ANGLIA RUSKIN UNIVERSITY

FACULTY OF HEALTH, EDUCATION, MEDICINE AND SOCIAL CARE

INVESTIGATING NURSING STUDENTS’ CLINICAL REASONING AND DECISION MAKING USING HIGH FIDELITY SIMULATION OF A DETERIORATING PATIENT SCENARIO.

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A thesis in partial fulfilment of the requirement of Anglia Ruskin University for the degree of Doctor of Philosophy

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ABSTRACT

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The ability of the nurse to make clinical decisions is an integral part of nursing practice and clinical competency. The shortage in clinical placement, the incidences of "failure to rescue" and the emphasis on patient's safety has driven the increased use of simulation in nursing education. Yet, there is a lack of evidence about how simulation affects students' decision-making skills and the way in which nursing students learn how to make decisions is not well understood.

The aim of this study was to investigate nursing students' clinical decision making using high fidelity simulation of a deteriorated patient scenario. Twenty-three nursing students in the final year of their nursing degree were recruited for this investigation. A pragmatist approach and a multiphase mixed method design were adopted. The Health Science Reasoning Test (HSRT), think aloud and observations were used in phase1. A semi-structured interview was applied in phase 2 to explore the benefits of this experience on students' clinical practice.

Phase 1 results showed a statistically significant improvement in the overall HSRT score post the simulation experience. The students applied both methods of reasoning, the forward and backward, in a dynamic manner to make decisions. They predominantly used the analytical type of decision making and forward reasoning to respond to a patient's deterioration. The equal application of the analytical and non-analytical types associated with a better effect on the HSRT score. The students were not always effective in cue acquisition and interpretation and these stages were affected by cognitive biases. Phase 2 revealed that simulation promoted deep learning and increased students' self-awareness.

The study draws the attention to the need for a clinical simulation design that based on a theory of decision making. It proposes a framework that has the potential to enhance the effectiveness of clinical simulation in teaching clinical decision making.

Key words: high fidelity simulation, clinical reasoning, clinical decision-making, nursing students, cognitive biases.

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LIST OF OPERATIONAL DEFINITIONS AND ABBREVIATIONS

ABCDE	An acronym used a systematic approach for assessing and treating patients in emergency situations (Airway, breathing, circulation, disability and exposure)
ABG	Arterial blood gases
AHA	American Heart Association
AMU	Acute medical units
APA	Assertional phrase analysis: the second step in verbal protocol analysis that identify the cognitive operators.
ARU	Anglia Ruskin University
ASPiH	Association of Simulated Practice in Healthcare
BLS	Basic Life Support
Backward reasoning	A method of reasoning that is hypothesis-driven. It occurs when the participants initially identify the problem then collect data to deductively verify and provide a rationale for their conclusion
BP	Blood Pressure
CASP	Critical Appraisal Skills Programme
CCT	Cognitive Continuum Theory
CCTDI	California Critical Thinking Disposition Inventory
CCTST	California Critical Thinking Skills Test
CD	Council of Deans
CDM	Clinical Decision Making: a complex process to choose between two or more discrete options. It is dependent on how information is processes and reasoned.
CL	Confidence Level
CR	Clinical Reasoning: is the process by which individual make decisions. It is classified to backward and forward reasoning.
CRM	Crew Resource Management
CS	Clinical Simulation: is an active learning strategy that utilises different modalities such as manikin, virtual reality or role-playing)
CSET	Clinical Simulation Evaluation Tool
CT	Critical Thinking

Debiasing	is an approach to increase the participants' awareness about their biases and the strategies that they could be used to mitigate for these biases.
DH	Department of Health
DPT	Dual Process Theory: a theory of decision making that considered the parallel and more integrated applications of both non-analytical and analytical approaches for reasoning and decision making.
DM	Decision Making
EDA	Exploratory Data Analysis
Forward reasoning	A method of reasoning that is data driven, where information is gathered and cues are collected trigger a hypothesis.
Hb	Haemoglobin
GPSEC	Perceived Self Efficacy and Self-Reported Competency Scores
HEE	Health East of England
HEI	High Education Institute
HESI	Health Education Systems Incorporated
HSRT	Health Science Reasoning Test: a valid and reliable test that assess the components of clinical reasoning among healthcare professionals.
HFS	High fidelity simulation: in this study it refers to manikin-based simulation.
ICD	International Statistical Classification Diseases
IV	Intravenous
JBI	Joanna Briggs Institute
LTM	Long-Term Memory
MCQ	Multiple Choice Question
MI	Myocardial Infarction
NDA	Nurse Directors Associations
NDM	Natural Decision Making
NHS	National Health Service
NMC	Nursing and Midwifery Council
NCEPOD	National Confidential Enquiry into Patient Outcome and Death
NICE	National Institute for Health and Care Excellence
NLNAC	National League for Nursing Accreditation Commission
NPSA	National Patient Safety Agency
O2	Oxygen

