams for a few weeks within his/her General Medicine term:

'I was with their team for three weeks and then I was off on the admitting roster and I've been back on the team for 3 weeks now … it's a really frustrating part of the Med rotation 'cause I can imagine I would be so much more um I don't know what the word is … advanced'. M2

In addition to the frustration of settling into one team and then being moved to another, the Interns uniformly described the considerable clerical workload as being a barrier to their learning. Most Interns described the imbalance they sensed between the pressing clinical needs of the hospital, and their own desire to learn. The tension between learning and clinical work was evident in the ways the Interns described their clerical load:

'We're so swamped with paperwork and the logistics of things. You're just kind of frantically trying to type the note while also faxing off a referral while also taking phone calls on your DECT [hospital] *phone and so I'd say 90% of the time I'm not really doing active thinking in terms of clinical reasoning'.* A4

This high degree of pressure to complete many clerical functions can lead to clinical errors. Intern R5 described how one dangerous error was instructive for him/her, but only after their Consultant gave feedback:

Oh, I remember writing up clexane for a patient who was supposed to go into theatre, because I was just mindlessly re-writing med charts for a patient and then the Consultant pulled me up in theatre later on that day and said, oh um the patient was really oozing in theatre. We had to transfuse them when they got back to the ward and then you had re-written that clexane had been written up'. R5

This Intern easily recalled the link between being too busy with clerical work, and the consequences of incorrectly writing-up the anticoagulant clexane for a patient about to undergo surgery. Although the burden of clerical work was regarded as a barrier to learning, the Intern noted that an important lesson had been learned. Closely related to the burden of clerical work, the Interns cited low staffing levels and imbalanced resourcing as having a detrimental impact on their learning:

'My biggest concern of med. is that it's under-staffed versus the amount of patients or it's not divvied up properly. And so, there's four teams but one team will have six and some other team will have 25 [patients] *for example. I'm not really learning the medicine aspect – it's not as I thought it would be coming into it. Because of the – just the – the volume and the pressure of giving paperwork. So, you don't feel – you don't feel like a doctor.* G3

The Interns commented that staffing levels appear not to match the requirements of the clinical work, and that low staffing levels add workload pressure, detracting from their ability to care for their patients and learn. The Intern perceptions of being too busy, gave rise to a feeling of being mentally overloaded, and not having the capacity to process the rationale behind the jobs they are required to do:

'I don't have the luxury to learn and understand everything I'm doing basically'. M2

'... to be honest, if I wanted to do the whole clinical reasoning process in my mind, I feel like I'd not get my jobs done and I'd be stuck here until very late at night and I would never get home'. A4

There was a feeling of desperation in the way these interns expressed their need to dispense with thinking as being too time-consuming. These Interns felt they only had time to do as they were told, not to understand why they did a task. It was noteworthy that A4 was interviewed for this study at the end of term four, which was close to the end of their Intern year. It was especially concerning that A4 felt thinking to be a time-consuming indulgence, especially at this later stage of their internship.

Sub-theme 2. *'Affect bias'*

Most of the Interns discussed thinking biases and how they may lead to errors in decision making:

'So, I mean one example is the widespread bias against patients who come in for example with schizophrenia or IV drug use. And even Aboriginals too. We have basically a mixture of drug using Aboriginal schizophrenic patient and she was basically dying on the ward and because she well was – one thing that she – she was aggressive when it came to putting on her bi-pap mask I think a lot of people took that as a symptom of her personality rather than as a symptom of hypoxia for example.' D3

The comment by Intern D3 gave a candid insight into how a thinking bias may have detrimentally modified the medical treatment of the patient. In recalling this incident, the Intern was indicating that this type of bias was unacceptable, but perhaps common. It was interesting to note the Intern did not indicate he/she did anything about the situation; the scenario was simply recalled as an example of bias interfering with optimal patient care. One Intern also mentioned how fear had influenced his/her attitude to a patient:

'... he tried to punch me once when I went to see him, he lost it. And then he's tried to throw something at me. And so, after that happened I wouldn't see him again by myself. I think that's more of a safety thing. But I stopped caring. That's the thing, I stopped caring'. C5

The Intern linked their response to negative patient behaviour, but other examples similar to that cited by C5 were not common amongst the Interns interviewed. The incident was memorable. Fear of injury by the patient made the Intern move past wanting to care for them, but the Intern was alarmed that they had stopped caring or having a desire to treat the patient. The Intern identified that attending to the clinical needs of the patient was influenced by the fear of injury from the patient. The Intern decided that if this type of incident arose again the best course of action be to either remove themselves from the situation, or to see the patient with a colleague.

Sub-theme 3. *'Electronic medical records'*

The electronic medical record was identified as a potential source of cognitive errors:

'You look through some notes, and some people just 'copy and paste' the histories and just get to the plan or something and so many errors could happen there'. G3

This comment about the ability to 'copy and paste' older information without further reflection was concerning. The Intern observations of these types of errors and biases provides evidence that they are aware of detrimental influences on their clinical reasoning processes. It was also reasonable to assume that these errors may go un-checked at times, leading to doctors-in-training making diagnostic or management errors.

Sub-theme 4. *'Imaging reports'*

Interns often stated they were required to order radiological scans for their patients. These scans were then reported by the Radiology Department medical staff for the General Medicine team that requested them. Often these scan reports were accepted at face value:

'Most of the time I think the radiologist report was the plan we'd go ahead with'. J4

'One definite bias I've seen happen a few times is in imaging. Junior doctors automatically assume, it must be this [as reported] *then, and nobody will go and actually look at the scan itself. But then the Consultants will always look at the films and go through them very closely and be like, no, no, no I'm not worried about the text. Let me look at the film first and make my own clinical decision before I look at the text. I think there's probably not enough perhaps – may be there's not enough teaching and explanation of how to properly go through imaging and stuff like that in the first place when – so then people are scared off – feel as though they can't you know, look for something – look at something themselves before making that decision'.* M5

Consultants were described as carefully interpreting the scan image for themselves before they read the radiological report. The Consultants appeared to use the radiological report to confirm or challenge their clinical impression, whereas the junior doctor seemed to accept the report without further reflection. Intern M5 reported that junior doctors appeared hesitant to trust their own abilities to interpret radiological images, and instead may accept the findings from the radiological report without seeking to make meaning from the scan for themselves. Although the Interns attribute reliance on the radiological report to insufficient teaching about interpreting images, the failure to '*actually look at the scan itself'* is problematic and may limit their ability to learn to interpret images for themselves.

6.6 Discussion

This study sought to explore how Interns understood their development of clinical reasoning skills during their General Medicine term. At the start of the term, the Interns were invited to a clinical reasoning PowerPoint presentation (Appendix 3). At the end of the term, consenting Interns were invited to be interviewed about their experience of learning clinical reasoning using a stimulated recall method (N=27/70). Analysis of the interviews generated three themes.

The *Characteristics of clinical reasoning experts* theme included concepts the Interns regarded as essential for expertise: *Knowledge and experience, Discernment, Proactivity, Cognitive flexibility* and a *Tolerance of uncertainty*. Many Interns felt that gaining clinical knowledge and experience were of paramount importance for developing expertise. Several Interns indicated they understood clinical expertise to be simply the sum of knowledge and experience gained over time.

The *Influences of colleagues on learning* theme comprised of: *Supportive attitude, Explain their thinking, Negative role modelling, Mimicking* and *Patient handover*. The sub-themes identified aspects of the learning climate that the Interns felt had an important shaping influence on their learning.

The *Influences of external factors* theme comprised of additional factors the Interns felt affected their learning including: *Rostering and workload, Affect bias, Electronic medical records* and *Imaging reports*. The Interns identified these external factors as often having an inhibitory influence on their learning. The *Affect bias* sub-theme included a concerning comment made by one Intern about the sub-standard care given to a hypoxic, schizophrenic Aboriginal patient. The Intern identified widespread clinician bias against those with mental illness, IV drug users and Aboriginals. The Intern indicated that this kind of racial and clinical bias is unacceptable, but prevalent.

Interns in this study understood the development of their clinical reasoning skills as a personal journey undertaken alone. The Interns reflected that, in developing their own path towards acquiring the *'Characteristics of clinical reasoning experts'*, they were influenced by two themes: *'Influences of colleagues on learning'* and the *'Influences of external factors'*. Figure 6.2 shows visually how these themes are linked.

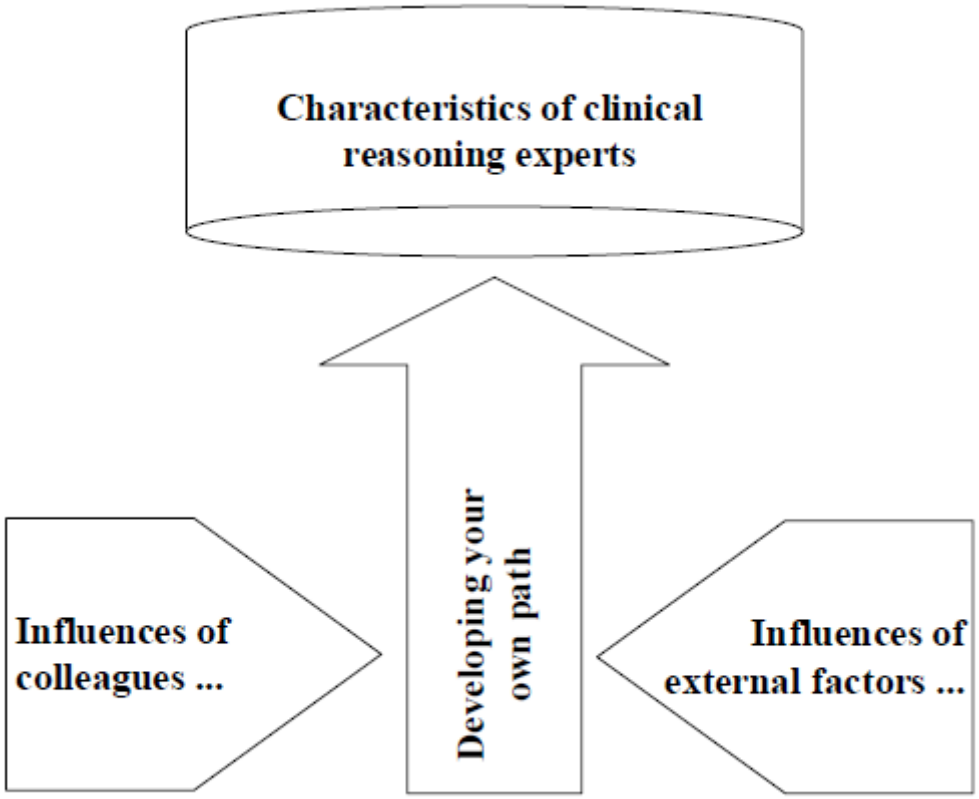

Figure 6.2 Diagram showing the themes generated from Intern interviews

In the theme *'Influence of colleagues on learning,'* the Intern described Consultants who were willing to explain their clinical decision-making processes teaching them in a conversational style. The Interns indicated that these Consultants produced a supportive and conducive learning climate. Although the Interns did not directly state that the Consultant is helping create a favourable 'learning climate', the characteristics described match closely with those in the literature, for example concepts identified in sub-domains of the D-RECT such as the *Role of the Consultant* and *Coaching and Assessment* (Boor et al. 2011; O'Sullivan 2015). The learning climate was important in providing a suitable context for the Intern to observe and seek clarification from senior clinicians in a safe and non-threatening environment (Sections 1.9.2 and 4.1 – 4.2). A non-judgmental attitude is an indicator of a healthy learning climate, in which the Intern is free to ask questions and volunteer answers without the risk of embarrassment or humiliation. Over the course of the Intern year, the Interns changed their focus from being predominantly task orientated to desiring to understand better how the Consultants made decisions.

Durning et al. (2013) explain that 'thinking aloud' helps the Intern to understand the connection between clinical data, and how it may be used to generate a diagnosis or management plan deductively. In some clinical scenarios, a Consultant may arrive at a diagnosis or management plan intuitively, by subconscious pattern recognition, which requires very little cognitive effort (Section 1.10.5). If the Consultant was asked to explain how they arrived at their decision in such cases, he/she might find it difficult to give a cogent explanation, as the process was subconscious. The unwillingness or inability of some Consultants to explain their decision-making rationale frustrated some of the Interns. This might explain why some Consultants feel ill-at-ease when asked to explain a decision, which they instinctively know to be correct but struggled to explain (Sandhu et al. 2006).

During the interviews, most of the Interns struggled to discuss what they would do if they came across clinical data that seemed to conflict with most of the information collated. One Intern commented:

'I guess when I get information that doesn't fit the first thing I ask is does that 'not fitting' outweigh the stuff that does fit? I'm always going, 'okay, yeah/ no that makes sense' or 'Oh, that doesn't make sense, I might come back to that later' sort of thing'. J5

The comments from J5 display a high degree of metacognitive awareness. This self-monitoring is often cited in the literature as an indicator of clinical wisdom and the development of clinical reasoning expertise (Colbert et al. 2015). It is worth noting that this term-five Intern was nearing the end of his/her internship. None of the Interns in terms 1 or 2 commented on what they would do if the clinical picture did not fit with aspects of the clinical data.

The interviewed Interns identified several characteristics he/she regarded as non-conducive to learning. An unsupportive attitude by some senior colleagues was identified in some of the Intern comments. The Interns described several examples of negative role modelling – experiences they felt were instructive in how not to conduct themselves in their future medical careers. Observing negative behaviours may be instructive to the Intern, but only if the Intern can reflect on the experience, and then transform his/her own behaviour (Mezirow 1997). This transformative learning experience requires metacognitive awareness and is described in the literature (Section 1.9.3). The interviewed Interns explained that they were encouraged to be

proactive and intentional in their learning. In the literature, the concept of proactivity has commonalities with the notion of learning by deliberate practice (Ericsson 2004).

The second sub-theme of *'Learning is Active'* was '*mimicking'*. The sub-theme of '*mimicking'* described copying various behaviours of more senior colleagues. In the literature, the concept of mimicking is regarded as an initial phase of a novice gaining acceptance within a professional team, called *legitimate peripheral participation* (Lave & Wenger 1991). To attain legitimate peripheral participation, the novice needs to be seen to act and behave in ways that adhere to the norms of that team (Section 1.9.1 and 1.12). The Interns in terms 1 and 2 tended to indicate that they actively tried to mimic their senior colleagues, which was dissimilar to the more experienced Interns in term 4 and 5. This change over the course of the internship year was likely due to Interns adapting and changing how they conducted themselves within the clinical team, as well as gaining more self-confidence in their clinical skills.

Learning through errors, created during patient handover, interpretation of imaging scans and the use of electronic medical records (EMR), were highlighted by the Interns. Human emotions also influence decision making (Artino Jr, Holmboe & Durning 2012b). The phenomenon of being over-influenced by the previous treating clinician is called *triage cueing* (Chew, Durning & van Merriënboer 2016). The interviewed Interns noted that incomplete patient handover might result in clinical errors due to triage cueing.

Some of the Intern comments attributed clinical errors to failures to synthesise patient information stored on electronic medical records (EMR). Varpio et al. (2015) highlighted that EMRs may disrupt the interconnection of clinical information, potentially impacting efficient clinical reasoning. Several authors promoted the benefit of doctors-in-training being taught about the different types and causes of clinical reasoning errors (Croskerry 2003b; Scott 2009). These authors suggest that raising awareness, vigilance levels and self-reflection may lead to reduced error rates. Evidence gathered during the Intern interviews indicated that Interns had not received sufficient teaching to raise their awareness of the different types of clinical reasoning errors, or how errors could be potentially mitigated.

The interviewed Interns identified several characteristics of experts, the most notable of which being that Consultants had more knowledge and experience. The Interns stated that gaining

more knowledge and experience had enabled the Consultants to develop sophisticated pattern recognition skills. It appeared from the interviews that many Interns believed that simply gaining more knowledge and experience produced clinical reasoning expertise. Many of the General Medicine Consultants also understood, and verbally emphasised, the belief that clinical reasoning expertise was a cumulative result of gaining more knowledge and experience (Section 5.5.3).

The interviewed Interns frequently stated that Consultant thinking was different from their own. The Consultants appeared to ask fewer but more focused questions, and then efficiently synthesised this information to direct their decision making. This difference in thinking skills between the Interns and Consultants resonates with the finding from the '*Consultants as Role Model*s' study (Section 5.5.1). The Consultants described their frustration at not being told the few pieces of clinical information by doctors-in-training, which they regarded as vital for making a clinical decision. The speed of thinking and the focused approach of experts' mirror findings in the literature (Schmidt & Rikers 2007). The speed of Consultant thinking is likely a result of pattern recognition and manifests itself as Type 1, or intuitive thinking (Croskerry 2009a; Pelaccia, Tardif, Triby, Ammirati, et al. 2011).

The Interns also noted that the Consultants were cognitively more flexible and tolerated a degree of uncertainty in their decision making. Tolerating uncertainty when making decisions is not a new construct (Fargason et al. 1997; Tversky & Kahneman 1974). It was a term three Intern, Z3, who noted that Consultants were able to make good clinical decisions with only limited clinical knowledge about the patient. It is noteworthy that Interns in this study stated they had not discussed or received any teaching from the Consultants about learning to tolerate a degree of uncertainty in their decision making. Cooke and Lemay (2017) stated that teaching and assessing a tolerance for uncertainty while coaching clinical reasoning skills is likely to be beneficial.

The literature suggested that, by helping to scaffold their decision-making rationale, the Consultant helps to shape and develop clinical reasoning skills of the doctor-in-training (Section 1.9.2). Ideally, the Consultant comprehended his/her vital role in helping the Intern to make sense of patient clinical information and then guided the Intern towards developing a diagnosis or management plan. In the language of Vygotsky, the Consultant is the *More*

Knowledgeable Other (MKO), who is functioning as the role model or coach, for Intern learning (Vygotsky 1978). Ideally, as the Intern accumulated knowledge and experiences their learning was supported and transformed into clinically useful illness scripts ready for later retrieval and usage (Charlin et al. 2007; Mezirow 2000).

The key finding from this study was that Interns understand the development of clinical reasoning expertise as a process of gaining knowledge and experience. Understanding and explaining the development of clinical reasoning expertise as primarily a process of gaining knowledge and experience is too simplistic. Expertise in clinical reasoning is based on both explicit and tacit knowledge (Epstein 1999).

This study has several strengths and weaknesses. The study took place in one tertiary referral teaching hospital in north Queensland over one academic year January 2014-5, so the results may not be transferable to all Australian hospitals. The researcher prepared and gave the Intern presentation at the start of each term and interviewed the 27 Interns. The researcher had previously worked in the Medical Education unit, but during this study was not employed by the hospital. A possible strength of the study was the development and use of the Intern PowerPoint presentation at the start of term. The researcher was confident that without the start of term presentation the Interns were likely to have struggled to provide the quality and depth of reflection revealed in their interviews. It is possible that Intern responses may have been biased by thinking that the researcher was employed in some capacity by the hospital, and this may have influenced their responses or decisions to participate in the study.

At this hospital, during 2014-5 there was a total of 70 Interns, of whom 27 were interviewed for this study. The lower proportion of male Interns interviewed may have resulted in some male viewpoints being under-represented, or even absent from this study. As no Interns over the age of 25 years participated in this study it may have limited the themes generated in this study.

The Intern comments reflected their experience of working in the General Medicine unit. A strength of this study was that it took place over the course of one Intern year. Conducting 27 interviews for this study represents a 39% cohort participation rate. Enough Intern interviews were undertaken and thematically analysed for the researcher to be confident that data

saturation had been reached. It is possible that more interviews may have yielded additional concepts for inclusion for analysis. The study adds confirmatory evidence to the '*Learning climate'* and the '*Consultants as role models'* studies, also undertaken at TTH. The extent of the generalisability of these results, along with the other studies are discussed in Chapter 7.

6.7 Summary

This study sought to explore how Interns at TTH learned clinical reasoning skills during their General Medicine term. Over the internship year 2014-5, 27 Interns were interviewed using a stimulated recall methodology to elicit their understanding of learning clinical reasoning skills. A finding from this study was that developing clinical reasoning skills receives little explicit emphasis from Interns and was rarely discussed between the Interns and their Consultants. Interns believed that developing these skills was a tacit, personal journey. Using the PowerPoint presentation at the start of the term appeared to be a successful strategy. The presentation helped to encourage Interns to effectively reflect on their learning during the interviews at the end of the term.

By thematically analysing the 27 interview transcripts, traits that influenced Interns in their learning of clinical reasoning skills were identified. Interns believed that the path to gaining expertise primarily required them to gain clinical knowledge and experience. The literature, and paradoxically the Interns' observations from this study however, provided compelling evidence that challenges this belief. The Interns interviewed identified traits that differentiated them from Consultants, but offered no explanation for these observations other than superior levels of knowledge and experience. It may be that the interns assume that these additional traits are simply by-products of acquiring knowledge and experience. Over the last three decades, many authors have sought to explain how knowledge is transformed into encapsulated networks and then later refined into illness scripts for storage and subsequent rapid retrieval (Brush, Sherbino & Norman 2017; Schmidt, Norman & Boshuizen 1990). Several factors influenced how fresh knowledge is added to existing mental schema to construct new meaning, including the capacity of doctors-in-training to monitor and regulate their thinking.

This study identified an important barrier to the development of clinical reasoning skills for doctors-in-training. Consultants and doctors-in-training appeared to believe that simply accumulating knowledge and gaining clinical experience lead to clinical reasoning expertise.

The Chapter that follows integrates the results from the four situational factor studies. These synthesised results are then used to provide supporting evidence for a proposed learning framework to help better support the development of clinical reasoning skills for doctors-in-training.

Chapter 7: Synthesis and Proposed Framework

7.1 Introduction

In recent years there has been a great deal of research interest in the clinical reasoning process. Some have utilised this research to generate teaching programs, for example, the Keele University five-week undergraduate course (Gay, Bartlett & McKinley 2013). Other applications of this research have focused attention on specific components of the clinical reasoning process, for example, the importance of improving reflection (Chamberland et al. 2015). Both of these approaches have merit, but as highlighted by Gruppen (2017), they risk the educator believing he/she can simplify and teach clinical reasoning as a generalisable skillset.

In Chapter 1 two main approaches to understanding clinical reasoning were identified: the empiricist and rationalist perspectives (Sections 1.9 – 1.10). Each of these two perspectives contains many lenses with which to view aspects of the clinical reasoning process. A central concept throughout the literature, however, was that acquiring clinical reasoning skills requires knowledge. Both the Consultants and Interns interviewed for this study regarded knowledge as having a central role in the development of clinical reasoning skills (Sections 5.5.1 and 6.5.1). The literature stated that this knowledge must be encapsulated and then used to generate mental schema called illness scripts (Section 1.10.3). Additional information is then either linked to existing illness scripts or used to construct new ones. The process of constructing and refining illness scripts may be powerfully influenced by the willingness and ability of the expert to explain his/her thinking processes to the doctors-in-training (Section 6.5.2). Personal, environmental factors and the metacognitive awareness of the learner were also cited as highly influential in helping the doctor-in-training to construct meaning (Chapters 5 and 6).

A second central concept cited in the literature was the importance of experience (Ericsson 2004; Pelaccia, Tardif, Triby & Charlin 2011). However, understanding how clinical knowledge is transformed through experience, along with the development of educational strategies aimed at reducing cognitive errors, have yielded only marginal benefits (Croskerry 2017; Norman et al. 2017). Even with the wealth of research evidence to date, there is no ‘best practice’ method of fostering clinical reasoning skills among doctors-in-training. Instead, the

large and fragmented body of research primarily offers a broad range of insights into the many and varied aspects of the clinical reasoning process. Learning clinical reasoning is a multidimensional endeavour but is a much more complex process than the sum of its components.

There appears to be a benefit in transforming the academic knowledge acquired to date into a practical framework which explicitly supports doctors-in-training in learning clinical reasoning skills more efficiently. The process by which Interns understand and develop clinical reasoning has been understudied, possibly due to the difficulty of being able to access this population for research purposes (Kiesewetter, Fischer & Fischer 2017). The research described in this thesis attempts to address this knowledge gap by seeking to understand how doctors-in-training in north Queensland currently learn clinical reasoning skills.

In the chapter that follows, the overall synthesised meaning across the four situational studies is explored. The second part of this chapter then uses these triangulated findings, along with insights from the literature, to identify a model for making expert thinking visible. Use of this model may provide better support for doctors-in-training to learn clinical reasoning skills. Each of the four studies has its strengths, weaknesses and different methodological approaches. Using a multi-methods research design allowed the weaknesses in one study to be supported and offset by overlapping strengths in the other studies

7.2 Methodological approach to the research

The multi-methods research design across four studies was detailed in Chapters 3-6. The methods used to answer each of the four main research questions were specific to the focus of the separate studies. In multi-methods research the studies are initially kept separate from each other. Only later are the results synthesised to generate overall meaning (Johnson, Onwuegbuzie & Turner 2007). Two of the research studies were primarily quantitative and two qualitative. In mixed methods research both qualitative and quantitative information are gathered in the same study and then synthesised to generate the overall results of that investigation (Creswell & Plano 2007). Only in the '*Learning climate'* study (Chapter 4) were both qualitative and quantitative data generated in the same study. These two types of data were initially analysed separately, and then later combined to give both breadth and richness to the results. Combining qualitative and quantitative results helped to answer the overall

research question: '*How do doctors-in-training in north Queensland learn clinical reasoning skills?'* The sections that follow summarise the main research findings from the four studies.

7.3 Main findings

7.3.1 Situational Factor Study 1. ***'Metacognitive awareness'***

The literature suggested a strong connection between metacognition and expertise in clinical reasoning (Colbert et al. 2015; Eichbaum 2014). Metacognitive skills help clinicians to effectively regulate their thinking and decision-making capabilities – which are essential for clinical reasoning. These skills, however, are not generally taught or assessed at either undergraduate or postgraduate level (Burman, Boscardin & Van Schaik 2014).

As metacognitive skills were cited as important, it was hypothesised that these skills would significantly improve among medical students between their first and fifth year of study, and that they would correlate with undergraduate examination performance. The results of the study showed there was no statistically significant difference in metacognitive awareness between the first and fifth year of medical school. There were, however, associations between metacognitive awareness scores and undergraduate examination performance. The overall finding from this study, like that of Colbert et al (2015), was that metacognitive awareness was important and should be actively cultivated to help doctors-in-training better self-regulate their decision-making capabilities. The '*Consultants as role models'* study also supported the notion that metacognitive skills are important, but not commonly taught (Section 5.5.1).

7.3.2 Situational Factor Study 2**. *'Learning climate'***

Interns work and learn within complex clinical contexts. The influence of this learning climate, which includes prevailing attitudes, standards and environmental conditions, impacts upon what and how they learn (Durning & Artino Jr 2011). Much of the clinical reasoning literature focuses on learning within the context of an undifferentiated patient case mix, a common occurrence in the General Medicine Intern term. This study focused on Interns during their General Medicine term.

The Dutch Residency Educational Climate Test (D-RECT) was modified for use in the Australian context, and Interns were then invited to complete the survey in The Townsville Hospital, which provided the setting of this research study (Boor et al. 2011; Pinnock et al. 2013). The learning climate sub-domains scores in *Coaching and assessment* and *Professional Relations between Consultants* were significantly lower in the General Medicine term than in the Emergency Department or General Surgery terms. The lower scores for the General Medicine term indicate areas of concern for Interns learning clinical reasoning skills in that important term. In addition, the results from this study, which included 53/60 Interns, identified Consultants as pivotal in helping to shape the Intern learning climate.

Several authors concurred with the findings from the *Learning climate* study, stating that senior clinicians are essential in helping to shape the learning climate for doctors-in-training through role modelling and providing feedback (Irby 2014; Rencic 2011; Weise 2010). These findings supported the investigation of the ways Consultants understand and seek to cultivate clinical reasoning skills among their doctors-in-training. The findings of the *Interns as learners* study also support the findings of the *Learning climate* study.

7.3.3 Situational Factor Study 3. *'Consultants as role models'*

Study 3 sought to apply qualitative methods to deepen the understanding of how Physician Consultants conceptualised their path to developing clinical reasoning expertise, as well as how they seek to foster these skills among doctors-in-training.

This study showed that during their training many of the Consultants had little awareness of their cognitive journey. They described their journey to developing clinical reasoning expertise as an unguided and tacit process that they seldom, if ever, had discussed. Many of the Consultants stated that gaining more knowledge and experience equated to the acquisition of expertise, whereas the literature provided evidence that this is only partially true. Although the Consultants identified many expertise-related traits that were described in the literature, they struggled to explain how they might cultivate these qualities in their junior medical staff. It was notable that the Consultants in this study did not regard themselves as role models to doctors-in-training, whereas the literature emphasises the importance of senior clinicians as role models (Section 1.14.3 and Section 5.6).

This study concluded that Consultants are likely to benefit from an improved understanding of how clinical reasoning expertise could be fostered, as well as acknowledging their function as role models. If Consultants actively and intentionally fostered the development of clinical reasoning skills, it is likely to be beneficial for doctors-in-training. The results of this study are supported by the findings from the *Interns as learners* and *Metacognitive awareness* studies. The experiences of the Consultants during their own training resonate with the findings from the *Interns as learners* study.

7.3.4 Situational factor Study 4. *'Interns as learners'*

This qualitative study sought to understand how Interns in their General Medicine term conceptualised the learning of clinical reasoning skills. Although the literature stated that clinical reasoning skills are central to medical practice, the Interns did not regard this as core to their role. The Interns described factors that may influence their learning while highlighting that gaining clinical reasoning skills was rarely, if ever, discussed. Interns stated they expected to develop clinical reasoning skills by gaining more knowledge and experience over time. This strongly held belief was similar to the belief the Consultants promoted that gaining knowledge and experience equated to acquiring clinical reasoning expertise. The Interns, in general, described their roles as predominantly clerical and administrative. This study provided evidence that it may be beneficial to intentionally focus on promoting and fostering the development of clinical reasoning skills during the Intern General Medicine term.

The *Interns as learners study* enabled the researcher to identify a key problem in the way doctors understood how clinical reasoning skills are fostered. Interns often believed clinical reasoning ability equalled the sum of knowledge and experience gained. Helping Interns to explicitly identify and intentionally cultivate the varied skills and attributes that comprise clinical reasoning skills may be beneficial for their development of expertise. The findings from the *Learning climate* study supported the findings of this study. The learning experiences described by the interns in this study were strikingly similar to those described *in the Consultants as role models* study.

7.4 Significance of the research findings

Although the literature is clear that clinical reasoning skills are foundational to medical practice, this focus was not explicit in the experiences reported by the Consultants or the Interns who were interviewed. For both Consultants and doctors-in-training, learning clinical reasoning skills was primarily a personal, meandering and subconscious process, with only tacit markers to guide them along a self-made learning journey.

Three key findings from this program of research were: firstly, metacognitive awareness skills are important in clinical reasoning, but they are seldom discussed or intentionally the focus of educational interventions at either undergraduate or postgraduate levels. Secondly, the learning climate of interns in their General Medicine term has noticeable and concerning deficits. Thirdly, some of the physician consultants interviewed had never discussed their clinical reasoning skill development before the interview, and most struggled to identify or explain tangible ways in which they could help doctors-in-training to further develop clinical reasoning skills. The General Medicine Consultants did not identify themselves a role models to their doctors-in-training.

The central findings from this program of research was that Consultants and doctors-in-training have an ingrained and culturally reinforced belief that by accumulating knowledge and gaining experience they will develop clinical reasoning expertise. Understanding the acquisition of clinical reasoning skills as primarily the sum of knowledge and experience gained is a concerning over-simplification. Reducing clinical reasoning to such a simple formula may be cognitively appealing, but disregards the wealth of clinical reasoning literature described in Chapter 1. It also ignores the finding from the four research studies detailed in Chapters 3-6. Additionally, learning clinical reasoning skills is made more difficult for doctors-in-training by Consultants failing to realise that they are role models to their junior colleagues. When these Consultants were training they identified their senior medical colleagues as role models.

Developing clinical reasoning skills means learning and being able to apply a complex combination of tacit and explicit skills. Some of the components of clinical reasoning are more obvious than others, such as an understanding that clinical knowledge is vital. Other aspects of developing clinical reasoning skills are subtler and more difficult to verbalise but are pervasive

and important. For example, the need for astute metacognitive skills extends from gathering and making meaning from knowledge, through to regulating the decision-making process.

Learning through an apprenticeship enables the apprentice to develop both tacit and explicit skills from the master (Lyons et al. 2017). By their very nature, tacit skills are difficult to conceptualise or verbalise, but are learned through the lived demonstration of the expert (Dornan 2005). Vygotsky describes the expert as the '*More Knowledgeable Other'* (MKO), and his/her role is to coach the learner (Section 1.9.2). Learning by apprenticeship does not require either the expert or the learner to make subconscious processes overt, only that the skills are transferred to the learner. Learning medicine through an apprenticeship model has been evident since the days of Osler but has recently come under severe strain. The specialisation of medical knowledge, along with shorter and more numerous clinical attachments, mean today's doctors-in-training are much less likely to benefit from an apprenticeship style of learning (Dornan 2005; Lyons et al. 2017). This contrasts with the Consultants interviewed in the '*Consultants as role models'* study, who are likely to have benefitted from learning through an apprenticeship model. Several of the interviewed Consultants referred to experts they regarded as key role models in their learning. A frequent comment made by the interviewed Consultants was that their journey to gaining clinical reasoning expertise was seldom, if ever, verbalised. The subconscious, non-verbalised acquisition and assimilation of clinical reasoning skills by these Consultants compounds the problem of coaching doctors-in-training in these skills.

In summary, it is important that doctors-in-training efficiently learn clinical reasoning skills, but the way these skills are currently learned may no longer be effective. With little exception, doctors understand the path to developing clinical expertise as a process of gaining knowledge and experience, but this oversimplification and fails to recognise its complexity. Currently, there is a growing awareness of the need for an explicit framework that helps cultivate the development and teaching of clinical reasoning skills for doctors-in-training within the clinical workplace (Croskerry 2017).

7.5 Identifying a learning framework

An explicit learning framework to support doctors-in-training in learning clinical reasoning skills needs to accommodate key findings from the literature and these studies, as well as being sufficiently practical to be able to be implemented within the clinical workplace. Two different

approaches for developing the learning framework were carefully explored for their practical utility by the researcher. Firstly, grounded theory was explored as a possible framework, which may have merit in helping to support the learning of clinical reasoning skills.

7.5.1 Grounded theory

Grounded theory is an established qualitative methodology which uses an inductive approach to gather and interpret information as a means of generating a new theory to explain the phenomenon in question (Charmaz 2015; Glaser & Strauss 1967; Mills, Bonner & Francis 2006). By exploring the resemblances between grounded theory and clinical reasoning the researcher hypothesised that grounded theory, although normally used as a research methodology, may be useful as a framework to help support doctors-in-training to learn clinical reasoning skills (Welch et al. 2017). The similarities and differences between grounded theory and clinical reasoning are explored below. Table 7.1 shows the components of grounded theory and the similarities to the process in clinical reasoning.

In recent years there has been growing emphasis on the importance of evidence-based medicine, underpinned by the belief that scientific knowledge is superior to experience-based knowledge (Farand & Arocha 2004). Several authors, however, regard clinical reasoning as a blend of both art and science, a type of phronesis, or practical wisdom (Braude 2012; Davis 1997; Montgomery 2005). Researchers using grounded theory make use of an explicit framework for gathering information, while at the same time accepting that new theory may be inductively generated.

Table 7.1 Comparing a grounded theory approach to the clinical reasoning process

Grounded theory methodology	Clinical reasoning analogy
Prior knowledge and experience	
Sensitising concepts	Clinical training and experience
Bracketing	Maintaining objectivity & avoiding bias
Sampling and data collection procedures	
Interview and observational data	History and examination
Un-blinded	Un-blinded
Iterative data collection and analysis	Iterative data collection and analysis
Negative case and maximum variation sampling	Seeking and explaining absent and/or inconsistent symptoms and signs
Continuous comparison and triangulation	Corroborating and cross-checking clinical findings
Saturation	Concluding the assessment when no further salient evidence can be elicited
Data analysis procedures	
Recording and transcribing interviews	Compiling clinical notes in the medical record
Quoting	Summarising key findings
Data reduction	Focussing on relevant details
Open coding	Identifying significant symptoms and signs
Axial coding	Seeking a unifying explanation for diverse findings
Preliminary analysis	Differential diagnosis
Data logic	
Theory building: inductively forming a theory (or explanatory model) grounded in the research data	Diagnosis: inductively arriving at a diagnosis based on the composite clinical findings

Source: Welch et al. (2017) p.4

During the clinical reasoning process, the clinician will often take the history of a patient and synthesise this information along with a physical examination, laboratory results and scanned images in order to generate a diagnosis. This process requires the clinician to interpret and

make a judgement based upon scientific information in the light of their integrated knowledge and experience. This experience is influenced by personal affect, bias and motivation (Artino Jr, Holmboe & Durning 2012b). The inductive theory referred to in the grounded theory literature was thought comparable with a doctor's diagnosis or patient management plan (Charmaz 2015).

The clinical reasoning process may be divided into four sections, which enable comparison with the stages of grounded theory. Both clinical reasoning and grounded theory make use of and recognise prior knowledge. In the second stage, both the clinical reasoning process and grounded theory have a definable process for gathering information. Both processes seek to be unbiased, are iterative and aim to triangulate and make comprehensive meaning from diverse sources. The third stage, data analysis, details how grounded theory and the clinical reasoning process make meaning from the information gathered during the sampling and data collection stages. The final stage, called data logic, highlights how both processes inductively build theory, or in the case of clinical reasoning, a diagnosis or management plan.