OSCE	Objective Structure Clinical Examination
PBG	Problem Behaviour Graph: graphs that illustrate person progression in solving a problem using cognitive operators
PBL	Problem-Based Learning
PIS	Participant Information Sheet
RPA	Referring Phrase Analysis: the first step in the verbal protocol analysis that aim to identify the concept of care on which the participants are focused on like airway, breathing or circulation.
RCT	Randomised Control Trial
SA	Script Analysis: the third step in the verbal protocol analysis that aims to identify the main process of reasoning and types of clinical decision making.
SEUT	Subjective Expected Utility Theory
SJT	Social Judgement Theory
SMOTS	Scotia Medical Observation and Training System
SpO2	Oxygen Saturation
STM	Short Term Memory
TA	Think Aloud: a method of data collection, classified as concurrent and retrospective and refer to participants verbalising their thoughts out loud. Concurrent TA refers to the verbalisation during performance. Retrospective TA refers to the verbalisation after performance.
Type 1	The non-analytical method for reasoning and decision making that includes pattern recognition, automated behaviour and intuition.
Type 2	The analytical method for reasoning and decision making that mainly includes the hypothetico-deductive approach.
UK	United Kingdom
USA	United States of America
VPA	Verbal Protocol Analysis: a method of analysing verbal data produced by the TA. It has three steps that include referring phrase analysis (RPA), assertional phrase analysis (APA) and script analysis (SA).
WGCTA	Watson-Glaser Critical Thinking Appraisal
WHO	World Health Organisation
WM	Working Memory
WMC	Working Memory Capacity

CHAPTER 1
INTRODUCTION

1.1 Rationale and background

Clinical decision-making (CDM) is an integral part of nursing practice and clinical competency (Nursing and Midwifery Council (NMC), 2014). Little is understood about the complex processes nurses use to clinically reason and make decisions in relation to patient conditions or the visible tasks they perform, or the relationship between the collected cues, identified problems and executed actions. Novice nurses are less able to reason accurately, think critically, process information effectively to form decisions and reach appropriate judgements (Benner, 1984; Del Bueno, 2005; Hoffmann, O'Donnell and Kim, 2007). Seventy percent of graduate nurses in a USA study scored "unsafe" levels of clinical reasoning which suggest poor decision-making abilities (Del Beuno, 2005). Similar results were reported in Australia (New South Wales Health, 2006).

In the last two decades, concerns have been documented about patients' safety and the raised incidences of suboptimal standards of care that were linked to worse patients' outcome (McQuillan et al 1998; Department of Health (DH), 2000; National Confidential Enquiry into Patient Outcome and Death (NCEPOD) 2005; National Patient Safety Agency (NPSA), 2007; Rattray et al, 2011; McGaughey et al, 2017). The mortality rate was significantly higher for patients with clinical deterioration who received suboptimal care in acute wards ($p<0.001$) compared to well-managed patients in critical care units (NCEPOD, 2005). In the UK, the shortage of intensive care unit (ICU) beds and premature patient discharge to the ward also have been linked to an increase in ICU readmission (Daly, Beale and Chang, 2001). NPSA (2007) reported that a major factor for 'failure to rescue' patients with acute clinical deterioration was a failure to recognise relevant clinical information and hence failure to make and implement appropriate clinical decisions. NCEPOD (2012) reported that deficiencies in the decision making and recognition of the severity of patient illness by junior doctors and nurses led to failure to rescue before cardiac arrest. This is also evident in Donaldson, Panesar and Darzi (2014) who analysed 2,010 incidents and found six major systemic failures that were linked to reported hospital mortality. They found that mismanagement of deterioration and failure of prevention together counting for 61% of these incidents. The most common systemic failure was failure to act on or recognise clinical deterioration (26%).

Nurses' decisions and contributions to clinical decision making can affect patients' safety and quality of care (NPSA, 2007; Rattray et al, 2011; Aiken et al, 2012; Aiken et al, 2016). McQuillan et al (1998) found that nurses made inappropriate decisions in response to patient clinical decline that resulted in a delayed referral to more senior and expert staff. Coiffi (2000) also found that nurses with effective clinical reasoning skills have a positive impact on the patient outcome, and those with poor clinical reasoning skills often fail to recognise and manage deteriorating patients, resulting in "failure to rescue". The healthcare team depends on the nurse's ability to recognise critical cues, interpret the importance of those cues, and reach accurate conclusions about patients' needs (Etheridge, 2007).

Developing clinical decision making is a central component in pre-registration nursing education, as this skill is vital for delivering a high-quality healthcare (Stayt, 2011; NMC, 2014; NMC, 2018). Therefore, a primary goal for nursing education is to help students develop skills that will facilitate accurate CDM. However, the way in which nursing students learn to make decisions is not well understood and there is a lack of educational interventions that are based on theories of decision making (Thompson and Stapely, 2011). The complexity of the theories of clinical decision making and the lack of widely accepted theory of CDM in nursing makes teaching this skill more difficult. Until clinical decision making is clearly understood in nursing, the educators will struggle to facilitate students learning and staff development.

Firstly, a number of nursing studies found that both experienced and novice nurses use different ways of reasoning and decision-making (Hoffman, 2007), with more focus on the use of the non-analytical approaches for the expert and the analytical approaches for the novice (Benner, 1984; Coiffi, 2000; O'Neill, Dluhy and Chin, 2005; Tanner, 2006; Lyneham, Parkinson and Denholm, 2008). The nursing research that focused on the expert decision-making tends to involve self-report of clinical situations (Standing, 2008), where study participants describe their perception of intuition or immediate grasp of the clinical situation as an approach for their CDM. These studies are often criticised because in using self-report participants can only report aspects of the decision-making process within the participants' awareness, whereas the unconscious aspects of their decisions are not usually reported.

Secondly, a group of nursing studies separately focused on exploring how nurses process information and make decisions in natural settings and usually compared expert to novice. Researchers often selected critical care units or emergency departments with little emphasis on acute wards and nursing students (Aitken, 2003; Hoffman, 2007; Aitken et al, 2011; Smith, 2013). However, the complex environmental and contextual factors might be difficult to replicate in a simulated environment and to articulate the part that could be teachable to students. Thirdly, a group of nursing researchers focused on information processing of clinical tasks carried by both novice and expert but used paper-based simulated scenarios (Jones, 1989, Lamond, Crow and Chase, 1996; Higuchi and Donald, 2002; Funkesson, Anbacken and Ek, 2007). However, most of those studies discussed the ways how decisions are made but provided a limited discussion about the effects of cognitive biases on the accuracy of the decisions made (Croskerry, 2009a).

Experienced nurses frequently used pattern recognition and intuition (Benner and Tanner 1987; Hoffman, 2007; Rew and Barrow, 2007; Smith, 2009). Novice nurses frequently use an analytical approach to CDM but not always in an effective way (O'Neill Dluhy and Chin, 2005; Hoffman, 2007). Despite intuition being considered an effective approach to decision making in the nursing literature, it has been found to be more prone to cognitive biases and potential errors affecting the quality of decision making (Croskerry and Nimmo, 2011; Cappelletti, Engle and Prentice, 2014). Overall, there is a lack of emphasis on the use of pluralistic approach for examining CDM in nursing, how to enhance the accuracy of patterns formation and how to regulate cognitive biases.

The issues of ineffective decision-making are still evident despite the research that has been carried out in this field (Dowding, et al, 2011; NCEPOD, 2012; Donaldson, Panesar and Darzi, 2014) and it is not clear how to educate and prepare novice nurses to apply more effective clinical decision-making skills. There is a sense of reliance on clinical practice and students' ability to learn that through reflection on their own experience supported by their mentors' feedback or through observing experienced nurses' performance. Thompson and Stapley (2011) found that the effectiveness of educational interventions to improve nursing judgement and decision making is unknown and requires further research. They also urge educators to use theories of CDM in designing educational interventions to improve nurses' decision-making skills.

This study came about through my interest in CDM and how to improve junior nurses' ability to recognise and effectively management acutely and critically ill patients. In the early stage of my academic career as a critical care lecturer, I did not see simulation as an authentic approach to teaching real patient situations, but this belief gradually changed through my teaching practice as I found it to have potentials to replicate parts of reality and to support deliberate practice. My passion in improving patients' safety and the growing interest I had for simulation led me to this investigative journey.

Conventional teaching and learning strategies may not consistently facilitate the development of the required level of clinical reasoning (CR) and CDM. I was actively seeking teaching and learning strategies to stimulate active participation, deep and meaningful learning that goes beyond recall and facilitates high order thinking. Moreover, clinical placements for students in the 'real' settings have become significantly scarce and simulation in the clinical laboratory is being widely used as a learning strategy in nursing education especially with the recent NMC decision to lift the cap on simulated practice hours for pre-registration nursing curricula in 2018.

Simulation is an educational technique that allows interactive and, at times, immersive activity by recreating all or part of a clinical experience without exposing patients to the associated risks. Simulation technology has been proven to enhance human performance in highly reliable industries such as aviation (Forrest, Mckimm and Edgar, 2013). However, there is still little evidence to support the use of simulation-based approaches in teaching clinical reasoning and decision making in nursing (Mok et al, 2016). Clinical simulation offers a constructivist and a problem-solving learning environment, provides an appropriate context to engage students in the learning process and enhances their experiential learning about how experience informs the next clinical situation encountered (Lasater, 2007; Dreifuerst, 2010). The effectiveness of simulation in teaching CR and CDM when dealing with a deteriorating patient is not well studied (Levett-Jones et al, 2011a). Dowding et al (2011) suggested that more research is needed to examine the impact of problem-based learning and simulation on clinical decision-making.

The use of deteriorating patient scenario and high-fidelity simulation also provides the researcher with an appropriate context to explore how students make decisions. This could lead to a theory-based simulation design that is built on the findings of this study and a decision-making theory. This simulation design could have the potential to enhance the effectiveness of clinical simulation in developing students' CR and CDM skills.

1.2 Methods and aims

The study main aim was to evaluate and explore clinical decision making among third- year pre-registration nursing students using High Fidelity Simulation (HFS). This exploratory and evaluative, multiphase mixed method study investigates clinical decision making during simulation experience and the effects of this experience on developing clinical reasoning skills in nursing students. The simulation environment was chosen to create consistency between the participants and also to examine whether simulation could be an appropriate strategy to effectively teach clinical decision making and create a theory-based simulation to enhance the quality of CDM.

1.3 Overview of thesis

The thesis is organised into nine chapters:
Following this introduction, Chapter 2, Clinical Decision Making, outlines the current models and approaches to clinical decision making (CDM), dentitions and factors that affect the decision making. It considers strengths and limitations of the identified models and their suitability as a theoretical framework for this study. The main approaches discussed are social judgement, information processing, intuitive models and dual theory models. Dual Process Theory that explicitly describes two types of CDM was adopted. The chapter also considers the factors that affect CDM such as complexity of the task, the context and decision maker knowledge and experience, including a critical discussion about the effects of cognitive biases on the quality of decision making.