Learning clinical reasoning skills, however, includes more than just effective data gathering, synthesis and analysis. Grounded theory does not accommodate fostering factors that influence clinical reasoning skill development. For example, the Intern learning climate described in Chapter 4 might be monitored and subsequently modified to ensure more effective learning and decision making can take place. It is also important to promote the development of metacognitive awareness skills, and to have the Consultants teach using the 'think-aloud' process described in Section 1.10.1. It was concluded that grounded theory provides benefit as an explanatory map to help describe and understand clinical reasoning, but not as a framework to help support learning. The researcher's published paper explores further how grounded theory has utility in helping to explain the clinical reasoning process due to its focus on rigorous data analysis (Welch et al. 2017).

7.5.2 The adaptive learner

On reflection, the grounded theory approach described above might be grouped with other educational initiatives that overemphasise the importance of knowledge organisation. Many learning frameworks tend to focus primarily on knowledge organisation and its application, but minimise the importance of how information is transformed during the process of patient care

(Mylopoulos, Kulasegaram & Woods 2018). Alternatively, initiatives that emphasise knowledge transformation often tend to lessen the importance of how knowledge is cognitively organised and used to provide clinical care. An effective framework to support learning clinical reasoning ought to promote improved knowledge, and also coach the traits associated with expertise within a conducive learning climate.

The general features of experts were discussed in Section 1.7. The literature has provided evidence that experts have characteristics that extend beyond intelligence or ability, and may be divided into routine and adaptive expertise (Lajoie & Gube 2018). Routine expertise emphasises the speed and efficiency of practice, while adaptive expertise seeks innovative solutions to difficult and novel problems and requires a high degree of cognitive flexibility (Cutrer et al. 2017; Spiro et al. 1988). Both types of clinical reasoning expertise are important and complement each other (Mylopoulos & Woods 2017). The adaptive expert reflects on his/her practice, challenges assumptions and commonly held beliefs, and displays high levels of metacognitive awareness (Cutrer et al. 2017; Hatano & Inagaki 1986).

A learning framework that fosters the development of clinical reasoning skills must account for the types of knowledge needed to develop expertise and the ways knowledge is harnessed to make clinical decisions (Croskerry 2018). Adopting a framework such as the grounded theory approach described above risks favouring the development of routine over adaptive expertise (Mylopoulos, Kulasegaram & Woods 2018; Mylopoulos & Woods 2009). A progressive learning framework must foster routine and adaptive expertise, efficiency and innovation in decision making as well as the cognitive flexibility to move between these modalities.

In addition, a useful learning framework needs to be functional within the hospital context by helping Consultants to recognise that they are clinical role models, and so need to make their thinking ‘visible’ to the learner. Such a framework should assist the Consultant to teach and the Intern to learn. The framework needs to promote the development of metacognitive awareness, facilitate monitoring of the learning climate and accommodate recent findings in the literature with the aim of deliberately fostering clinical reasoning expertise. One learning framework that supports the factors necessary for learning clinical reasoning skills is the Cognitive Apprenticeship Learning Model (Brown, Collins & Duguid 1989).

7.6 Cognitive Apprenticeship Learning Model (CALM)

Clinical reasoning is complex and involves both intuitive and explicit knowledge. Marcum (2012) explained that 'knowing how' to do a task cannot be fully articulated, whereas 'knowing what' or 'knowing that' can be satisfactorily explained verbally. Medicine is different from traditional apprenticeships because the clinical educator needs to externalise their heuristic, or practical approach, and make their internal thinking process explicit in order for the learner to understand (Daniel, Clyne & Fowler 2015). The Cognitive Apprenticeship Learning Model (CALM) accommodates learning that is difficult to explain by making thinking visible to the learner (Collins, Brown & Holum 1991).

The Cognitive Apprenticeship Learning Model (CALM) was developed by Collins et al. in the late 1980s for primary and secondary school education (Collins, Brown & Newman 1989). The purpose of developing the CALM was to help students gain the thinking and problem-solving skills necessary for developing literacy and numeracy skills. CALM intentionally focuses on the development of both the cognitive and metacognitive skills needed to develop expertise (Collins, Brown & Holum 1991). By the late 1990s, researchers were using the CALM in clinical nursing education (Taylor & Care 1998). In 2005 Dornan wrote that learning medicine through the traditional apprenticeship model was becoming increasingly strained (Dornan 2005). Since then Stalmeijer (2015) has promoted CALM as a framework that deserves more attention from medical educators due to its emphasis on the cognitive aspects of expertise development. A review paper by Lyons et al. (2017) evaluated the growing body of CALM literature, and recommended that new applications of the model may help learners as it helps make expert thinking visible and fosters both the cognitive and metacognitive processes needed for developing expertise. Additional recommendations from the Lyons et al. (2017) study include considering contextual influences (e.g. learning climate) and faculty development.

CALM improves upon the grounded theory approach described earlier, and goes beyond the established ideas of an apprenticeship, which in the medical context is often summarised by the maxim '*see one, do one, teach one*' (Collins, Brown & Newman 1989; Lyons et al. 2017). Only once the learner has understood what the clinical expert has modelled are he/she able to assimilate and use this new knowledge (Brush, Sherbino & Norman 2017; Charlin et al. 2007). CALM places emphasis on the processes used by experts to handle complex decision making, which is especially important within the context of clinical uncertainty (Collins, Brown &

Newman 1989). By observing and understanding the cognitive and metacognitive processes modelled for them by experts, doctors-in-training are likely to be better equipped to refine their clinical reasoning capabilities. The CALM described by Brown et al. (1989) has four domains: Content, Method, Sequencing and Sociology, as shown in Table 7.2.

Table 7.2 The four domains of the CALM

Content	**Types of knowledge required for expertise**	
	Dimension knowledge	Subject matter specific concepts, facts and procedures
	Heuristic strategies	Generally applicable techniques for accomplishing tasks
	Control strategies	General approaches for directing one's solution process
	Learning strategies	Knowledge about how to learn new concepts, facts and procedures
Method	**Ways to promote the development of expertise**	
	Modeling	Teacher performs a task so students can observe
	Coaching	Teacher observes and facilitates while students perform a task
	Scaffolding	Teacher provides supports to help the student perform a task
	Articulation	Teacher encourages students to verbalize their knowledge and thinking
	Reflection	Teacher enables students to compare their performance with others
	Exploration	Teacher invites students to propose and solve their own problems
Sequencing	**Keys to ordering learning activities**	
	Increasing complexity	Meaningful tasks gradually increasing in difficulty
	Increasing diversity	Practice in a variety of situations to emphasize broad application
	Global to local skills	Focus on conceptualizing the whole task before executing the parts
Sociology	**Social characteristics of learning environments**	
	Situated learning	Students learn in the context of working on realistic tasks
	Communities of practice	Communication about different ways to accomplish meaningful tasks

Source: Collins (2005)

Figure 7.1 shows CALM applied to fostering the learning of clinical reasoning skills. Both Consultants and doctors-in-training understand the importance of gaining knowledge and experience. ‘Knowledge’, as discussed by learners and supervisors in this research, can be considered a component of the Content domain in CALM. CALM emphasises several types of knowledge, such as Dimensional knowledge, Heuristic strategies, Control strategies and Learning strategies. Each type of knowledge is important for developing the expertise identified in earlier sections of this thesis. The methods of learning the Content are shown as smaller circles intersecting with the central Content domain. These smaller circles show the sub-domains of the Method domain. Developing clinical reasoning expertise is influenced by the learning climate, referred to in CALM as Sociology. Along the bottom of the diagram, the arrow indicates the increasing levels of expectation placed on learners as they gain experience, identified in CALM as Sequencing. The research evidence and literature support use of a modified CALM (mCALM) to foster the learning of clinical reasoning skills. Practical applications of CALM are discussed in Section 7.8.

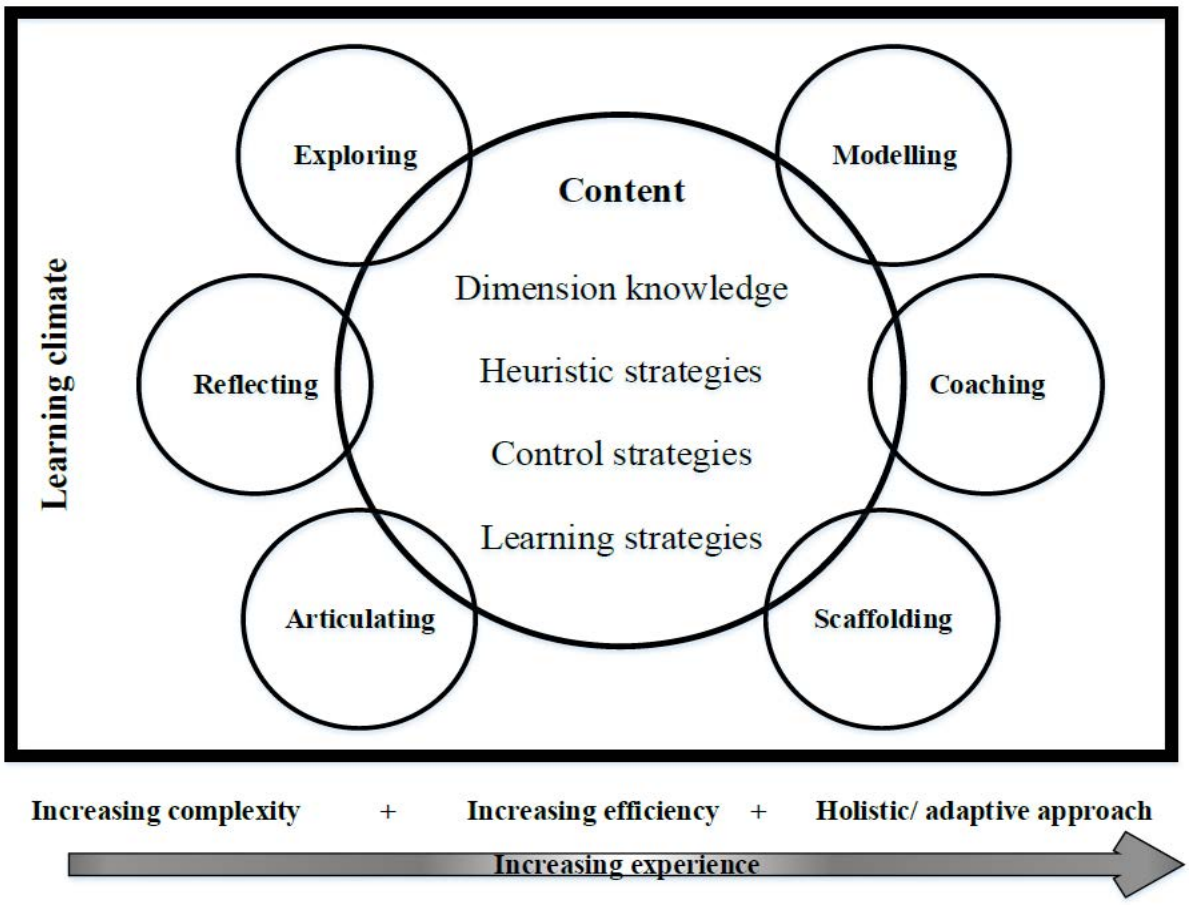

Figure 7.1 Components of CALM

7.6.1 Content

Learning clinical reasoning is a constructivist endeavour made up of several integrated stages (Dennick 2016). The Content domain describes the distinct types of knowledge required for expertise: 1. Dimension knowledge, 2. Heuristic strategies, 3. Control Strategies, and 4. Learning strategies (Collins 2005).

Dimension Knowledge

Dimension knowledge requires the doctor-in-training to understand and learn basic biomedical sciences, including human anatomy, physiology and pathology. Understanding how these different biomedical lenses inform a clinical presentation enables the doctor-in-training to construct an elaborate network of interlinked information. Condensing this information to a limited number of named concepts enables more relevant evidence to be gathered, for example mentally gathering together the various causes of biliary tract obstruction (Schmidt & Rikers 2007). This process of encapsulation or chunking information would be a demanding process and may cause a noticeable cognitive load for the trainee as they organise their clinical knowledge into a form that can more easily be manipulated (illness scripts). The next stage in building expertise is for trainees to refine their illness scripts (Charlin et al. 2007). The many illness scripts developed by trainees enables them to link their knowledge to specific clinical presentations. For example, linking a symptom of jaundice with possible biliary obstruction and a likely diagnosis of pancreatic cancer in a person who is over 50 years of age, experiencing pain and weight loss illustrates the process. As trainees gain experience through being involved in the diagnosis and treatment of patients, they may further refine and modify specific illness scripts.

In both the '*Consultants as role models'* and '*Interns as learners'* chapters (Chapters 5 and 6), there was an important level of agreement that knowledge and experience are important in the development of clinical reasoning expertise. Across all the studies described in this thesis, however, there was little mention of the need to intentionally learn heuristic, control or learning strategies. These concepts are described in the clinical reasoning literature as being important and integral to the development of expertise (Bodemer, Hanoch & Katsikopoulos 2015; Chamberland et al. 2015). By using a modified CALM framework to support the development of clinical reasoning skills, these components will receive the attention necessary.

Heuristics

Heuristic strategies, often described as 'rules of thumb' have been extensively researched and are frequently cited as being characteristic of clinical reasoning experts (Bodemer, Hanoch & Katsikopoulos 2015). CALM specifically highlights the importance of learning heuristic strategies to develop expertise. By explicitly highlighting the importance of learning heuristic strategies, doctors-in-training and their Consultants are likely to be more aware how important a part of the learning process it is. In both Chapters 5 and 6 the Consultants and Interns only made passing reference to heuristics. Using CALM, Consultants and doctors-in-training would be encouraged to identify, discuss and proactively teach clinical heuristic strategies to trainees. Over time learners are then likely to use and later develop their own heuristic strategies as they assimilate new knowledge and gain further experience.

Control strategies

Control strategies encompass concepts similar to the sub-domains in the Regulation of Cognition domain of the Metacognitive Awareness Inventory (MAI). These include information gathering strategies, debugging, planning and evaluation. These are important aspects of the clinical reasoning process but are seldom named or discussed by clinicians – as evidenced in the '*Consultants as role models'* study. Included within control strategies are dual process theory concepts, meaning a decision may be made through a process of intuition or require an analytical approach (Norman 2009). Being mindful of how a clinical decision was made may stimulate metacognitive awareness (Colbert et al. 2015). Often more senior clinicians may use intuitive reasoning, but seldom give thought to the nature of this process. Evidence from the *'Interns as learners study'* shows that it would be beneficial to doctors-in-training if these concepts were named, described and discussed with their clinical supervisors during training. From the '*Consultants as role models'* and '*Interns as learners'* studies it is clear that discussing these Control strategies is uncommon, which deprives the trainee of valuable reflection and therefore learning opportunities.

Learning strategies

Learning strategies that make up part of the Content component in CALM equate to similar concepts as the Knowledge of Cognition domain in the Metacognitive Awareness Inventory. The Knowledge of Cognition domain in the CALM is made up of Declarative Knowledge,

Procedural Knowledge and Conditional Knowledge. Naming and discussing how a trainee may learn and assimilate new knowledge would likely be beneficial to the trainee. Highlighting these factors is a first step in enabling them to be discussed and assimilated by trainees. These processes are likely to help shape and build their clinical reasoning skill levels. In this way the expert would share their own experience and help the trainee to reflect on how they could improve their learning.

In the program of research undertaken for this thesis, both Consultants and Interns described the ability of experts to rapidly identify a range of possible diagnoses and to generate a suitable questioning strategy to test these hypotheses. Clinical reasoning skills are built and refined over time with the help of increasing levels of knowledge and clinical experience. Knowledge and experience alone, however, only partially account for the development of expertise. By using a framework to help a trainee and the supervisor discuss some of the additional learning and control strategies, the learning is moved beyond the simple transmission of information, to a deeper and more integrated level of knowledge construction, which includes an awareness of how knowledge is used, and its veracity tested within the clinical setting. These additional components of expert thinking currently lie hidden for many clinicians. One of the Consultants commented on this by saying: '*no one ever suggested I think about my thinking'*. There is a growing body of evidence, apart from that described in this thesis, that thinking about one's thinking or metacognition is a vital component of developing expertise (Colbert et al. 2015; Croskerry 2000; Medina, Castleberry & Persky 2017). Using a modified CALM framework would enable both the expert and doctor-in-training to name, define and discuss these additional components. Using the learning framework may help to foster a culture of metacognitive awareness in trainees, and therefore help them in their development of clinical reasoning skills.

In summary, the literature and the findings of this research thesis agree that Dimension knowledge, as well as Heuristic strategies, Control strategies and Learning strategies, are important in developing clinical reasoning skills. Currently, however, it is only the contents of Dimension knowledge that are emphasised and regarded as important by the Consultants and doctors-in-training interviewed in this program of research.

7.6.2 Method

Within the Method domain of CALM, there are the following sub-domains: a. Modelling, b. Coaching and scaffolding, c. Articulation, d. Reflection and e. Exploration. In Figure 7.1 these are each indicated as circles that overlap, helping to facilitate learning in the Content domain. These sub-domains are each mentioned in the literature as important for developing clinical reasoning skills.

Modelling

Modelling describes the notion of the expert being observed as they undertake a task, which could be making a diagnosis or developing a management plan. In the '*Consultants as role models'* study (Chapter 5) the Consultants described several traits they felt were very important to nurture for the doctor-in-training, including being mindful of and vigilant for the way new clinical information aligns with the unfolding clinical picture. The Consultants felt that doctors-in-training would often gather large amounts of information without thought as to its relevance or weighted importance. It is important that Consultants understand and identify their function as role models.

Coaching and Scaffolding

Coaching and scaffolding are key components in helping trainees to organise their clinical knowledge, so they can solve a challenging or novel clinical problem which would not have been possible for them on their own (Cutrer, Sullivan & Fleming 2013; Wood, Bruner & Ross 1976). Coaching may include a Socratic style of questioning, such as asking questions directed at helping trainees to narrow their thinking or help them progress along the steps necessary to arrive at a diagnosis or management plan. The use of questioning prompts would help trainees to re-organise their knowledge by refining their illness scripts (Charlin, Tardif & Boshuizen 2000). In the *'Interns as learners'* study, the Interns stated the benefits to their learning if the Consultant asked them to articulate their thinking and then to justify their diagnosis or a proposed management plan.

Immediate feedback to doctors-in-training is important for scaffolding learning by helping reorganise their knowledge, but it is also critical to the subsequent development of intuitive reasoning (Bowen 2006). Central to scaffolding is the importance of expert feedback to inform

and further shape the clinical reasoning skills of the Intern. The importance of timely and informed feedback was mentioned in the Intern interviews and is repeatedly cited in the literature as being helpful for learning (Graber et al. 2012).

Articulation

Within the Method domain of CALM the sub-domain of articulation, which is equivalent to the 'think-aloud' process described in the literature. The use of 'think-aloud' protocols have a long and rich history in the clinical reasoning literature, but were initially used as a methodology for seeking to understand the differences between novices and experts (Elstein, Shulman & Spaka 1978; Neufeld et al. 1981). 'Think-aloud' is a useful way for a clinical supervisor to better understand the rationale of a trainee's decision making, before offering timely feedback (Durning, Artino Jr, et al. 2013).