Chapter three, Simulation, explores the concepts and modalities of clinical simulation. It critically examines the research to date on the impact of high fidelity simulation on clinical reasoning and decision making in nursing literature. It examines how high-fidelity simulation could be used to explore and potentially enhance CDM for undergraduate nursing students.

Chapter four, Methodology, describes how the methodology of this study was chosen and justified. Due to the complexity of CDM and decision makers' lack of awareness about part of their decision, a pragmatist approach and a multiphase mixed method design was selected as being the best approach to answer the study research questions. This chapter also described data collection methods, participant selection and ethical processes. Think aloud (TA), clinical reasoning tests and observations were used to investigate CDM among undergraduate nursing students. A semi-structured interview was used to explore the usefulness of this experience to the participants' clinical practice. Finally, a number of validation strategies were used to ensure the validity of the study findings.

Chapter five, Data Analysis, describes data analysis technique used to answer the study questions. The study used four methods of data analysis in two distinct phases:

i. Statistical analysis including descriptive and inferential statistics of the Health Science Reasoning Test findings and comparing these findings to think-aloud results.

ii. How Verbal Protocol Analysis (VPA) and Problem Behaviour Graph (PBG) analysis of think-aloud data was used to identify cognitive operators, methods of reasoning and type of CDM
iii. Content analysis was used to identify the type of biases, the content of the task that includes types of used cues and accuracy of interpretation and selected actions. It also includes content analysis of the observational data.
iv. Thematic analysis of the one to one semi-structured interview in phase 2

Chapter six, Results of Phase 1, presents the findings of HSRT, the cognitive operators, clinical reasoning processes and type of CDM based on VPA from the TA and the content analysis from the observational data. It identifies the cognitive biases used by students that affected the quality of decision making. A comparison between the findings of TA is compared to the observational data as a validation technique and to add more depth to the findings. The HSRT score is then compared CR process and type of CDM to answer the study research questions.

Chapter seven, Results of Phase 2, identifies 5 themes about the usefulness of high fidelity simulation experience to students and how they perceive the benefits of simulation for their learning and developing self-awareness.

Chapter eight, Discussion, discusses the research findings and how they relate to the wider literature in healthcare practice and education. It presents a model for clinical decision making that could be integrated into nursing education and simulation practice. It also provides a debiasing tool to enhance the quality of CDM that requires further research and validation.

Chapter nine, Conclusion, addresses the study strengths and limitations and the implications of this study on nursing education and future research.

CHAPTER 2

CLINICAL DECISION MAKING: THEORETICAL PERSPECTIVES

2.1 Introduction

This chapter examines the literature on the theories of clinical decision-making (CDM) in the context of acute care settings. Few theories in cognitive and social psychology have emerged that draw some attention in the medical and nursing literature to explain and improve healthcare professionals' decision-making skills. The initial objective, therefore, was to examine the literature in order to build an idea about what is known and what needs further clarifications. The aims of this chapter were to:

1. Compare the relevant theories and models in decision-making.
2. Critically discuss the strength, weakness, the utility of different theories and the nursing research related to these theories.
3. Identify a theoretical framework for this study
4. Identify how the theoretical framework would inform the methodology in answering the study questions.

An appropriate research methodology should be utilised to examine how we make decisions in a simulated environment and to assess how to translate the learning into the real world of clinical practice. A clarification of what we mean by decision-making needs to be critically discussed to produce an operational definition for clinical decision making for this study. Part of the problem in teaching decision making is that there was no general agreement about the decision-making process. A variety of theoretical approaches exist that led to arrays of contrasting definitions that have been used in nursing research. These approaches need an examination to ensure they complement the aim of this research study and the suitability of the selected methodology.

The following sections will provide a detailed and critical analysis of the decision-making processes, theoretical approaches to decision making and features. It will integrate nursing literature in the discussion and assess any contradictory findings in the previous research and identify the best approach for this study to enhance students' decision-making skills.

2.2 Definition of clinical decision-making

A variety of terms referring to clinical decision-making (CDM) are used interchangeably in the literature, demonstrating confusion and lack of consensus. Many examples have been cited in the nursing literature including diagnostic reasoning (Carnevali et al, 1984), clinical judgment (Tanner, 2006), clinical reasoning, clinical decision making (Luker and Kenrick, 1992; Hoffman, 2007; Levett-Jones et al, 2009) and clinical problem-solving (Elstein, Schulman and Sprafka, 1978; Grobe, Drew and Fonteyn, 1991; Alexander, 1997). Decision making is considered a complicated process that is not clearly understood, perhaps due to the lack of clarity about the different theoretical approaches used to explain it. The nurse is required to be skilful in problem-solving, to develop the abilities to make decision and judgement and since all these variables are linked together in managing clinical situations, this also might have caused confusion about the clarity of these terms.

The ability to think critically is fundamental and is a prerequisite for good clinical decision making (Thompson and Dowding, 2009). Clinical reasoning is the process by which individuals make judgements and decisions. Judgement is defined as “an assessment between alternatives” and an output of the reasoning and decision-making process. A decision may be defined as a “choice between two or more discrete options” (Thompson et al, 2004). It has been suggested that decision-making is the ability to identify the patient problem and select the appropriate interventions in a process that consists of data gathering in the form of cues handling, evaluating data to diagnose a problem and evaluating alternatives to formulate a plan of action (White et al, 1992; Lauri et al, 2001). Shaban (2005) suggested that nurses make decisions based on their initial assessment of a clinical situation, using prediction to judge the impact of that decision. Their assessment is based on gathering and interpreting the clinical cue by processing the collected data in an analytic way or intuitive way. This approach has been referred to recently in the cognitive psychology and medicine as Dual Process Theory (DPT), a theory that has grown in popularity in recent years to explain clinical decision making (Croskerry, 2009a; Evans and Stanovich 2013a; Pirret, 2013).