Several authors promote 'think-aloud' as a useful method for helping to make expert thinking 'visible', and therefore understandable to the learner (Bowen 2006; Eva 2005). The literature, along with the results of this research highlighted the hidden nature of expert thinking processes. When the expert thinking processes are passively hidden from the doctor-in-training, it was difficult for the trainee to comprehend how these decisions were made. Several of the Interns commented on the frustration they experienced as their Consultant was either unwilling or unable to explain his/her rationale for action. Several of the Consultants also commented that during their training, they had very little insight into how their Consultants made clinical decisions. One of the Consultants stated:

'…the way experts worked were a complete and utter mystery to me as to how they got the diagnosis…'. C1

Fostering a learning environment which prompts experts to 'think-aloud' is likely to help the doctor-in-training to understand the decision-making process better, and in turn, may enable them to make better clinical decisions (Bowen 2006; Eva 2005). In the evidence gathered from the '*Interns as learners'* study only one of the Interns mentioned that their Consultant made use of the 'think-aloud' method to help teach the Interns. In the context of this research, it seems clear that Interns would benefit if more Consultants were aware of and used 'think-aloud' as part of their teaching repertoire. One of the Consultants interviewed felt that having trained in a culturally very hierarchical non-Australian environment, where 'think-aloud' had

never been modelled to them made it more difficult for them to adopt 'think-aloud' as a teaching method.

The benefits of using 'think-aloud', as described in the literature and mentioned by the Interns, are contrasted with the absence at TTH. If a modified CALM were adopted as a framework to support the learning of clinical reasoning, it is likely that 'think-aloud' may become a more commonly used technique. The 'think-aloud' process may also be used by expert clinicians as a way of better understanding the reasoning processes of their trainees. Faculty education initiatives are suggested in Section 7.7.

Reflection

Loftus (2012) describes one of the central problems in learning clinical reasoning is 'knowing how to talk about it' (Dory & Roex 2012; Loftus 2012). The literature indicates that practising reflection has a key role in helping doctors-in-training generate meaning from their experiences, which may inform their future behaviour (Chamberland et al. 2015). The *Metacognitive awareness* study described in Chapter 3, as well as the associated literature, adds evidence to the notion that metacognitive awareness, a component of SRL, is important in helping to develop expertise in clinical reasoning.

Developing reflective practice, which may include using the 'think-aloud' process, may need to be intentionally cultivated within all the medical teams. Reflective practice is probably best achieved through Consultants role modelling this to their doctors-in-training. Integral to reflection is the need to foster cognitive flexibility when problem-solving (Spiro et al. 1988).

Exploration

In the context of CALM, 'exploration' refers to the trainee taking the initiative by making a diagnosis and then developing a patient management plan independent of the direct influence of their Consultant. For the doctor-in-training in Australia, a patient management plan would be discussed with their Consultant or supervisor, before being implemented. In the *'Interns as learners'* chapter, one Intern described how his/her Consultant would encourage him/her to identify a diagnosis and then to suggest an appropriate management plan. This type of encouragement is an ideal scenario, but one which did not appear a typical experience for most doctors-in-training at TTH. Instead, the Interns often described being given a list of tasks to

do, with little explanation as to the rationale behind the requests. The process of semi-independent ‘exploration’ encourages the trainee to link the clinical data in a way which helps them take ownership of their clinical decision, while remaining in a supportive environment in which they receive constructive feedback.

In summary, the CALM domain of Method appears to give perspective, structure and depth to the ideas discussed by both the Consultants and doctors-in-training. Using CALM as a framework to support doctors-in-training while they learn clinical reasoning would promote effective learning and constructively challenge the notion that gaining knowledge and experience, alone, contribute to gaining clinical reasoning expertise.

7.6.3 Sequencing

Clinical reasoning skill acquisition is a proactive, constructivist process. The incremental process of building expertise in clinical reasoning requires deliberate practice and conscious attention to detail over a protracted period (Ericsson 2008). Regardless of the clinical barriers to learning, humans learn by constructing their understanding (Section 1.9.1). For the CALM model to be effective, faculty education is necessary to help coach the clinical educator in their vital role of helping doctors-in-training to sequence learning experiences . To help sequence the learning the Consultant may ask ‘how…?’ and ‘why…?’ questions of the learner, in order to ascertain the existing levels of understanding. As doctors-in-training develop and link their knowledge with its clinical use, they develop increasingly complex illness scripts. With a proactive clinical educator and conducting deliberate practice, doctors-in-training may be able to increase the efficiency with which they retrieve, reflect on and apply their clinical knowledge.

The next stage of learning for the doctor-in-training may see him/her start to develop a more holistic or adaptive approach to diagnosing and managing patients (Mylopoulos, Kulasegaram & Woods 2018). As he/she develops this level of expertise, the doctor-in-training has developed a broad repertoire of clear conceptual models for different but specific case presentations. Practically, these conceptual models help the doctor-in-training envisage each stage or decision point in the patient’s progress by harnessing their previous experience of similar patients. In the surgical context, surgeons, may mentally rehearse each stage or potential

complication of an operation before they commence (Crebbin et al. 2013). The adaptive expert may use his/her clinical knowledge innovatively if required.

The Interns identified Consultant traits that were different from their own – for example, the speed of their decision making, greater levels of insight and agility of thinking, and greater levels of knowledge and experience, as well as the ability to manage incomplete information and tolerate a variable degree of uncertainty. As the knowledge and experience of the doctor-in-training are transformed to become clinically useful, the cognitive flexibility and ability to link existing knowledge and experience to novel situations may develop. Several of the Consultants interviewed described being given increasing levels of responsibility, which had helped them to consolidate their clinical reasoning skills. With increasing practise and experience, the Consultants described being able to diagnose and manage clinical situations faster and more efficiently.

The utility of CALM for fostering the development of clinical reasoning skills is highly dependent on Consultant and Registrar clinical educators. Being aware of the need to sequence teaching and learning may make learning more effective and reduce confusion when complex diagnoses and management plans are being discussed. For the model to be effective, there is a need for tailored, on-going faculty development, as discussed in Section 7.8. Figure 7.1 shows CALM applied to fostering the learning of clinical reasoning skills. Both Consultants and doctors-in-training understand the importance of gaining knowledge and experience. 'Knowledge', as discussed by learners and Consultants in this research, can be considered a component of the Content domain in CALM. CALM emphasises several types of knowledge, such as Dimensional knowledge, Heuristic strategies, Control strategies and Learning strategies. Each type of knowledge is important for developing the expertise identified in earlier sections of this thesis. The methods of learning the Content are shown as smaller circles intersecting with the central Content domain. These smaller circles show the sub-domains of the Method domain. Developing clinical reasoning expertise is influenced by the learning climate, referred to in CALM as Sociology. Along the bottom of the diagram, the arrow indicates the increasing levels of expectation placed on learners as they gain experience, identified in CALM as Sequencing. The research evidence and literature support use of a modified CALM (mCALM) to foster the learning of clinical reasoning skills. Practical applications of CALM are discussed in Section 7.8.

7.6.4 Sociology

The importance of learning in a clinical context is well established in medicine. Since Osler's time in the early part of the twentieth century, the modern clinical working context has become highly complex. It is no longer enough to encourage learning within a clinical context. The quality of the learning climate in a workplace is also important, and impacts the effectiveness of learning. Often a patient with several co-morbidities will be cared for by many different health professionals. Working in complex health care teams as well as inter-professional learning, further highlights the importance of a conducive learning climate (Dunston et al. 2018).

The fourth domain of the CALM is 'Sociology'. Within the clinical context, this is better called the Learning Climate. The domain includes situated learning and the community of practice sub-domains. Constructing knowledge and expertise is a personal experience. No one assimilates information in the same way as someone else. If the learning climate is conducive to learning and the clinical supervisor is supportive, the explicit role modelling of the Consultants may help the doctors-in-training to learn.

The results from the '*Learning climate'* study identified specific areas of concern for Intern learning during their General Medicine term (Section 4.10). Learning clinical reasoning skills takes place within a complex community of practice (Lave & Wenger 1991). There is much evidence in the literature in addition to the studies detailed in this thesis, that highlight the importance of a community of practice that is conducive to learning (Section 1.9.2).

A practical means for monitoring the learning climate may be to measure it using the D-RECT instrument (Boor et al. 2011). Monitoring the learning climate at regular intervals would enable improvements within specific domains to be charted as well as identifying areas of concern that require attention. It is important that the learning climate is monitored, both from a learning and patient safety perspective. In a learning climate in which there are systemic communication concerns between professionals, as detailed in Chapters 4 and 6, there is an increased likelihood of the occurrence of clinical errors (Eggins & Slade 2015).

7.7 Modifying CALM

In the previous section, the research evidence and the literature supported considering CALM as a framework to help foster the learning of clinical reasoning skills among doctors-in-training. The modified CALM (mCALM) was generated to be utilised within the clinical context. In the sections below mCALM is discussed, followed by consideration of how it might be utilised within the General Medicine unit of The Townsville Hospital.

7.8 mCALM

CALM needs to be adapted and modified for use within the research hospital. The mCALM includes an adapted form of CALM, plus the ability to measure and monitor the learning climate and metacognitive awareness levels of doctors-in-training. Figure 7.2 shows the components of mCALM which are then described in detail below.

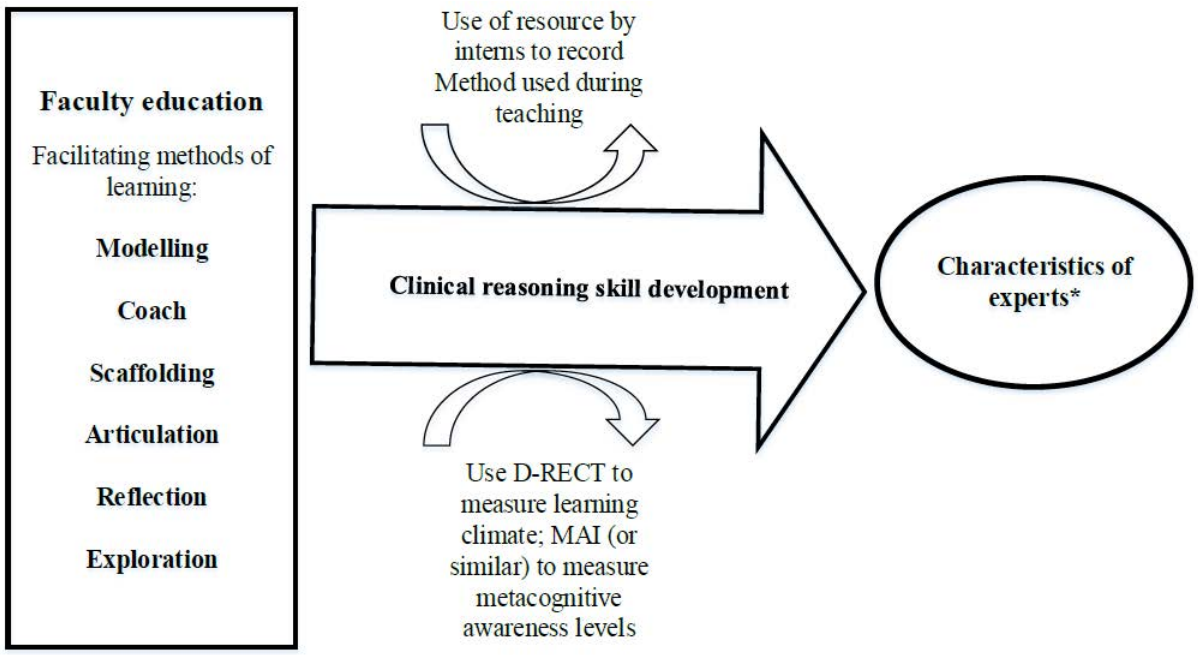

Figure 7.2 Components of the mCALM

The first component of the mCALM would be faculty education for the Physician Consultants. This research has shown that Consultants are vital role models who have a key function in fostering the development of clinical reasoning skills. An initial step maybe to help Consultants understand that they are vital role models to learning. Encouraging Consultants to identify with the need for an educational intervention and then commit to implementing it is important, and

described in Section 7.9. Interns and Consultants in this research understood the importance of gaining knowledge and experience. The knowledge the Consultants and Interns described, equates to Dimension knowledge (Section 7.6.1). Apart from Dimension knowledge (in the Content domain) doctors-in-training also need to acquire Heuristic strategies, Control strategies and Learning strategies to progress to develop expertise. An effective faculty education program will aim to teach the Consultants about the four types of knowledge, and then equip them to use the six different processes described in the Methods domain. The explicit focus of mCALM will be intentional fostering of the expertise attributes included in the '*Characteristics of clinical reasoning experts*' domain, Section 6.5.1.

The effectiveness of a faculty education initiative may be evaluated by developing a methodology or resource, possibly in the form of a mobile phone application (app), for doctors-in-training. This resource could be used to record the method of teaching used, as well as recording feedback from the Interns. The data generated may be useful in evaluating the effectiveness of the faculty education program and triangulating feedback that could be gained from the Consultants. Developing and evaluating a valid method for data entry, such as a mobile phone app, is beyond the scope of the current study.

The findings from this research and the literature have supported the notion of learning clinical reasoning skills as a personal journey. This journey towards gaining the *'Characteristics of clinical reasoning experts'* is influenced by many factors, but a conducive learning climate is essential. Monitoring the learning climate with an instrument such as the D-RECT would enable deficiencies to be detected and interventions designed to remediate areas of concern (Boor et al. 2011).

The central aim of using mCALM will be to help make expert thinking 'visible' and foster adaptive expertise. Intentionally fostering metacognitive awareness is important. Measuring metacognitive awareness within this learning context will be helpful as it is linked with clinical reasoning expertise. The MAI could be employed to determine if there is any change in scores for Interns over the course of their General Medicine term. This study would be similar to the study described in Chapter 3. If mCALM was considered relevant and useful in General Medicine, it might be applied to different terms within the Intern year, or even across the whole

of the Intern year. There are additional governance considerations in implementing mCALM, which include motivating key staff to adopt and promote this new initiative.

7.9 Implementing the mCALM - governance considerations

For the implementation of this clinical reasoning coaching initiative to be successful, it will be important to identify key stakeholders and effectively convince them of its merits. Key stakeholders include the Director of Medical Services, the Director of Clinical Training, Physician Consultants and doctors-in-training. These decision-making stakeholder roles are replicated in most teaching hospitals across Queensland. The Director of Medical Services (DMS) initially proposed investigating the possibilities and practicalities of improving the way Interns learn clinical reasoning skills to the researcher (Section 2.2.2). The Director of Clinical Training (DCT) manages the Medical Education Unit, oversees Intern training and leads the Medical Education Unit (MEU). The third group of key stakeholders are the Consultants within the General Medicine unit where the piloting of mCALM would take place. The fourth group of important stakeholders are representatives from the Intern cohort. All Interns rotate through the General Medicine unit over the course of the year. All four groups of stakeholders will need to be convinced and motivated to pilot using the mCALM.

A persuasion framework could be used in helping to explain the benefits of improving how doctors-in-training learn clinical reasoning. Monroe's Motivated Sequence adopts a five-stage process for effectively persuading an audience to adopt a new initiative (Monroe 1951). Table 7.3 applies Monroe's Motivated Sequence to the context of implementing mCALM at the teaching hospital.

Table 7.3 Monroe's Motivated Sequence applied to implement the mCALM

Stage	Application
Gain the attention of stakeholders	For example: Highlight clinical reasoning error rates, patient safety concerns, climate of increasing risk of litigation – use local data.
Establish the need for change	For example: Clinical reasoning skills vital, but traditional apprenticeship model of learning clinical reasoning under strain due to time, workload and over-reliance on technology. Lack of knowledge among Consultants as to how best to foster clinical reasoning skill development. Highlight consequences of failure to act.
Satisfy the need – introduce mCALM	For example: Introduce purpose and rationale for mCALM. How mCALM may be applied in the clinical workplace. Have prepared responses for those opposed to the initiative.
Visualise the future	For example: If mCALM is applied – Interns may learn clinical reasoning skills more effectively, improved patient care, improved College exam results, cultivation of metacognitive awareness skills, improved climate of learning.
Call to action	For example: What are the next steps? Determine the level of support for this initiative. Faculty (Consultant) education to increase awareness and equip who? with skills to coach using Methods of mCALM. Educate Intern doctors-in-training of benefits of actively participating in mCALM.

Source: Monroe (1951)

Table 7.4 Stages for implementing the mCALM

1. Motivate stakeholders: DMS, DCT, MEU Consultants, Interns	2. Faculty education - mCALM model	3. Implementation: Stakeholder roles	4. Monitoring progress	5. Evaluation
Monroe's motivated sequence • Gain attention of stakeholders. • Establish need for change. • Satisfy the need – introduce mCALM. • Visualize the future. • Call for action.	**De-construct mCALM** Show how mCALM can be used to coach clinical reasoning skills. Emphasise the methods domain. **Content** Encourage awareness of ALL components of: domain knowledge, heuristic, control and learning strategies. **Method** Coach modelling, coaching, scaffolding, articulation, reflection, exploration. **Sequencing** Encourage sequencing of learning and synthesis of information. **Sociology** measure and monitor learning climate – D-RECT.	**Consultants** Emphasise the use of a variety of learning methods and content domains including sequencing: mindful of learning climate. **Doctor-in-training** Deliberate practice, proactive attitude and active reflection. **MEU** Motivate stakeholders, app uptake and its use, monitor learning climate, evaluate model.	**Doctors-in-training** App developed for recording learning experience in the sub-domains of the CALM model. Encourage explicit reflection. Data for later analysis and evaluation. **MEU** Resource development. Facilitate faculty education program and measure and monitor Intern learning (D-RECT) climate and report feedback. Development of evaluation process.	**Survey instruments designed** **For Consultants** to evaluate trainees' heuristics, control and learning strategies, domain knowledge, reflective abilities, ability to articulate thinking processes. **For Doctors-in-training** to evaluate effectiveness of methods used by Consultants. D-RECT survey results. Possible use of MAI or similar to determine change in metacognitive awareness levels.
				

The stages of Monroe's Motivated Sequence are illustrated in Table 7.4. It is important that a compelling presentation be made to the key stakeholders to convince them to pilot this initiative, as detailed in Figure 7.3. Without an effective strategy to motivate the stakeholders to engage, understand and be supportive of mCALM, this educational initiative will remain untested.

7.10 Limitations of this research

The findings from this program of research have several limitations which may affect the reliability and transferability of its findings. The individual limitations of each of the four studies have been discussed earlier in each of Chapter 3-6. A critical limitation for the '*Metacognitive awareness'* study described in Chapter 3 was the small sample size of volunteer medical students. The volunteers for this study chose to respond to an email invitation which was sent on three occasions. Due to the low participation rate, it seems likely that many students either actively chose not to participate or may not have read the email requests. The four multi-methods research studies were designed to support each other, so the overall findings of this program of research were not over-reliant on any one study. Although the results of the '*Metacognitive awareness'* study could have been more statistically robust, the importance of metacognitive awareness in clinical reasoning development was strongly supported in the *Consultants as role models* and *Interns as learners* Studies. Also, the participant examination results, compared to their cohorts, showed no significant differences, meaning the student participants were representative of their cohorts. The small sample size does limit the generalisability of the results from the metacognitive awareness study. The sample size for the '*Learning climate'* study (Chapter 4) and the numbers of Interns interviewed for the *'Interns as learners'* study (Chapter 6) was considered sufficient to be representative. The '*Consultants as role models'* study (Chapter 5) interviewed all the General Medicine Consultants plus three additional Physicians during the interview piloting phase.

The MAI survey instrument used for the study described in Chapter 3 has had limited prior use in medical education, as metacognitive awareness is a developing field of interest. Psychometric analysis of the MAI has not been undertaken in the context of Australian medical education research. The stimulated recall methodology described in the *Interns as learners* study has been used for clinical teaching, but seldom as a method to stimulate participants to reflect on their experience in the way described in Chapter 6. The relative novelty of some of

the methodologies used in this program of research may be regarded as a limitation. Alternatively, using these methodologies may be viewed as broadening the repertoire of instruments available to medical education researchers. The transcripts from the *Interns as learners* study yielded a rich source of information for thematic analysis. If a semi-structured interview guide had been used instead with no initial presentation to the Interns, the researcher was confident that the richness and depth of comments gathered would have been less.

Another limitation was that all four studies were undertaken at one medical school campus and one tertiary referral hospital in north Queensland and the research focused attention mainly on the General Medicine Intern term. Despite the similar way that Intern training is organised across Queensland, the suggested mCALM learning framework may therefore not be suitable for use in other Intern terms or other locations. The use of the multi-methods approach brought with it a reliance on the researcher to gather, analyse and then triangulate the results to generate a cohesive meaning from each of the studies. The researcher's life experience, perspective and personality will have influenced the interpretive components of the program of research. Researcher influence/bias was identified as a potential limitation of this research and advice was sought from the supervisory team throughout the researcher's candidature.

7.11 Future research

Future research should aim to repeat the *Metacognitive awareness* and *Learning climate* study with larger numbers of participants. These studies could be repeated in the same location as detailed in this study and at additional sites. Multi-centred studies would increase the reliability and generalisability of the results. Future work based on the findings from this program of research could also focus on developing, implementing and then evaluating the mCALM framework in the General Medicine unit. After mCALM has been successfully trialled in the General Medicine unit, it could then be applied in other clinical units. Once trialled and its utility evaluated, mCALM is likely to require further modification. When mCALM is modified, the researchers need to be cognisant of developments detailed in the literature at that time.

Before mCALM is implemented, careful consideration needs to be given to engaging key stakeholders and considering the practicalities of governance surrounding the use of mCALM. Introducing this kind of educational initiative will affect many busy medical and administration staff. Implementing mCALM is likely to be met with some resistance, due to the changes and

increased workload it represents. If stakeholder support is gained, and mCALM is implemented there will be future research opportunities for developing instruments to evaluate the effectiveness of these changes for patient clinical outcomes.

7.12 Conclusion

The research detailed in this thesis sought to understand how clinical reasoning skills develop among doctors-in-training in north Queensland during their General Medicine term, and then to identify a learning framework to better support their learning. A multi-methods research design was used to explore the importance of metacognitive awareness to undergraduate student performance, the learning climate of Intern doctors, Consultants as role models and Interns as learners. The overall findings from this program of research were not reliant on any one study, as the multi-methods research design facilitated triangulation between each study.

The key findings from the four studies were: firstly, metacognitive awareness is a hidden but essential component of clinical reasoning expertise and needs to be a focus of clinical education. The Intern learning climate in General Medicine contains elements that reduce the quality of the learning climate and may need to be remedied. Consultants understand the development of clinical reasoning expertise to be primarily a process of gaining knowledge and experience. They identified the characteristics of clinical reasoning expertise, but struggled to explain how these could be fostered. The Consultants did not identify themselves as role models to learners. Interns also believe that acquiring knowledge and experience results in the development of clinical reasoning expertise.

Conceptualising clinical reasoning expertise as the sum of knowledge and experience gained is too simplistic, and ignores the findings described in the literature and the results of this study. There is a need for a learning framework that fosters the development of routine and adaptive clinical reasoning expertise for doctors-in-training, while recognising Consultants as role models.

The results of this research, in conjunction with the literature, support applying the modified Cognitive Apprenticeship Learning Model (mCALM). The mCALM makes expert thinking ‘visible’ by externalising cognitive domain knowledge and strategies which normally remain hidden from the learner. Hidden factors, such as heuristic strategies and regulating decision

making, as well as understanding how clinical knowledge is constructed, refined and applied greatly influence the development of clinical reasoning expertise. The Consultants and doctors-in-training in this study gave evidence they were aware of some of these hidden factors but had no means to define or foster these skills. The mCALM helps to bridge this gap by providing an explicit learning framework which enables these tacit elements of the clinical reasoning process to be better discussed, understood, learned and applied. Importantly mCALM supports the development of 'big picture' thinking, which is critical to cultivating adaptive expertise.

In summary, clinical reasoning is a core skill for effective medical practice but receives little attention from either Consultants or doctors-in-training at the research hospital. The development of these skills is not well understood, and is simplistically regarded as a process of gaining knowledge and experience. The mCALM is an explicit learning framework which may help clinicians to intentionally foster and improve the learning of clinical reasoning skills. To implement the mCALM framework, it is important that key stakeholders, including management staff, Consultants and doctors-in-training are made aware of its novelty and benefits to learning and patient safety. Consultants identifying as role models to learners is necessary. The next step in the development and implementation of the mCALM is the faculty education program for Consultant clinicians. The faculty education program will help the Consultants to use the mCALM. Further developing and evaluating the effectiveness of mCALM in fostering clinical reasoning skill development is important.

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Appendix 1 Metacognitive Awareness Inventory (MAI)

Question ID	Questions	Domain ID	Domain Code	Domain
1	I ask myself periodically if I am meeting my goals.	M1	M	Monitoring
2	I consider several alternatives to a problem before I answer.	M2	M	Monitoring
3	I try to use strategies that have worked in the past.	PK1	PK	Procedural Knowledge
4	I pace myself while learning in order to have enough time.	P1	P	Planning
5	I understand my intellectual strengths and weaknesses.	DK1	DK	Declarative Knowledge
6	I think about what I really need to learn before I begin a task.	P2	P	Planning
7	I know how well I did once I finish a test.	E1	E	Evaluation
8	I set specific goals before I begin a task.	P3	P	Planning
9	I slow down when I encounter important information.	IMS1	IMS	Information Management Strategies
10	I know what kind of information is most important to learn.	DK2	DK	Declarative Knowledge
11	I ask myself if I have considered all options when solving a problem.	M3	M	Monitoring

Question ID	Questions	Domain ID	Domain Code	Domain
12	I am good at organising information.	DK3	DK	Declarative Knowledge
13	I consciously focus my attention on important information.	IMS2	IMS	Information Management Strategies
14	I have a specific purpose for each strategy I use.	PK2	PK	Procedural Knowledge
15	I learn best when I know something about the topic.	CK1	CK	Conditional Knowledge
16	I know what the teacher expects me to learn.	DK4	DK	Declarative Knowledge
17	I am good at remembering information.	DK5	DK	Declarative Knowledge
18	I use different learning strategies depending on the situation.	CK2	CK	Conditional Knowledge
19	I ask myself if there was an easier way to do things after I finish a task.	E2	E	Evaluation
20	I have control over how well I learn.	DK6	DK	Declarative Knowledge
21	I periodically review to help me understand important relationships.	M4	M	Monitoring
22	I ask myself questions about the material before I begin.	P4	P	Planning
23	I think of several ways to solve a problem and choose the best one.	P5	P	Planning
24	I summarize what I've learned after I finish.	E3	E	Evaluation

Question ID	Questions	Domain ID	Domain Code	Domain
25	I ask others for help when I don’t understand something.	DS1	DS	Debugging Strategies
26	I can motivate myself to learn when I need to.	CK3	CK	Conditional Knowledge
27	I am aware of what strategies I use when I study.	PK3	PK	Procedural Knowledge
28	I find myself analysing the usefulness of strategies while I study.	M5	M	Monitoring
29	I use my intellectual strengths to compensate for my weaknesses.	CK4	CK	Conditional Knowledge
30	I focus on the meaning and significance of new information.	IMS3	IMS	Information Management Strategies
31	I create my own examples to make information more meaningful.	IMS4	IMS	Information Management Strategies
32	I am a good judge of how well I understand something.	DK7	DK	Declarative Knowledge
33	I find myself using helpful learning strategies automatically.	PK4	PK	Procedural Knowledge
34	I find myself pausing regularly to check my comprehension.	M6	M	Monitoring
35	I know when each strategy I use will be most effective.	CK5	CK	Conditional Knowledge
36	I ask myself how well I accomplished my goals once I'm finished.	E4	E	Evaluation

Question ID	Questions	Domain ID	Domain Code	Domain
37	I draw pictures or diagrams to help me understand while learning.	IMS5	IMS	Information Management Strategies
38	I ask myself if I have considered all options after I solve a problem.	E5	E	Evaluation
39	I try to translate new information into my own words.	IMS6	IMS	Information Management Strategies
40	I change strategies when I fail to understand.	DS2	DS	Debugging Strategies
41	I use the organisational structure of the text to help me learn.	Domain not denoted		Domain not denoted
42	I read instructions carefully before I begin a task.	P6	P	Planning
43	I ask myself if what I'm reading is related to what I already know.	IMS7	IMS	Information Management Strategies
44	I re-evaluate my assumptions when I get confused.	DS3	DS	Debugging Strategies
45	I organise my time to best accomplish my goals.	P7	P	Planning
46	I learn more when I am interested in the topic.	DK8	DK	Declarative Knowledge

Question ID	Questions	Domain ID	Domain Code	Domain
47	I try to break studying down into smaller steps.	IMS8	IMS	Information Management Strategies
48	I focus on overall meaning rather than specifics.	IMS9	IMS	Information Management Strategies
49	I ask myself questions about how well I am doing while I am learning something new.	M7	M	Monitoring
50	I ask myself if I learned as much as I could have once I finish a task.	E6	E	Evaluation
51	I stop and go back over new information that is not clear.	DS4	DS	Debugging Strategies
52	I stop and reread when I get confused.	DS5	DS	Debugging Strategies

Appendix 2 D-RECT questionnaire

Sex (please circle) ☐ Male ☐ Female Sept 2012

Current rotation .....

The following questions all relate to your current experience. Please read each statement and rate it as it applies to your own feelings about your present experience in this hospital. Please answer all items.

Please tick the appropriate box.

		Strongly agree	*Agree*	*Uncertain*	*Disagree*	*Strongly disagree*
1	The guidelines clearly outline when to request input from a supervisor	☐	☐	☐	☐	☐
2	The amount of supervision I receive is appropriate for my level of experience	☐	☐	☐	☐	☐
3	It is clear which Consultant supervises me	☐	☐	☐	☐	☐
4	I am asked on a regular basis to provide a rationale for my management decisions and actions	☐	☐	☐	☐	☐
5	My Consultants coach me on how to communicate with difficult patients	☐	☐	☐	☐	☐
6	My Consultants take the initiative to explain their actions	☐	☐	☐	☐	☐
7	My Consultants take the initiative to evaluate my performance	☐	☐	☐	☐	☐
8	My Consultants take the initiative to evaluate difficult situations I have been involved in	☐	☐	☐	☐	☐
9	My Consultants evaluate whether my performance in patient care is commensurate with my level of training	☐	☐	☐	☐	☐
10	My Consultants occasionally observe me taking a history	☐	☐	☐	☐	☐
11	My Consultants assess not only my medical expertise but also other skills such as teamwork, organisation or professional behaviour	☐	☐	☐	☐	☐
12	My Consultants give regular feedback on my strengths and weaknesses	☐	☐	☐	☐	☐
13	Observation forms are used to structure feedback	☐	☐	☐	☐	☐
14	Observation forms are used periodically to monitor my progress	☐	☐	☐	☐	☐
15	Consultants, nursing staff, other allied health professionals and residents work together as a team	☐	☐	☐	☐	☐
16	Nursing staff and other allied health professionals make a positive contribution to my training	☐	☐	☐	☐	☐

		Strongly agree	*Agree*	*Uncertain*	*Disagree*	*Strongly disagree*
17	Nursing staff and other allied health professionals are willing to reflect with me on the delivery of patient care	☐	☐	☐	☐	☐
18	Teamwork is an integral part of my training	☐	☐	☐	☐	☐
19	Residents work well together	☐	☐	☐	☐	☐
20	Residents, as a group, make sure the day's work gets done	☐	☐	☐	☐	☐
21	Within our group of residents, it is easy to find someone to cover or exchange a call	☐	☐	☐	☐	☐
22	Continuity of care is not affected by differences of opinion between Consultants	☐	☐	☐	☐	☐
23	Differences of opinion between Consultants about patient management are discussed in such a manner that is instructive to others present	☐	☐	☐	☐	☐
24	Differences of opinion are not such that they have a negative impact on the work climate	☐	☐	☐	☐	☐
25	The work I am doing is commensurate with my level of experience	☐	☐	☐	☐	☐
26	The work I am doing suits my learning objectives at this stage of my training	☐	☐	☐	☐	☐
27	It is possible to do follow up with patients	☐	☐	☐	☐	☐
28	There is enough time in the schedule for me to learn new skills	☐	☐	☐	☐	☐
29	My Consultants take time to explain things when asked for advice	☐	☐	☐	☐	☐
30	My Consultants are happy to discuss patient care	☐	☐	☐	☐	☐
31	There are *no* Consultants who have a negative impact on the educational climate	☐	☐	☐	☐	☐
32	My Consultants treat me as an individual	☐	☐	☐	☐	☐
33	My Consultants treat me with respect	☐	☐	☐	☐	☐
34	My Consultants are all in their own way positive role models	☐	☐	☐	☐	☐
35	When I need a Consultant, I can always contact one	☐	☐	☐	☐	☐
36	When I need to consult a Consultant, they are readily available	☐	☐	☐	☐	☐
37	Residents are generally able to attend scheduled educational activities	☐	☐	☐	☐	☐
38	Educational activities take place as scheduled	☐	☐	☐	☐	☐

		Strongly agree	*Agree*	*Uncertain*	*Disagree*	*Strongly disagree*
39	Consultants contribute actively to the delivery of high-quality formal education	☐	☐	☐	☐	☐
40	Formal education and training activities are appropriate to my needs	☐	☐	☐	☐	☐
41	The supervisor monitors the progress of my training	☐	☐	☐	☐	☐
42	The supervisor provides guidance to other Consultants when needed	☐	☐	☐	☐	☐
43	The supervisor is actively involved in improving the quality of education and training	☐	☐	☐	☐	☐
44	In this rotation evaluations are useful discussions about my performance	☐	☐	☐	☐	☐
45	My plans for the future are part of these discussions	☐	☐	☐	☐	☐
46	During evaluations, input from several Consultants is considered	☐	☐	☐	☐	☐
47	When there is criticism of a management plan I have developed in consultation with my Consultant, I know the Consultant will back me up	☐	☐	☐	☐	☐
48	Handover takes place in a safe climate	☐	☐	☐	☐	☐
49	Handover is used as a teaching opportunity	☐	☐	☐	☐	☐
50	Consultants encourage residents to join in the discussion during handover	☐	☐	☐	☐	☐

What three aspects of the junior doctor learning environment would you alter?

1. _____

_____

2. _____

_____

3. _____

_____

Thank you for your time.

Appendix 3 Intern PowerPoint Presentation

Clinical reasoning

Paul Welch

… expertise …

Why is clinical reasoning important?

$$$ Mortality data
Errors and bias

- Definition:

"The ability to sort through a cluster of features presented by a patient and accurately assign a diagnostic label, with the development of an appropriate treatment strategy as the end goal."

Eva, K. Medical Education 2005

Experiential learning (Kolb)

Acquiring clinical reasoning skills is a type of experiential learning.

Quote:

'For the things we have to learn before we can do them,
we learn by doing them"

Aristotle, The Nichomachean Ethics

Becoming an expert …

comes from ……

knowing more & seeing more cases?

… only partially…

✓ *learn to think like an expert…*

The clinical reasoning process

- 1. Prior knowledge and experience
- 2. Sampling and data collection processes
- 3. Data analysis processes

1. Prior knowledge and experience

– Clinical training

– Maintaining objectivity and avoiding bias

Case presentation:

- 25 year old Vietnamese woman, non-English speaking
  brought in by ambulance from home at 4 pm
- Presents complaining of vomiting
- Short slim, 50Kg
- Patient and husband both ate "dodgy" sandwich for lunch
- Husband "not so bad"
- Live on property 15 km out of town, take no recreational drugs
- "social" alcohol, non smoker
- No medication

What are you thinking?

- Patient pale, P 100, BP 80/50
- Mouth dry, coated tongue, pain with movement from trolley to bed
- Abdomen slightly distended, moderately tender (more than expected)

2. Sampling and data collection

Medically relevant information:

- Examination, scans & tests
- Actively identifying absent/ inconsistent signs & symptoms

NO NEW EVIDENCE (data saturation)

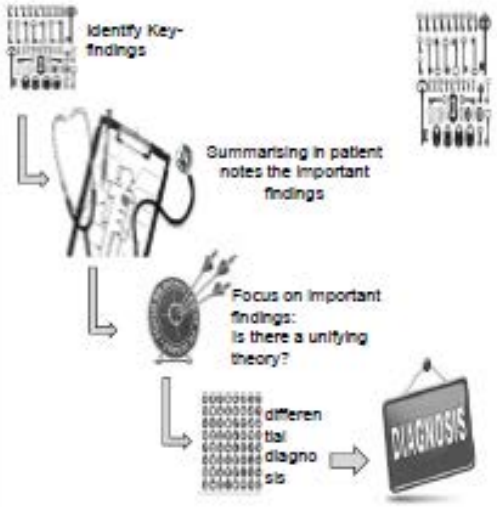
Patient:

- History – think which questions; why and how they are asked? Where am I going in my thinking?
- Actively corroborating and cross-checking clinical findings.

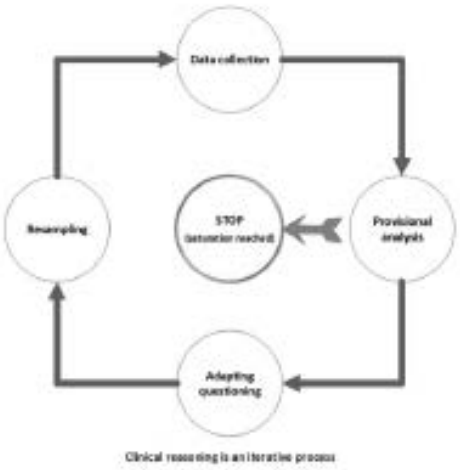
Data saturation?