Overall, clinical decision-making is a complex process, requiring more of the nurse than making defined choices between limited options. Nursing staff are required to make decisions with different foci (assessment, diagnosis, intervention and evaluation) (Thompson et al, 2004; Smith, Higgs and Ellis, 2008). CDM is dependent on how information is processed and reasoned to inform the value of different options. Therefore, CDM involves clinical reasoning, and judging different alternatives, then selecting and evaluating specific actions. Decision making is not affected by nurses’ cognitive processes alone but also by contextual factors, the complexity of tasks, how they give information clinically value based on their knowledge and experience, all of which will affect the nurses' ability to recognise and respond to salient aspects of the clinical situations (Harries and Harries, 2001; Thompson and Dowding, 2009; Smith, 2013).

2.3 Approaches to clinical decision-making

According to Bell, Raiffa and Tversky (1988) decision making theories can be classified into two main approaches; prescriptive (or descriptive) and normative. The normative approach is based on the rationalist paradigm and considers "what should people do". The normative theories in decision making have a strong theoretical foundation and are associated with logical, scientific and evidence-based decision informed by statistical analysis of large-scale experiments such the use of Bayesian hypothesis testing; this approach could be useful for minimising errors (Thompson, 2002). The prescriptive approach considers 'what people should or can do in practice', given that might not be perfect, so people need to be aware of their biases. The prescriptive theories are associated with guidelines, algorithms, and frameworks to enhance specific decision. The nursing process is considered as a prescriptive approach to guide problem-solving and decision making.

The last but not least is the descriptive approach that considers what people actually do or have done. It is associated with observing, describing and analysing how decisions are made. The Dreyfus and Dreyfus (1980) model for skills acquisition and "reflection in action" and "reflection on action" (Schon,1983) are good examples of the descriptive approach. Descriptive theories in decision making describe how people reach their decisions, so giving a focus on the process of making decisions. In contrast, normative theories assume that people are rational and follow logical, therefore focusing on how decisions should be made in an ideal world without considering how it is really made in the real world. Finally, the prescriptive theories try to enhance people's decisions, by examining how they actually make their decisions and attempt to help them (Standing, 2010).

2.4. Theories of clinical decision-making in nursing

Mitroff and Linstone (1993) suggested that it would be useful to utilise multiple perspectives of decision making that attempt to consider different concepts of a problem. The following sections discuss the key decision-making theories that have been commonly discussed in psychology, nursing and medical literature. This discussion supports how these theories will support the selection of appropriate research methods to answer this study research questions.

2.4.1. Social Judgement Theory (SJT)

This theory explains how individuals judge the messages they receive. People accept or reject a message based on their cognitive map and their own ego-involvement and whether the message falls within the individuals' latitude of acceptance. It predicts that individuals accept, or reject specific attitudes and messages and therefore it provides means to measure the accuracy and consistency of a person's judgments (Dowding and Thompson, 2003). This theory was based on the "Lens Model" proposed by Egon Brunswick, who suggested the need for examining people's perception and judgement while taking into account the probabilistic nature of the environment (Dowding and Thompson, 2009). Doherty and Kurz (1996) suggested that Brunswick was concerned about the ecological validity of cognitive research and the need to use a method that is representative of the real environment.

This model provides a representation of the relationship between the individual's judgment and his or her environment. Brunswick (cited in Harries and Harries, 2001) suggested the need to understand a range of an individual's judgements in a range of situations. His model had left and right sides; the left side represents the actual situation in the real world and this is known as the judgement ecology. This side correlated with clinical cues and each cue has a weight associated with ecology which can be analysed side captures the individuals weighing the importance of the presented cues to make their decision, this weighing could be statistically measured to an analyse individual's judgement. Therefore, the accuracy of the individual's judgement in a situation or context is dependent on the weight or the clinical value that the individual attaches to different cues in that situation (Dowding and Thompson, 2003). So, if the weighing or the clinical value was not accurately reflecting the real world, the judgement may not be accurate but if the given value of a cue was accurately reflecting the real world, then judgement is likely to be accurate.

The lens model has been used frequently in nursing research to evaluate nurses' judgements and to improve individual's judgements in a given task (Thompson and Dowding, 2009). Thompson et al (2005) applied the SJT in a small feasibility study that examined nurses' use of clinical information in critical care education using simulated case scenarios. Their findings demonstrated that nurses' use of information is not linear and the utility for judgement derived from clinical data is not distributed equally, therefore it showed variability in the choices of information that nurses use. It concurs with Thompson et al (2009) multiple centres study who used SJT and judgement analysis of 245 acute care nurses from four different countries and found variability in weightings given to information and nurses related information in non-linear ways that contributed little to decisional accuracy.