- Do I have all the information I need?
- What else do I think I need to find out?

3. Data analysis processes



It's an iterative process



Differentials:

- Gastro - most likely
- Perforated ulcer
- Ectopic - easy to exclude with pregnancy test/FAST scan

Ultra sound scan

What next?

- Know and use the three step process:
  - 1. Prior knowledge and experience
    - You have some knowledge: Consciously try to avoid bias and thinking errors
  - 2. Sampling and data collection processes
    - Iterative process: Questioning: Seek absent/ inconsistent data: Cross-check data: Data saturation
  - 3. Data analysis processes
    - Summarising key findings: focusing on important details: Unifying theory possible?
    - Inductively arrive at final diagnosis based on composite clinical findings
      - are all red flags accounted for?

… expertise …

Take home message:

Data analysis procedures:
- Key findings → notes
- Focus on relevant details
- Unifying theory?
- Differentials
- Does diagnosis accommodate all info?

Prior knowledge and experience:
- Your knowledge relevant
- Need to remain objective and avoid bias and beware of thinking errors

Sampling and data collection:
- Iterative process
- Seek absent/ inconsistent findings
- Cross-checking clinical findings
- Has data saturation been reached

How to use model:

- In your own clinical practice
- As you observe seniors in practice
- In clinical teaching sessions
- Learn to consciously be aware of the thinking practice of others.
- Be active in how you develop your clinical reasoning skills – where do you make mistakes & why? Where can you learn the most do?

Appendix 4 Publications

Metacognitive awareness and the link with undergraduate examination performance and clinical reasoning

Paul Welch, Louise Young, Peter Johnson & Daniel Lindsay

MedEdPublish 2018 7(2)

* Based on findings of Chapter 3

Welch P, Young L, Johnson P, Lindsay D
MedEdPublish
https://doi.org/10.15694/mep.2018.0000100.1

Research article Open Access

Metacognitive awareness and the link with undergraduate examination performance and clinical reasoning

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Abstract

Theory: Metacognitive awareness is a component of self-regulated learning and helps us to understand and control our thinking and learning. Thinking about thinking is also an important aspect of the clinical reasoning process for medical practitioners.

Hypotheses: This pilot study researched the link between metacognitive awareness and undergraduate examination performance. The Metacognitive Awareness Inventory (MAI) is a validated 52 item survey instrument for measuring metacognitive awareness. It has eight sub-scales grouped into two domains: Knowledge of Cognition and Regulation of Cognition. It was hypothesised that MAI scores would increase between first and fifth-year undergraduate medicine students and secondly that MAI scores would correlate with undergraduate examinations results.

Method: Medical students at James Cook University, Australia were invited to complete the MAI and consented to give access to their examination scores.

Results: The results of this pilot study found that metacognitive awareness was not significantly different between first and fifth-year undergraduates in this sample. For first-year medical undergraduates there were correlations between the Knowledge of Cognition domain and their end of year examination results, but not with the Regulation of Cognition domain. For fifth-year students there were correlations between both the Knowledge and Regulation of Cognition domains and their end of year examination results.

Conclusion: This study identified that metacognitive awareness is not significantly different between first and fifth-year medical students. This may cause concern given that the study identified the importance of both MAI domains in undergraduate medical examinations. This study should be repeated on a larger scale and may confirm that raising metacognitive awareness levels among students is desirable. Increasing metacognitive awareness may raise

examination performance and better prepare students for developing clinical reasoning skills.

Keywords: Clinical reasoning, Metacognition, Undergraduate examinations, Expertise, Learning

Introduction

Clinical reasoning failures are a noteworthy cause of patient mortality and morbidity and result in approximately 40,000 deaths per year, as well as being the cause of 28.6% of malpractice claims in the USA (Newman-Toker & Pronovost, 2009; Saber Tehrani et al., 2013). In Australia 27.6% of adverse events were due to a failure to synthesise, decide or act upon available information, or failing to arrange an investigation, procedure or consultation (Wilson, Harrison, Gibberd, & Hamilton, 1999). Clinical teachers consider clinical reasoning problematic to conceptualise and teach, as well as difficult for students to grasp, but it is considered central to the medical education process (Charlin, 2012; Cutrer, Sullivan, & Fleming, 2013).

In medical practice, doctors gather clinical data about a patient and then make decisions based on the meaning they attribute to this information. These clinical reasoning skills can be defined as the "ability to sort through a cluster of features presented by a patient and then to accurately assign a diagnostic label, with the development of an appropriate treatment strategy being the end goal" (Eva, 2005, p. 98) Helping medical students and junior doctors develop clinical reasoning skills is a central aim of medical education and requires knowledge and experience (Cutrer et al., 2013).

Seeking to better understand self-regulated learning among medical students has attracted attention from medical educators in recent years for two reasons (Bruin, Dunlosky, & Cavalcanti, 2017; Song, Kalet, & Plass, 2011). Firstly, self-regulated factors have been identified as a source of achievement differences between students (Zimmerman & Pons, 1986). Secondly, self-regulated learning (SRL) has been demonstrated as an effective means of raising student achievement (Schunk, 1981). In the 1980s, Schunk showed that students who are proactive self-regulators set goals, devise and implement effective learning strategies, create an effective learning environment, seek feedback and help when necessary, show tenacity as well as self- monitoring and being able to assess their progress towards specific goals (Zimmerman & Schunk, 2011). Studies have shown that metacognitive skills, a component of SRL, increase during adolescence, plateau during early adulthood and then decline in older age (Palmer, David, & Fleming, 2014; Weil et al., 2013).

Metacognition, or thinking about your thinking, is vital to the development of clinical reasoning skills due to its role in monitoring and regulating cognitive processes (Colbert et al., 2015; Croskerry, 2003a, 2003b; Dunphy et al., 2010; Marcum, 2012). Medical accreditation authorities recognise metacognitive skills as important and seek to mandate their development by practising clinicians (CPMEC, 2016; ACGME, 2015; GMC, 2016). Although metacognitive skills are widely regarded as important for the development of clinical reasoning, they are seldom directly taught or assessed at medical school (Colbert et al., 2015). Metacognitive skills are a component of SRL which manage the cognitive aspects of learning and thinking (Bruin et al., 2017; Göntülü & Artar, 2014). Effective SRL skills are positively associated with superior levels of student achievement, as well as expertise in clinical reasoning (Zimmerman & Schunk, 2011).

Cognitive skills are needed to perform a task, whereas metacognition is required to manage these cognitive skills (Garner, 1987). Metacognitive awareness skills include the Knowledge of cognition, which enable a person to have knowledge about their thinking and learning processes (Göntülü & Artar, 2014; Schraw, 1998). The second component of metacognitive awareness is the Regulation of cognition. Being able to regulate their cognition enables

an individual to self-monitor the effectiveness of their learning and decision making, regarded as vital to all clinicians, regardless of whether they are students or experts (Bruin et al., 2017).

Knowledge of cognition comprises declarative, procedural and conditional knowledge. Declarative knowledge encompasses knowing about things and covers facts, information, events, rules and processes. It involves networks of facts, is public knowledge and originates from what teachers state or declare (Anderson, 1982). Knowledge is encoded declaratively and then interpreted for it to be understood. For knowledge to be converted into behaviour, it must first go through this interpretive stage. Declarative knowledge may be thought of as conceptual, propositional, descriptive or explicit knowledge.

When declarative knowledge is put to work and involves knowing how to do something, it becomes procedural knowledge which undergoes a process of continual refinement with increases in processing speed. Procedural knowledge refers to the performing of knowledge or implicit knowledge and is a behaviour or skill. If knowing when and why to use a particular skill is important it becomes conditional knowledge which involves the regulation of memory, thought and learning (Ackerman & Zalmanov, 2012).

Regulation of cognition helps the student control or manage their learning or decision making e.g. a medical student may ask themselves if they understand the significance of a specific piece of clinical data, or if they comprehend the rationale behind a clinical decision or management plan. Regulation of cognition comprises of planning, information management, monitoring, debugging strategies and evaluation (Schraw & Dennison, 1994).

Planning involves choosing the best strategy alongside managing the required information to achieve the desired outcome. Monitoring refers to the ability to self-test the progress being made on a task. Debugging strategies concerns intentionally looking for disconformity evidence to reduce the risk of confirmation biases. Finally, evaluation refers to the ability to globally assess the progress towards solving a clinical problem or gaining mastery in learning.

Figure 1 Shows how the components of metacognitive awareness may interact with four stages of the clinical reasoning cycle.

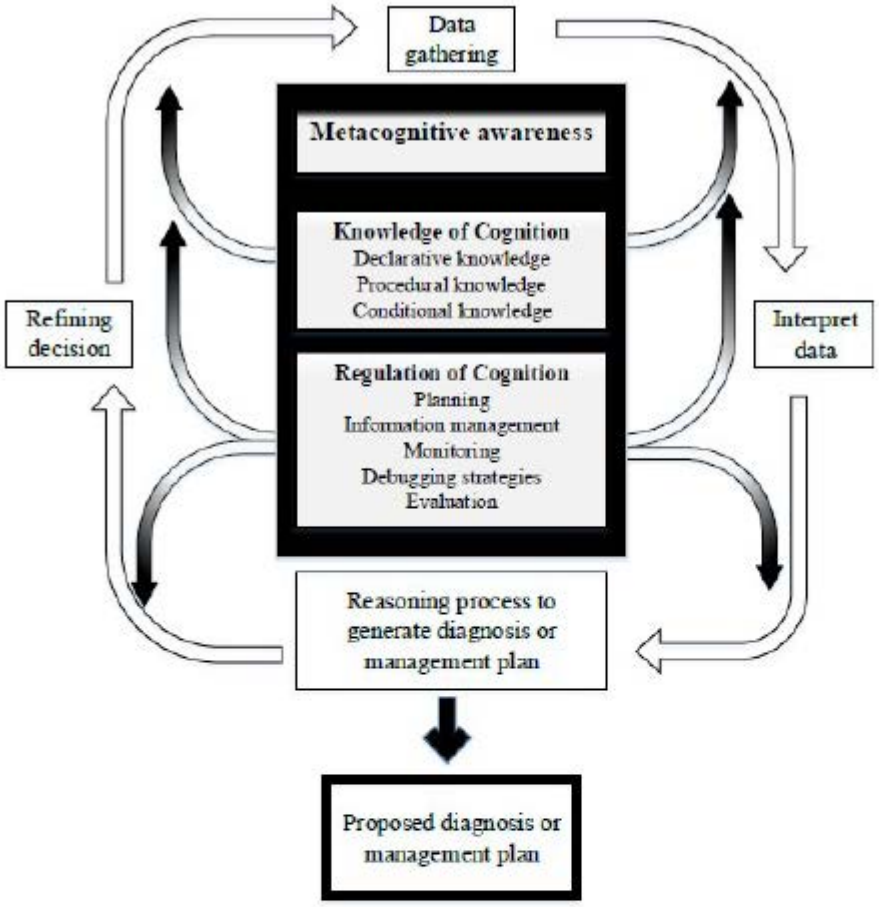


Figure 1 shows how Regulation of cognition sub-domains interacts with all stages of the clinical reasoning cycle as the individual plans, monitors and evaluates new information in the light of existing knowledge. As the doctor in training makes use of debugging strategies they test their reasoning for its robustness (Croskerry, 2003a). The Knowledge of cognition sub-domains help the clinician to encode and interpret new information by linking it to their existing knowledge structures. This new knowledge may then be used in the clinical reasoning process. Knowledge already possessed by the doctor in training guides them to seek new patient data, as well as helping to make sense of the clinical findings. Clinical reasoning is an iterative process (Charlin, 2012). It may take place rapidly and with little metacognitive guidance input, but this may increase the clinical reasoning error rate (Croskerry, 2003b; Graber, 2003; Kiesewetter et al., 2016).

Clinical reasoning errors appear not to be predominantly due to incompetence or a lack of knowledge, but arise due to the complexity of the case, or under conditions of uncertainty or time pressure (Scott, 2009). The various errors and biases that impact on clinician judgement have been well documented, and commonly include premature closure whereby a diagnosis or management plan is decided upon before all the possibilities have been adequately considered (Nendaz & Perrier, 2012; Scott, 2009).

Medical school examinations test student knowledge and clinical skills with the goal of producing intern doctors prepared for clinical practice. Part of this preparation includes developing the clinical reasoning capabilities of their graduates and by inference, their metacognitive capacities, in readiness for clinical reasoning in the workplace. In this paper, the authors test the hypothesis that there is a correlation between the metacognitive awareness of medical students and their examination performance and secondly, that there will be an increase in metacognitive awareness levels between first and fifth-year students of a medical course.

This research took place with volunteer undergraduate medical students at James Cook University (JCU), Australia. The university and hospitals used for clinical placements are in regional and rural northern Queensland, Australia. The first year of the medical program at JCU is regarded as the first of three pre-clinical years. Although there are several clinical placements, most of the time is spent in class or laboratory sessions. For the last three years of the program, students are primarily taught while on clinical placements. During their medical course, students are periodically required to write reflectively about their clinical experiences, but they are not explicitly taught metacognitive techniques.

Research questions

The research questions hypothesised firstly, that metacognitive awareness levels would positively correlate with undergraduate examination scores. Secondly, it was hypothesised that there would be an increase in metacognitive awareness scores from the first to the fifth year of the medical course.

Method

Ethical approval was obtained for this pilot study from James Cook University Human Research Ethics Committee reference H6008. This study used a between-subject design with data collected at one point in time.

Students were invited to participate in this study by email. For participating first-year medical undergraduates (43 from a total of 197)), their mean age was 19.19 (SD = 2.7) years with 19 male and 24 female students. For the fifth-year students (13/177) their mean age was 25.69 (SD= 6.16) years, with seven male and six female students. This study was undertaken in September 2015. Two types of measurement instrument were used, medical school examination results and the metacognitive awareness inventory (MAI) (Schraw & Dennison, 1994).

Measurement instruments

Medical School Examinations

A variety of examinations are used by the medical school to test knowledge and clinical skills, and these include the Objective Structured Clinical Examination (OSCE), Key Features Papers (KFP) and Multi-Station Assessment Task (MSAT). An OSCE is a focused examination consisting of approximately 20 stations where students may be asked, for example, to take a patient history, examine a part of the body or interpret a laboratory report (Harden, 1988). These tasks form part of the information gathering and analysis components of the clinical reasoning process (Welch

et al., 2017). The OSCE is a commonly used and highly regarded method of assessment around the world, both in undergraduate and postgraduate examinations (Khan, Ramachandran, Gaunt, & Pushkar, 2013).

Key Features Papers (KFP) were designed as a means of evaluating clinical problem solving and decision-making skills (Page & Bordage, 1995; Page, Bordage, & Allen, 1995). The examination is a written test consisting of between 15-20 brief cases where the student is required to make qualified decisions based on the information presented. The Multi-Station Assessment Tasks (MSAT) have strong similarities to the OSCE examination but are adapted for medical students in years 1-3 at JCU. There is a debate in the literature about how best to measure clinical reasoning (Gruppen, 2017). The absence of a 'gold standard' test means that reliance on testing depends on several different types of examinations including the OSCE and KFP examinations (Ilgen et al., 2012; Rencic, Durning, Holmboe, & Gruppen, 2016).

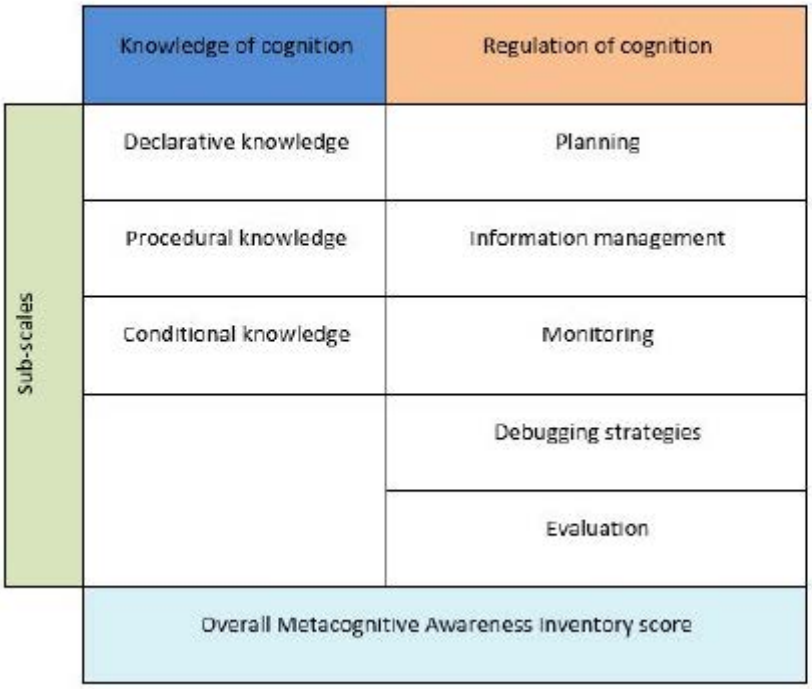
Studies have shown that metacognitive awareness allows individuals to plan, sequence and monitor their learning in a way that improves their overall examination performance (Swanson, 1990). Metacognitive skills are essential for any complex learning process, but there is a lack of evidence connecting metacognitive awareness with performance in medical school examinations. This study investigates how metacognitive skills are associated with performance in undergraduate medical examinations.

The Metacognitive Awareness Inventory (MAI)

The Metacognitive Awareness Inventory (MAI) was developed to quantify the different components of metacognitive awareness see Table 1 (Schraw & Dennison, 1994). The MAI has sub-scales within the Knowledge of Cognition domain including *declarative knowledge*, *procedural knowledge*, and *conditional knowledge*. From the perspective of clinical reasoning, it is important for the clinician to understand how knowledge is added to what they already know about the signs and symptoms of a patient. This knowledge about a patient medical data is declarative knowledge (Schraw & Moshman, 1995). Procedural knowledge is concerned with how practical procedures are sequenced and executed, for example how a patient's abdomen is palpated to feel for an enlarged liver. Conditional knowledge is knowing why and when to apply various cognitive actions, for example knowing which heart sounds to listen for, based on the result of a patient's ECG and history (Schraw & Moshman, 1995).

The second domain of the MAI is Regulation of Cognition and is associated with controlling one's thinking and learning. There are five sub-scales in this domain including *Planning*, *Information Management*, *Monitoring*, *Debugging* and *Evaluation* (Schraw & Dennison, 1994). Planning involves controlling one's thinking and actively developing a strategy for solving a clinical problem. Information Management means actively reflecting on whether there is enough information gathered to enable a decision to be made. If there is insufficient information, the clinician can develop a strategy to obtain the extra information he/she needs to make a decision. Monitoring means the real-time awareness of how the clinician is utilising the information they are receiving and checking how they are performing clinically. Debugging techniques may be used to correct understanding and performance errors. For example, a student may think why they placed undue emphasis on a particular clinical detail which then took their thinking to an incorrect conclusion. Finally, the evaluation sub-scale is linked with analysing the whole decision-making process and reflecting on its effectiveness. This evaluation step is particularly important in enabling the learner to deliberately and consciously make better decisions next time (Ericsson, 2004).

Table 1 – Domains and sub-scales of the Metacognitive Awareness Inventory (Schraw & Dennison, 1994)



The Metacognitive Awareness Inventory (MAI) was deployed via the online tool Smart Sparrow and consisted of a series of 52 short statements, for example, "*I consider several alternatives to a problem before I answer*, and *I consciously focus my attention on important information*" (Schraw & Dennison, 1994; Smartsparrow, Accessed Sept 2014).

the MAI Knowledge of cognition domain is calculated as the mean score of the declarative, procedural and conditional knowledge scores, while the Regulation of cognition domain score is the mean score for the planning, information strategies, monitoring, debugging strategies and evaluation sub-scales.

The inventory required participants to indicate their level of agreement with each statement by positioning a sliding point on a 10-point scale bar. The far right of the scale bar (10) indicated strong agreement while the far left (1) denoted strong disagreement. Individual statement item scores ranged from 1-10, and scores for each sub-scale were totalled and recorded as a percentage of the maximum available for each sub-scale. Following online completion and submission of the MAI, participants were given a breakdown of their percentage scores in each of the eight sub-scales and feedback about how they could improve skills in each domain.

The following student examination scores were obtained from consenting participants, depending on their year of the undergraduate medical program.

- First year: Overall year mark, end of year Multi-Station Assessment Task (MSAT) examinations, Key Features Papers (KFP) examination scores.
- Fifth year: Overall year mark, end of year Objective Structured Clinical Examination (OSCE) and their Key Features Paper (KFP).

All academic performance data was de-identified by the College of Medicine and Dentistry Assessment Unit before analysis by the researchers. The data was stored and retrieved on password protected electronic files.

Results

Results are summarised in Table 2 below.

Table 2 – Results showing the significant correlations between the domains and sub-scales of the Metacognitive Awareness Inventory and Year 1 and 5 student examination results.

MBBS Year 1					
Overall examination Result					
Knowledge of Cognition	**r_s (CI)**	**p**	**Regulation of cognition**	**r_s (CI)**	**p**
Declarative Knowledge	0.31 (0.01 - 0.55)	0.04	Planning		
Procedural Knowledge			Info management strategies		
Conditional Knowledge	0.33 (0.03 - 0.57)	0.03	Monitoring		
			Debugging strategies		
Knowledge of Cognition	0.32 (0.02 - 0.56)	0.04	Evaluation		
MAI overall			Regulation of cognition		
MSAT yr1/ OSCE yr 5					
Knowledge of Cognition	**r_s (CI)**	**p**	**Regulation of cognition**	**r_s (CI)**	**p**
Declarative Knowledge			Planning		
Procedural Knowledge			Info management strategies		
Conditional Knowledge	0.29(0.00 - 0.49)	0.04	Monitoring		
			Debugging strategies		
Knowledge of Cognition			Evaluation		
MAI overall			Regulation of cognition		
EPP					
Knowledge of Cognition	**r_s (CI)**	**p**	**Regulation of cognition**	**r_s (CI)**	**p**
Declarative Knowledge	0.34(0.04 - 0.58)	0.03	Planning		
Procedural Knowledge			Info management strategies		
Conditional Knowledge	0.33(0.02 - 0.57)	0.03	Monitoring		
			Debugging strategies		
Knowledge of Cognition	0.32(0.04 - 0.58)	0.03	Evaluation		
MAI overall			Regulation of cognition		

MBBS Year 5					
Overall Examination Result					
Knowledge of Cognition	**rs (CI)**	**p**	**Regulation of cognition**	**rs (CI)**	**p**
Declarative Knowledge	0.58 (0.27 -0.82)	0.04	Planning		
Procedural Knowledge			Info management strategies	0.60 (0.28 - 0.80)	0.04
Conditional Knowledge	0.61 (0.31 -0.83)	0.04	Monitoring		
			Debugging strategies		
Knowledge of Cognition	0.60 (0.33 -0.80)	0.04	Evaluation		
MAI overall			Regulation of cognition		
MSAT yr 1 / OSCE yr 5					
Knowledge of Cognition	**rs (CI)**	**p**	**Regulation of cognition**	**rs (CI)**	**p**
Declarative Knowledge			Planning	0.61 (0.38 - 0.82)	0.04
Procedural Knowledge			Info management strategies	0.58 (0.11 - 0.77)	0.04
Conditional Knowledge			Monitoring		
			Debugging strategies		
Knowledge of Cognition			Evaluation		
MAI overall			Regulation of cognition	0.48 (0.07-0.71)	0.04
KFP					
Knowledge of Cognition	**rs (CI)**	**p**	**Regulation of cognition**	**rs (CI)**	**p**
Declarative Knowledge	0.74 (0.33 -0.94)	0.01	Planning	0.50 (0.18 - 0.74)	0.04
Procedural Knowledge	0.62 (0.18 -0.84)	0.02	Info management strategies	0.58 (0.21 - 0.79)	0.03
Conditional Knowledge	0.76 (0.33 -0.92)	0.01	Monitoring		
			Debugging strategies		
Knowledge of Cognition	0.82 (0.41 -0.95)	0.01	Evaluation	0.56 (0.021 -0.73)	0.04
MAI overall	0.63 (0.30 -0.83)	0.01	Regulation of cognition	0.62 (0.26 - 0.82)	0.02

Scale for interpreting the Spearman's correlation coefficient

r_s = 0.0-0.3 negligible

r_s =0.3-0.5 low positive

r_s = 0.5-0.7 moderate positive

r_s = 0.7-0.9 high positive

r_s = 0.9-1.0 very high positive (Hinkle, Wiersma, & Jurs, 2003)

In comparing the first and fifth year overall MAI results there was no significant difference were found (all p's >.05).

Analyses

Descriptive statistics were used to characterise the sample. As the data were not normally distributed, Spearman correlation was used for correlation calculations. The Spearman's coefficient, r_s, the confidence intervals, CI, and the p values are indicated in Table 2 along with the scale used for interpreting the Spearman's correlation coefficient. The effect size may be determined by comparing the r_s value with scale for interpreting the Spearman's correlation

coefficient. Mann-Whitney tests were performed to examine any differences in MAI scores between first and fifth year students.

The first research question hypothesised that MAI scores would correlate with examination scores. For the first-year students, their overall examination result for the year had a low but significant correlation with the Knowledge of Cognition domain scores of the MAI ($r=0.32$, $p<0.04$) and their Key Features Paper result also had a low correlation with the Knowledge of Cognition domain score ($r=0.32$, $p<0.03$). There were no significant correlations within the Regulation of Cognition domain score for the first-year student examination results.

For fifth-year students, their overall end of year examination result was moderately correlated with the Knowledge of Cognition domain score ($r= 0.69$, $p<0.04$) and their Key Features Paper (KFP) was highly correlated with the Knowledge of Cognition domain ($r= 0.82$, $p<0.01$). The Regulation of Cognition domain was moderately correlated with performance in the KFP examination ($r= 0.62$, $p<0.02$) and there was a low correlation with the Regulation of Cognition domain score for their OSCE examination ($r= 0.48$, $p<0.04$). The fifth-year overall MAI score was moderately correlated with performance in the KFP examination ($r= 0.63$, $P<0.01$).

Discussion

For first year students, the Knowledge of Cognition domain and some of its sub-scales were correlated with examination performance. However, the relative unimportance of the Regulation of Cognition domain would infer that performing well in first-year examinations is not significantly correlated with the skills of self-monitoring, self-evaluation and information management strategies (some of the sub-scales of the Regulation of Cognition domain).

When undergraduate students reach the fifth-year, both the Knowledge and Regulation of Cognition domains show important correlations with examination performance. The most notable difference between the first and fifth year students is the increased importance of the Regulation of Cognition domain. For the fifth-year students, the results of this research shows an increasing necessity to regulate their cognition in clinical examinations like the KFP and OSCE.

The purpose of the OSCE examination is to assess clinical competence in a planned and structured manner, while Key Features Papers are designed to assess clinical reasoning. (Harden, 1988; Hrynchak, Glover Takahashi, & Nayer, 2014). This study provides evidence that performance in both the KFP and OSCE examinations is correlated with performance in the Regulation of Cognition domain of the MAI.

The second important finding from this research is that there was no significant increase in metacognitive awareness from first to fifth-year students. From the findings of our earlier results, we can see that metacognitive awareness becomes increasingly correlated with performance in the fifth-year examinations. If there is no significant change in a student's metacognitive awareness from first to the fifth year, a lower scoring student may struggle in the later years of medical school where metacognitive awareness is more important. Secondly, and of relevance to graduates, the literature indicates there is a strong link between high levels of metacognition and clinical reasoning expertise – a crucial factor in clinical practice (Croskerry, 2003a).

The limitations of this study include the small number of students participating. Due to the small number of participants in this pilot study and the data not being normally distributed, Spearman's correlation was used. Another limitation may be that the MAI has not been used extensively with medical undergraduates before. The overall examination performances of the first and fifth-year students were not significantly different from the overall mean

results for their cohorts, meaning the participants in this study were representative of their year cohort. The single site location of this study means the result cannot be generalised.

Future research should aim to confirm that MAI scores do not vary significantly between first and fifth-year medical students and that there are correlations between components of the MAI and the OSCE and KFP examinations for fifth-year students. Future research may extend this study to include students from other medical schools in both Australia and internationally. Practising clinicians may also be studied to investigate the relationship between their performance in Script Concordance Tests or postgraduate clinical fellowship examinations and their MAI scores (Boulouffe, Doucet, Muschart, Charlin, & Vanpee, 2013).

Conclusion

This pilot study found there was no significant difference in metacognitive awareness between first and fifth year medical students. This may be a cause for concern given the importance of metacognitive awareness in self-regulated learning and expertise in clinical reasoning. The positive correlations between the sub-scales of the Regulation of Cognition domain and the fifth year KFP and OSCE examinations highlight the importance of metacognitive awareness for undergraduate clinical examination performance. Our evidence along with the literature, support reviewing the need to support raising the metacognitive awareness of medical students which may benefit both their examination performance and their clinical reasoning skill acquisition (Berkhout et al., 2015; Bruin et al., 2017).

Take Home Messages

- Clinical reasoning is core to medical practice.
- Metacognitive awareness is a key trait of clinical reasoning experts.
- Metacognitive awareness levels appear to be correlated with some undergraduate examinations.
- Supporting the learning of metacognitive awareness skills may assist undergraduate examinees and help foster the development of clinical reasoning expertise.

Notes On Contributors

Paul Welch

Paul has over twenty years of experience in education in both the secondary and tertiary sectors. His qualifications include BSc. (Hons), PGCE, MA and he is currently a PhD candidate at James Cook University, Queensland in the College of Medicine and Dentistry. His particular interest is in the development of clinical reasoning skills amongst doctors-in-training. Paul has taught and presented both within Australia and internationally.

Louise Young

Louise has a PhD and over 30 years experience in education. Louise's research interests involve all aspects of medical/health professional education including innovations in teaching and learning, development of clinical

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Peter Johnson

Associate Professor Peter Johnson is the MBBS Course Coordinator and Director of Foundation Studies for the Medicine and Physician's Assistant programs at James Cook University. He has over 20 years of experience as an educator and curriculum developer in over 30 biomedical and allied health degree programs across 5 universities.

Daniel Lindsay

Daniel has expertise in quantitative research methodology and statistical analyses. He currently has a Bachelor of Psychology with Honours, as well as a PhD in Psychology. Research interests include health behaviours, innovations in teaching and learning and health economics.

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Appendices

Appendix 1. The Metacognitive Awareness Inventory (MAI) (Schraw and Dennison, 1994)

Question ID	Questions	Domain ID	Domain Code	Domain
1	I ask myself periodically if I am meeting my goals.	M1	M	Monitoring

2	I consider several alternatives to a problem before I answer.	M2	M	Monitoring
3	I try to use strategies that have worked in the past.	PK1	PK	Procedural Knowledge
4	I pace myself while learning in order to have enough time.	P1	P	Planning
5	I understand my intellectual strengths and weaknesses.	DK1	DK	Declarative Knowledge
6	I think about what I really need to learn before I begin a task.	P2	P	Planning
7	I know how well I did once I finish a test.	E1	E	Evaluation
8	I set specific goals before I begin a task.	P3	P	Planning
9	I slow down when I encounter important information.	IMS1	IMS	Information Management Strategies
10	I know what kind of information is most important to learn.	DK2	DK	Declarative Knowledge
11	I ask myself if I have considered all options when solving a problem.	M3	M	Monitoring
12	I am good at organising information.	DK3	DK	Declarative Knowledge
13	I consciously focus my attention on important information.	IMS2	IMS	Information Management Strategies
14	I have a specific purpose for each strategy I use.	PK2	PK	Procedural Knowledge
15	I learn best when I know something about the topic.	CK1	CK	Conditional Knowledge
16	I know what the teacher expects me to learn.	DK4	DK	Declarative Knowledge
17	I am good at remembering information.	DK5	DK	Declarative Knowledge
18	I use different learning strategies depending on the situation.	CK2	CK	Conditional Knowledge
19	I ask myself if there was an easier way to do things after I finish a task.	E2	E	Evaluation
20	I have control over how well I learn.	DK6	DK	Declarative Knowledge
21	I periodically review to help me understand important relationships.	M4	M	Monitoring
22	I ask myself questions about the material before I begin.	P4	P	Planning
23	I think of several ways to solve a problem and choose the best one.	P5	P	Planning
24	I summarize what I've learned after I finish.	E3	E	Evaluation
25	I ask others for help when I don't understand something.	DS1	DS	Debugging Strategies
26	I can motivate myself to learn when I need to.	CK3	CK	Conditional Knowledge
27	I am aware of what strategies I use when I study.	PK3	PK	Procedural Knowledge
28	I find myself analysing the usefulness of strategies while I study.	M5	M	Monitoring
29	I use my intellectual strengths to compensate for my weaknesses.	CK4	CK	Conditional Knowledge
30	I focus on the meaning and significance of new information.	IMS3	IMS	Information Management Strategies
31	I create my own examples to make information more meaningful.	IMS4	IMS	Information Management Strategies
32	I am a good judge of how well I understand something.	DK7	DK	Declarative Knowledge
33	I find myself using helpful learning strategies automatically.	PK4	PK	Procedural Knowledge
34	I find myself pausing regularly to check my comprehension.	M6	M	Monitoring
35	I know when each strategy I use will be most effective.	CK5	CK	Conditional Knowledge
36	I ask myself how well I accomplished my goals once I'm finished.	E4	E	Evaluation
37	I draw pictures or diagrams to help me understand while learning.	IMS5	IMS	Information Management Strategies
38	I ask myself if I have considered all options after I solve a problem.	E5	E	Evaluation
39	I try to translate new information into my own words.	IMS6	IMS	Information Management Strategies
40	I change strategies when I fail to understand.	DS2	DS	Debugging Strategies
41	I use the organisational structure of the text to help me learn.	Domain not denoted		Domain not denoted

42	I read instructions carefully before I begin a task.	P6	P	Planning
43	I ask myself if what I'm reading is related to what I already know.	IMS7	IMS	Information Management Strategies
44	I re-evaluate my assumptions when I get confused.	DS3	DS	Debugging Strategies
45	I organise my time to best accomplish my goals.	P7	P	Planning
46	I learn more when I am interested in the topic.	DK8	DK	Declarative Knowledge
47	I try to break studying down into smaller steps.	IMS8	IMS	Information Management Strategies
48	I focus on overall meaning rather than specifics.	IMS9	IMS	Information Management Strategies
49	I ask myself questions about how well I am doing while I am learning something new.	M7	M	Monitoring
50	I ask my self if I learned as much as I could have once I finish a task.	E6	E	Evaluation
51	I stop and go back over new information that is not clear.	DS4	DS	Debugging Strategies
52	I stop and reread when I get confused.	DS5	DS	Debugging Strategies

Declaration of Interest

The author has declared that there are no conflicts of interest.

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Personal view and opinion piece **Open Access**

Grounded theory - a lens to understanding clinical reasoning

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Abstract

Clinical reasoning is fundamental to medical education and clinical practice (Schmidt & Mamede, 2015). Despite its centrality, clinical reasoning is often regarded as difficult to conceptualise and teach (Charlin, 2012; Pinnock & Welch, 2014). The pivotal role of clinical reasoning constitutes a compelling case for better understanding, more efficient teaching and practice that is more systematic and evidence-based. Clinical reasoning has been regarded as an art rather than a science (Braude, 2012) and has attracted less research effort than befits its important function. The authors examined the suitability of grounded theory methodology to provide a more complete understanding of the clinical reasoning process. Grounded theory and clinical reasoning are processes which both qualitatively evaluate and analyse information from an interview subject as well as additional sources and arrive at a robust, defensible theory to explain their findings. Grounded theory offers considerable utility for (i) understanding and modelling clinical reasoning, (ii) researching clinical reasoning and (iii) as a heuristic for teaching clinical reasoning skills. This paper explores the parallels between grounded theory methodology and clinical reasoning, as well as the suitability of grounded theory as a framework for informing and transforming our understanding of clinical reasoning.

Keywords: clinical reasoning, teaching clinical reasoning, researching clinical reasoning, clinical interviewing, grounded theory

Article

Background

Evidence-based practice is central to modern health care. In medicine, evidence has often been taken to mean the knowledge gained through the application of quantitative scientific methods, such as laboratory experiments and clinical trials. Regardless of how robust the scientific data or how precise the

technology used, clinical medicine remains an interpretative practice (Montgomery, 2005). Clinical reasoning is the cognitive process of evaluating and managing a patient's problems (Barrows & Tamblyn, 1980) and makes practical use of empirical medical knowledge and evidence. For clinicians, it is particularly significant that qualitative inquiry is regularly used to make critical clinical decisions. This is despite there being an entrenched scepticism about qualitative methods elsewhere in the medical sciences (Malterud, 2001; Sofaer, 2002). We suggest that for evidence-based healthcare to be most effective, there is a pressing need for a more systematic understanding of the handling and analysis of the qualitative information generated during each clinical interaction.

Despite appeals for medicine to be 'evidence-based' and 'scientific', clinical reasoning does not conform to the conventional criteria for a scientific methodology. It uses a sample size of one (the patient), employs individual interviews to gather information, analyses and interprets imaging information qualitatively, qualitatively interprets objective quantitative laboratory results and takes an iterative approach to arrive at the final diagnosis. Furthermore, clinical reasoning is often a shared cognitive process taking place in a busy and time-pressured environment, involving conversations between the patient, clinicians and often relatives. It is suggested that an appropriate model for understanding clinical evaluation needs to embrace and reflect these characteristics. A broader look at robust qualitative research methods that meet the demands of academic peer review may well have utility to better understand clinical reasoning.