This could explain Hoffman's (2007) findings that expert critical care nurses were more effective compared to novice nurses in collecting more critical cues. Likewise, Lamond and Farrell (1998) used a convenience sample of 14 nurses and found that junior nurses utilised more non-specific cues compared to experienced nurses who used more specific but limited number of cues in solving a paper-based clinical problem of wound ulcer. It could be linked to the lack of recognising deteriorating patient as nurses may be using data that has no utility for the judgement in question (Cioffi, 2002), or they may be placing too much importance on a specific type of information and neglecting other important cues. Kydonaki et al (2016) found that inexperienced critical care nurses collected a larger number of cues but with reduced accuracy compared to experts in their approach to wean patients from mechanical ventilation. The lack of clinical experience among novices could affect the valuation or perception of key clinical signs and symptoms causing lack of recognition of patient condition or delayed intervention. However, these studies did not clearly refer to SJT, their findings can be related to the STJ about the importance of cue valuation. Similar results identified among nursing students in Walsh (2010), Endacott et al (2010) and Levett-Jones et al (2011a) who examined the clinical reasoning and decision making using high fidelity simulation, found that students frequently miss or misinterpret critical cues that affected the accuracy of solving the clinical problem. Levett-Jones et al (2011a) discussed the importance of collecting the "right cue" to effectively reach appropriate decision.

The usefulness of the social judgement theory in its focus on how people interpret clinical cues to reach judgments. Hursch and Todd (1964) argued the complexity of the ecology structure of the lens model and that the number of presented cues and the time available to make the judgement will dictate the type of information process required to perform the task successfully.

2.4.2. Information processing theory

Information process theory is an influential descriptive theory that has been used as the basis of many nursing studies (Newell and Simon, 1972; Nibbelink and Brewer, 2017). Newell and Simon (1972) explained that people's reasoning is bound by the limited information they have and their limited memory capacity. This theory considered the person's mind like a computer process that receives data entry from the sensory sources, then processes it against the stored knowledge or chunks and produces output.

The theory uses different operators to process the information and interact with memory as the nurse followed a series of cognitive steps by which the diagnosis can be reached and the appropriate interventions initiated (Martin, 1999). Newell and Simon (1972) discussed the concept of 'problem space', a mental presentation of a problem, created by the individual. The subject moves through the problem space by going through a series of knowledge states. Knowledge states are transformed by applying cognitive operators to move from one state of knowledge to the next until the goal is achieved. The cognitive operators and mental strategies represent each step of the individual's cognitive reasoning during the decision-making process, for example 'collect', 'review data', 'choose', 'relate data', 'interpret', 'diagnose', 'act' (Jones, 1988; Fonteyn, Kuipers and Grobe, 1993).

This theory has been frequently applied in the field of computer science. The researchers in this field suggested that the output from one cognitive process could become input for the next the cognitive process. A criticism of this theory is about the way decision is made in a linear manner, and that it presumed the nurse made a logical and rational analysis of a situation. However, this does not reflect the complexity, reality, ambiguity and uncertainty of clinical practice, especially in the dynamic clinical environment and when patients are clinically unwell (Currey and Botti 2003; Smith, 2013). Moreover, human performance is not based on programming, but on learning, which is a continuous process shaped by personal experience, culture and surrounding environment (Taylor, 2000).

Information processing in humans is believed to be an active process that attempts to understand the presented data, by organising and integrating the received cues into the individual's existing knowledge base. Therefore, the individual's interpretation and understanding of the data presented in a clinical situation would inform the decision-making and the direction regarding how the problem will be solved (Taylor, 2000). Hoffman (2007) used this approach as a theoretical framework to compare the decision-making process between four experienced and four novice critical care nurses in natural settings. The experienced nurses were more effective in processing clinical information and reaching accurate decisions.

2.4.2a. Hypothetico-deductive process

The research that utilised the information process has examined how the nurses make decisions and suggested that the reasoning process goes through a number of stages. Elstein, Schulman and Sprafka (1978) explain the stages as cue acquisitions, hypothesis generation, cue interpretation and hypothesis evaluation, and this process is called the hypothetico-deductive process. Both Carnevali et al (1984) expanded on those stages to seven stages and Tanner et al (1987) suggested five stages in nursing (Table 2.1). Lee, Chan and Philips (2006) defined it as an "active process of information processing in which a series of clinical judgements are made during and after data collection, culminating in informal judgements or formal diagnosis" (p.58). Zunkel et al (2004) provided us with a similar definition that is based on data processing and considered it as a dynamic process that is driven by clinical hypothesis. This type of inference is called backwards reasoning or hypothesis-driven reasoning. The forward reasoning or data-driven hypothesis occurs where information is gathered and cues are collected trigger a hypothesis (Jones, 1988; Hoffman, 2007).

Many researchers in nursing applied a range of cognitive operators that matched the hypothetico-deductive process as described in the Table below (Table 2.1). These studies have explorative designs that used concurrent or retrospective think aloud or self-reported approaches as data collection methods and generally used a small sample size. Many of these studies compared between novice and expert (Hoffman, 2007) or mainly explored how experts' process information and make decisions (Fonteyn, Kuiper and Grobe, 1993; Simmons et al, 2003; Funkesson, Anbacken and Ek, 2007; Han et al, 2007). Many of these studies either used paper-based simulated scenarios (Jones, 1989; Fonteyn and Fisher, 1995; Lamond, Crow and Chase, 1996; Greenwood and King, 1995; Higuchi and Donald, 2002) or explored CDM in naturally settings (Hoffman, Aitken and Duffield, 2009).