Advancing our understanding and modelling of clinical reasoning should enable us to teach it better. Clinical reasoning research to date has progressed along two primary axes: Information processing theories and situativity theories (Durning & Artino, 2011). Conceptual complexity, case-to-case irregularity and ill-structured knowledge domains in medicine pose significant problems for traditional learning theories (Coulson, Feltovich, & Spiro, 1997). In the late 1980s, Spiro and colleagues developed *Cognitive Flexibility Theory* as a means of refining traditional learning theories to accommodate advanced knowledge acquisition in ill-structured domains like medicine (Spiro, Coulson, Feltovich, & Anderson, 1988). The theory challenges and seeks to remediate some of the common errors of learners, for example, the tendency to oversimplify complex concepts and an overreliance on a single basis for mental representations (Spiro et al., 1988). Understanding this complexity and case-by-case variability led Schmidt to identify distinct phases the novice passes through on their way to developing expertise in clinical reasoning (Schmidt, Norman, & Boshuizen, 1990). These phases help explain the need for the learner to understand, assimilate and produce their own mental schema linking and storing information for future retrieval and use in the clinical situation. This stored data is later used to enable pattern recognition, which is increasingly used in the clinical reasoning process as experience and expertise develop. Each clinical case is slightly different and requires a reasoning process tailored to the case (Mandin, Jones, Woloshuk, & Harasym, 1997).

This paper proposes using grounded theory as a framework for understanding and explaining clinical reasoning and for harnessing the data analysis methodology used by grounded theory as a means of coaching clinical reasoning (Ericsson, 2004; Pinnock et al, 2014). Glaser and Strauss first described grounded theory in their seminal 1967 book *The discovery of grounded theory* (Glaser & Strauss, 1967). Since then, grounded theory has been extensively deployed and peer reviewed as a data gathering and analysis tool in qualitative research (Charmaz, 2014); evolved into an accepted systematic approach that copes well with relatively small sample sizes and complex systems; and been adapted to allow for the incorporation of evidence in the form of documents, observations and artefacts (Charmaz, 2016; Layder, 1993). This is relevant in the medical context where additional information such as laboratory test results

and imaging data help to shape the decision-making process. In recent years grounded theory has become accepted as a useful methodology in medical education research (Watling & Lingard, 2012). The complexity of clinical reasoning entails information gathering, storage, retrieval and use highlighting the need to identify a framework to coach clinical reasoning that accommodates these features (Mandin et al., 1997).

Clinical reasoning viewed as a qualitative researcher

Qualitative research methods are widely accepted by the academic research community and regularly satisfy the rigours of peer review (Yamazaki et al., 2009). The close parallels between the process of clinical reasoning and that used in grounded theory led us to hypothesise that grounded theory might offer an invaluable explanatory model for clinical reasoning. Charmaz's constructivist grounded theory 'brings to the fore the notion of the researcher as author' (Mills, Bonner, & Francis, 2006). This approach resonates strongly with the clinical reasoning process where the clinician gathers and interprets this clinical information. Below we expand on how this grounded theory approach is relevant to the clinical reasoning process. Similarities between grounded theory and clinical reasoning will be discussed by considering: i. Prior knowledge and experience; ii. Sampling and data collection; iii. Data analysis procedures and iv. Data logic.

Grounded theory methodology	Clinical reasoning analogy
Prior knowledge and experience	
Sensitising concepts	Clinical training and experience
Bracketing	Maintaining objectivity & avoiding bias
Sampling and data collection procedures	
Interview and observational data	History and examination
Un-blinded	Un-blinded
Iterative data collection and analysis	Iterative data collection and analysis
Negative case and maximum variation sampling	Seeking and explaining absent and/or inconsistent symptoms and signs
Continuous comparison and triangulation	Corroborating and cross-checking clinical findings
Saturation	Concluding the assessment when no further salient evidence can be elicited
Data analysis procedures	
Recording and transcribing interviews	Compiling clinical notes in the medical record
Quoting	Summarising key findings
Data reduction	Focussing on relevant details
Open coding	Identifying significant symptoms and signs
Axial coding	Seeking a unifying explanation for diverse findings
Preliminary analysis	Differential diagnosis
Data logic	
Theory building: inductively forming a theory (or explanatory model) grounded in the research data	Diagnosis: inductively arriving at a diagnosis based on the composite clinical findings

Table 1: Comparison of grounded theory and clinical reasoning

(i) Prior knowledge and experience

As with every research project, each clinical interaction is informed by prior knowledge, experience and insights. These pre-conditions, known to researchers as 'sensitising concepts', represent the insights the researcher brings to the analysis and provide a necessary basis for launching the inquiry (Bryant & Charmaz, 2007). Implicit in the idea of 'sensitising concepts' is recognition that the researcher is not a blank slate. In a similar way, the clinician does not, and should not, come to a new case without prior training and knowledge.
For the researcher, the challenge is to leverage these insights for the benefit of the inquiry without

unduly pre-empting the outcomes before the evidence is fully delineated. For researchers, this leads to a counterbalancing concept known as 'bracketing' (Bryant & Charmaz, 2007; Creswell, 2013; Janesick, 2000; Kvale & Brinkmann, 2009). Bracketing acknowledges the need to hold pre-existing knowledge in abeyance in order to take a fresh look at the data with the aim of being open to alternative, possibly better, explanations. So for the qualitative researcher, there is a recognition of the importance of maintaining a balance between using prior knowledge to inform the investigation, and preventing it from prejudicing the current inquiry by pre-empting the outcome. Clinicians think of this balance as maintaining 'objectivity' and avoiding 'biases' to prevent the error of premature closure (Scott, 2009).
In the clinical context, each case is subtly different, requiring both inductive and deductive approaches to careful information gathering which is targeted at making a diagnostic or management decision. Yet in order to reach a diagnosis, the clinical process seeks to discover the features each unique case has in common with other cases and the pre-existing evidence-base. Matching the patient's unfolding clinical story against the clinician's store of previously stored cases is a deductive process. Whilst carefully gathering and synthesising information the clinician is mentally searching for a name or description to assign to the sum of the patient's salient presenting complaints to arrive at a diagnosis.

(ii) Sampling and data collection

The ultimate aim of a grounded theory study is to collect and analyse data systematically in order to develop a theoretical model that explains the phenomenon under study (Glaser & Strauss, 1967; Layder, 1993). A diagnosis that arises from a clinical presentation is very similar and involves a theory about the presenting patient that is grounded in the data obtained during the clinical inquiry.
A striking parallel between the clinical assessment and grounded theory is that both revolve around the conduct and analysis of interviews and are supplemented by information gathering. Like a clinician, a grounded theory researcher would typically start an interview with broad, non-specific questioning and encourage the participant to relate their account in their own words (Kvale & Brinkmann, 2009). Possible explanations start to emerge as the interview unfolds and the inquiry becomes increasingly focused until it is judged that sufficient data has been collected to draw the investigation to a close. Both the clinical interview and the grounded theory interview follow very similar formats.

(iii) Data analysis procedures

Sampling decisions are a central issue for rigorous interview-based qualitative studies (Bryant & Charmaz, 2007). Likewise, sampling, in terms of choosing suitable interview probes, is important for clinical reasoning. The clinical assessment can be led dangerously astray by poorly chosen questions as well as imaging or laboratory findings that distract from an underlying diagnosis. To manage these issues, the grounded theory researcher takes a procedural approach to sampling, and this strategy offers valuable clues for the clinical assessment.
Grounded theory research uses a form of *purposive sampling*, known as *theoretical sampling* (K. Charmaz, 2000; Creswell, 2013; Merkens, 2004). As the name suggests, sampling is conducted with a particular *purpose* in mind, in this case, to build a *theory* to explain what is being observed. Like a diagnosis, many grounded theories are simply modest models that help to explain the accumulating evidence. In that sense, a grounded theory shares many similarities with a diagnosis, which can be considered to be a grounded theory that seeks to provide a unifying explanation for the patient's

presenting complaint.

There are two levels of data sampling that take place in qualitative research. The first consists of the selection of research participants and the second consists of the choice of probes used in individual interviews. In terms of sampling which participants to interview, the grounded theory researcher seeks key informants who are in a position to share information and experiences that shed light on the phenomenon being studied. In contrast, the history taking and the tests a clinician might order are pre-determined by the manner in which the patient presents to the clinic. In the case of sampling data from individual participants during an interview, the grounded theorist researcher is guided by the need to develop a coherent explanatory model or theory (thus the term *theoretical sampling*). Likewise, for the clinician, their questions, physical examination, imaging and tests ordered are guided by the need to devise a unifying model that explains the various clinical findings so as to arrive at a diagnosis or management plan. These sampling decisions further highlight the similarities between grounded theory and the clinical reasoning process.

Neither clinical reasoning nor grounded theory analysis are blinded processes, nor should they be – randomisation has no role here. Interviews do not consist of a random selection of questions and statements but are systematic and sequential as earlier revelations will guide subsequent questioning. Both qualitative research methods and clinical reasoning take an iterative approach to data collection and analysis that is designed to accumulate evidence, test possibilities, seek out alternatives and construct explanations. Similarly, for clinical data gathering, it is standard practice in grounded theory research to revise the sampling approach and to adjust the interview guide in the light of the findings that emerge as the study unfolds. In this way, both the clinical reasoning process and qualitative research study progressively focus in on an emerging explanation.

Qualitative research methods, and in particular grounded theory, come to the fore when exploring the unknown, when analysing complex systems, and when handling relatively small sample sizes. Each of these characteristics also applies to clinical reasoning for an unknown diagnosis, complex pathophysiological systems, and a sample size of one. In order to adapt to these requirements, qualitative research has developed a specialised approach to determining the sample size known as *saturation* (Bryant & Charmaz, 2007; Creswell, 2013). This approach specifies that sampling should continue until the data become repetitive, and no new and/or variant data can be discovered. Thus the sample size only becomes finalised while data is being collected (Figure 1). A similar situation prevails for clinical assessment where the data gathering is drawn to a close when additional clinical details no longer add further clarity to the clinical picture that has emerged.

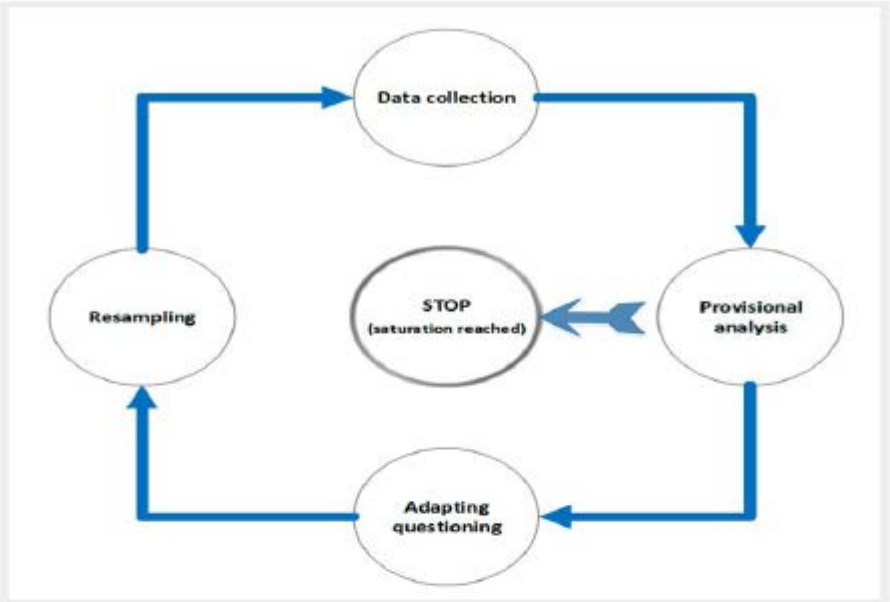

Figure 1: Clinical assessment and reasoning is iterative, un-blinded and inductive

A further characteristic of purposive sampling, known as variant case or maximum variation sampling (Creswell, 2013), also offers important insights for clinical reasoning process. Variant case sampling entails seeking out and examining cases that vary from what has been observed, in order to make sure that the emerging theory is sufficiently robust and up to the task of explaining variant findings. Collecting a rich variety of accounts helps to elaborate a more robust and complete explanatory theory, as does the confirmation of one finding by another. This corroboration between findings is known as *triangulation* in qualitative research (Creswell, 2013).

An extreme version of variant case sampling is negative case sampling (Bryant & Charmaz, 2007). Here too, the emerging explanation must be able to explain why a characteristic is missing (negative case) when the explanation developed so far suggests it should be present. Identifying and analysing a variant should lead to the theory either being modified to take it into account or abandoned in favour of a better explanation. In this sense, qualitative research adopts a different approach from conventional scientific method, which may tend to dismiss anomalous data as statistical outliers. Grounded theory researchers and experts in clinical reasoning typically seek out and pay careful attention to 'outliers' because of their importance as indicators of whether the emerging explanation is adequate or not. If a clinician ignores 'outlier' information that seems not to fit the clinical picture it may have disastrous consequences leading to an entirely wrong diagnosis or management plan. The clinical reasoning literature emphasises the need for experts not to ignore 'outlier' information that does not appear to fit the clinical picture, but to continue to search for a diagnosis that accommodates all of the patient's clinical data (Marcum, 2012). Following consideration of procedures related to grounded theory research and the steps in clinical reasoning comes the interpretation of data.

Analysis and interpretation of data in grounded theory research and how this relates to clinical reasoning is the next similarity.

(iv) Data logic

At the core of grounded theory research is the analytical process. Unlike conventional scientific methods, which are sequential, controlled and blinded, the analytical process in grounded theory is iterative, un-blinded and takes place concurrently with data collection. In this regard, grounded theory research is very similar to the clinical reasoning process.

Analysis of grounded theory research interviews takes place at a number of points in the research process. First, constant analysis occurs *during the interview* and provides a basis for further (iterative) questioning as the interview unfolds. Second, there is preliminary analysis *after each interview*. At this stage, the analysis aims to: (a) review the interview for clues that will contribute to the progressive development of an explanatory model; (b) explore the material for new and unexpected possibilities and to revise the interview guide accordingly to explore these in more detail in subsequent interviews; and (c) to progressively revise the sampling approach using theoretical, maximum variation and negative case sampling in order to fill knowledge gaps and test alternative explanations. Third, there is a *formal summative analysis* which ultimately leads to the generation of an explanatory theory grounded in the data (a grounded theory).

Unlike clinical interviews, research interviews are typically audio-recorded and transcribed verbatim. The analysis is based on the evidence contained in these transcripts. The first step is to identify statements that appear to offer significant insights into the issues being studied. Deciding which statements are significant is based on their relevance to the research question, prior sensitising concepts, and preliminary analysis during interviews. This step is commonly known as 'quoting' (Kvale & Brinkmann, 2009). Quoting serves a dual function of drawing out significant evidence in the form of statements made by participants ('quotes') while filtering out superfluous material and assisting with data reduction. Extracting notable quotes and filtering out superfluous details offers a systematic way of focussing and summarising interview data which in many qualitative projects can be voluminous. A similar result is achieved in the way clinical notes are written, which separate out and summarise pertinent data with the aim of formulating a diagnosis.

Once quotes are identified by the qualitative researcher, the next step is to code them see Saldana for a full exposition (Saldana, 2013). Coding is a complex process which assigns one or more tag words or phrases to each quote. These tags have two primary functions: first, as a *label* that summarises a feature of a quote that sheds light on the research question (known as *open coding*); and second, to *classify* the quote and thus group it with other evidence to highlight the common ground and to reveal patterns and commonalities that help to explain the findings (known as *axial coding* in qualitative methods).

Ultimately these thematic groupings of related codes can be used as the basis for postulating a coherent explanatory model that draws the various pieces of evidence together into a grounded theory. An analogous situation in a clinical setting would be a history of deep central discomfort (code: chest pain) that when related to other findings (axial coding) such as age, sex, smoking, family history, radiating pain down the arm or vomiting blood, could lead to the clinician theorising (a grounded theory) that the person is suffering a heart attack or gastric ulcer respectively.

Summary

In summary, a number of simultaneous processes take place during a grounded theory interview or

clinical reasoning (Table 1). The overarching elements which aim to build a robust explanation include:

1. Progressive funnelling of questioning from broad open-ended questions towards a final clinical outcome (a process known as continuous comparative or iterative analysis)
2. Incorporation of clinical evidence in the form of observations, physical examination findings and clinical documentation (analogous to Layder's grounded theory adaptations that introduce evidence from observations, documents and physical artefacts (Layder, 1993))
3. Constant, un-blinded, comparative analysis applied to each new piece of clinical data to ensure that the resulting explanation is coherent and corroborated by as many other finding as possible (analogous to triangulation).
4. Actively seeking and explaining variant and negative findings because of their potential value as 'flags' for problems with the diagnosis, which may need revising (analogous to maximum variation and negative case analysis).
5. Drawing the clinical assessment to a close when no new data is forthcoming (known as saturation).
6. Arriving at a diagnosis grounded in the clinical findings (known as a grounded theory in grounded theory research).

Conclusion

Clinical reasoning is a complicated process, and despite being the subject of an extensive body of work our understanding of it is far from complete. The primary approach to the clinical reasoning process is qualitative being based on the clinical history, physical examination and additional imaging and laboratory results. Due to these similarities, we turned to disciplines that have an established track record of using qualitative methods to shed further light on clinical reasoning. The clinical reasoning process shares many similarities with grounded theory including strong methodological similarities. Grounded theory is a valuable framework (i) for understanding and modelling clinical assessment and reasoning; (ii) for researching clinical reasoning; and (iii) for coaching clinical reasoning in the working clinical environment.

Take Home Messages

- Clinical medicine is an interpretive practice not a precise science.
- Clinical reasoning is vital to medical practice, but difficult to conceptualise and teach.
- Grounded theory provides a robust methodology to better understand the clinical reasoning process.

Notes On Contributors

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Appendices

Declaration of Interest

The author has declared that there are no conflicts of interest.

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VIEWPOINT

Learning clinical reasoning

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Abstract: Errors in clinical reasoning continue to account for significant morbidity and mortality, despite evidence-based guidelines and improved technology. Experts in clinical reasoning often use unconscious cognitive processes that they are not aware of unless they explain how they are thinking. Understanding the intuitive and analytical thinking processes provides a guide for instruction. How knowledge is stored is critical to expertise in clinical reasoning. Curricula should be designed so that trainees store knowledge in a way that is clinically relevant. Competence in clinical reasoning is acquired by supervised practice with effective feedback. Clinicians must recognise the common errors in clinical reasoning and how to avoid them. Trainees can learn clinical reasoning effectively in everyday practice if teachers provide guidance on the cognitive processes involved in making diagnostic decisions.

Key words: clinical reasoning; diagnosis; education; teaching/methods.

Key Points

1. Experienced clinicians generally use rapid unconscious cognitive reasoning processes.
2. By slowing down and verbalising their thinking, experts can make their reasoning explicit for learners.
3. When learners do the same, their reasoning processes can be assessed and improved with feedback.

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Using the D-RECT to assess the Intern learning environment in Australia

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* Based on findings of Chapter 4

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