Some of these studies found novice nurses predominantly used backward reasoning compared to experts who mainly used forward reasoning (Lamond, Crow and Chase, 1996; Hoffman, 2007). However, other studies produced contradictory results where experts used backward reasoning more and students regularly used forward reasoning. Twycross and Polws (2006) examined clinical decision making of expert paediatric nurses and found that the participants mainly used backward reasoning and similar findings were reported among senior physiotherapists (Thackray and Roberts, 2017). Johnsen, Slettebo and Fossum (2016) investigated the reasoning approaches used by eight novice community nurses and found that nurses used both inductive and deductive reasoning equally. Arocha, Patel and Patel (1993) and Pottier et al (2010) found that medical students mainly used forward reasoning during problem solving compared to more experienced colleagues. Perhaps the use of different types of reasoning does not only depend on the level of experience and that other factors may affect this process.

In most of these studies, cue acquisition was the most frequently used stage in the clinical reasoning process by both experienced and novice nurses. Cue interpretation came the second and hypothesis generation and evaluation had very low frequency (Jones, 1989; Greenwood and King, 1995; Lamond, Crow and Chase, 1996; Higuchi and Donald, 2002). Aitken (2003) explored decision making of eight expert critical care nurses in natural settings using concurrent think aloud and found that they used a limited number of cues to generate hypotheses and a gambling strategy for their decision making. Another similar study conducted by Aitken et al (2011) in natural setting found that expert critical care nurses focused on patient assessment and cue acquisition. Overall, there is limited studies that explored how students process information and learn how to reason. Most of the models of clinical reasoning in nursing are based on nursing literature that explored experienced nurses' clinical reasoning (Tanner, 2006; Levett-Jones et al, 2009).

Table 2.1. Hypothetico-deductive process and associated cognitive operators

Hypothetico-deductive process		
Elstein et al., 1978	Carnevali et al., 1984	Tanner et al., 1987
• Cue acquisition • Hypothesis generation • Cue interpretation • Hypothesis evaluation	• Exposure to pre-encounter data • Entry to the data search field • Coalescing of cues into clusters • Activating possible diagnostic explanations • Hypothesis and search of the data field • Testing diagnostic hypothesis for the goodness of fit • Diagnosis	• Cue acquisition • Hypothesis generation • Interpretation • Explanation • Evaluation

Cognitive operators associated with the hypothetico-deductive process	
Hypothetico-deductive	**Cognitive operators**
Cue acquisition	plan, collect, study, read, observe, describe, plan
Cue interpretation	explain, review data, relate data, interpret data, reason, rationale, infer
Hypothesis generation	select, conclude, diagnose, choose, goal
Cue acquisition	evaluate, confirm information, confirmation, verify, verification,

2.4.3. The intuitive model of decision making

Intuition has been frequently cited in several nursing studies as nurses relying on their "gut feeling" or intuitiveness as a method of clinical judgment. It is often related to nurse expert based on Dreyfus and Dreyfus (1980) model and Benner (1984) work; Benner developed her model using phenomenology and she focused on the clinical practitioners that attracted the attention to her model. Benner's research has a strong theoretical foundation and she used Kuhn and Heidegger (cited in Cash, 1995) as an authority to create a distinction between clinical and theoretical knowledge and based her work on Dreyfus and Dreyfus (1980) stages of skills acquisition (Table 2.2). Intuition is considered as a way to guide nurses' practice as per Carper (1978) who suggested that nurses guide their clinical practice by "ways of knowing", which may come from different perspectives such as intuition. It is "understanding without a rationale" and it is a "trait of an expert nurse" (Benner and Tanner 1987 p23). In a literature review by Rew and Barrow (2007), nurses reported that intuition is a salient to expert and should be carefully taught to nursing students.

Table 2.2. Novice to expert

Stage	Description
Novice	No or limited experience with real situations, context-free. The nursing student following instructions and guidance
Advanced beginner	Have experience with actual real situations and start to develop understanding the context with some guidance from mentors. Newly graduate students
Competent	Nurse who has been on the job for more than 2 years. Able to recognise patterns from clinical situations and cope with complexity but lacks speed and flexibility.
Proficient	Able to see the situational as a whole, predicts typical progression of the situation. Adjusts plan to respond to different situations
Expert	They do not rely on rules, they have an intuitive grasp of the situation. Focuses on the most important aspect of a situation and articulates the most important actions.
	Source: Dreyfus and Dreyfus (1980) and Benner (1982)

Cioffi (1997) noted that nurses described intuition as a form of knowing that is beneath consciousness, originates from experience and depends on the availability, memory recall with a sense of appropriateness in a specific clinical situation. Hodgkinson, Langan-Fox, & Sadler-Smith (2008) described it as an "affectively charged judgment " (page. 4). Intuition is not always considered a "legitimate type of knowledge", as it lacks evidence and rationality. In a phenomenological study by Hassani et al (2016), experienced critical care nurses reported that the use of intuition in their decision led to appropriate actions, which convinced them to follow their intuition that is more based on their previous experience. Many nursing studies support the accuracy of intuitive judgment (Price et al, 2017) and the credibility of intuitive knowing as based on reflection and experience. However, there is a question about the validity of such judgment that relies on associations, participant's recall of similar incidents and a form of knowledge that cannot be measured in an objective way (Croskerry, 2009a; Kahneman and Klein, 2009). Hammond et al (1967) viewed it as uncertain and inconsistent with rules, lacking rationality and not explicit. Moreover, people tend to recall those incidents where decision-making was successful and are not good at remembering those incidents when intuition fails.

Smith (2009) found that novice nurses, including nursing students, used intuition in clinical situations showing that intuition is a legitimate form of knowing instead of just an expert trait. Smith (2009) suggested the need to explore intuition with the assumption that experience might not be essential. Johansen and O'Brien (2015) discussed the importance of the role of the emotional and physiological feelings as well as theoretical knowledge in making decisions and felt that the heart and brain are involved in decision-making. Dreyfus and Dreyfus (1986) outlined six key aspects of intuition as; pattern recognition, similarity recognition, common sense understanding, skilled know-how, sense of salience and deliberative rationality.

Melin-Johansson, Palmqvist and Ronnberg (2017) found that intuition is based on clinical knowledge and experience and should be used to support decision-making to enhance the quality and safety of patient care. However, Cioffi (2002) concluded that intuition works well in making decisions in situations with a low level of uncertainty and complexity. Kosowski and Roberts (2003) used interpretive phenomenological study in the USA of 10 novice nurses, found they dominantly used intuition, and gut feeling. Likewise, Offredy et al (2008) carried a study in the UK exploring prescribing knowledge of 25 participants and found intuition remains the main type of decision-making. The study population was mainly registered nurses with two at nurse practitioner level and the study has small sample size with limited generalisability. Thompson et al (2009) found that intuition can lead to poor diagnosis and may put patients at risk. They used judgement analysis of 245 nurse and showed that nurses predominately used intuitive reasoning for decision-making and made a range of errors. This suggests that intuition might not always lead to optimal and accurate judgement.

Thompson and Dowding (2009) suggested that researchers fail to differentiate between intuition as a form of knowledge or as a way of thinking, and if it considered a type of knowledge then caution needs to be taken about the nature of this knowledge and how it inform our decisions. They discussed the importance of theoretical and scientific knowledge to inform evidence-based, safe and effective practice.

2.4.3a. Pattern recognition

Pattern recognition is associated with an experienced clinician, and the use of intuition type of CDM. Botti and Reeve (2003) suggested that experts effectively distinguish between critical and relevant cues from the irrelevant, act on patterns of information and produce fast and more accurate decisions. They are more likely to use pattern recognition and use meaningful patterns of information due to their experience. Harjai and Tiwari (2009) described it as the individual ability to locate relevant parts of the knowledge stored, using similarity recognition and use this to develop pattern recognition (p. 306). The process of making a judgement based on a few critical cues (Offredy, 1998), matching subtle patterns, relationships among cues and changes in patient condition that the nurse is familiar with. This concurs with Tanner's (2006) model of clinical judgement who put an emphasis on the initial grasp of a situation by noticing a typical presentation of a clinical situation using reasoning patterns.

Benner and Tanner (1987) described it as common-sense understanding, a sense of salience and skilled of know- how. Nurses have described it as a sense that something has changed in their patient's condition, something is different and wrong (Benner and Tanner 1987). It has been described as automatically retrieving data from well-structured blocks of knowledge (Offredy, 1998), and therefore instantaneously realising the problem within seconds of encountering a patient. Pattern recognition process is described as taking shortcuts or maxims to reduce cognitive load (Sandhu et al, 2006). These shortcuts use rules of thumb or heuristics based on individuals' experience. Therefore, it is subjected to bias and potential errors (Kahneman, 2011; Croskerry, Singhal and Mamede, 2012).

Coderre et al., (2003) suggested that pattern recognition requires extensive expertise to develop and might not be available for the novice. However, in their study they found novice medical students using pattern recognition in 13% of their decisions. Manias, Aitken and Dunning (2004) have similar findings but the use of pattern recognition was more prevalent among new graduate nursing. They conducted an observational study of 12 recently graduated nursing staff with 8-10 months of clinical experience post-graduation and found that they used the hypothetico-deductive approach as the main approach to decision making with 25 decisions following this pathway (68%), followed by the use of pattern recognition with 10 decisions (27%) and intuition was identified only twice (5.4%). Recently, many researchers found both novice and expert used pattern recognition (Pelaccia, Klang and Petersson, 2011).

They found that novices used familiar but irrelevant cues to inform the pattern-formation and decision-making and the experts reach quicker decisions and use more relevant data.
In the medical literature, it was found that practitioners used both hypothetico-deductive reasoning and pattern recognition concurrently (Piele, 2004). Hoffman (2007) found that both novice and expert critical care nurses used pattern recognition but experts used it more frequently. Similar findings among primary care nurse practitioners (Burman et al, 2002). The advantage of the interpretive approach in natural settings is the exploration of CDM in the real dynamic world with high ecological validity. However, there is a limitation in the data collection methods that could be used in a complex clinical environment.

Walsh (2010) carried out a quasi-experimental study that investigated the impact of simulation and pattern recognition on 54 nursing students' clinical reasoning skills. They found that the typical simulation and pattern simulation had improved pattern recognition and clinical reasoning. Walsh (2010) emphasised the positive impact of a theory-based simulation designed and debriefing on students' clinical reasoning skills. Offredy (1998) found pattern recognition is associated with analytical and intuitive approaches to decision making. Klein (2008) considered that pattern recognition requires a mixture between analysis and intuition.

2.4.4. Cognitive Continuum Theory (CCT)

Hammond et al (1967) developed a theory called the Cognitive Continuum Theory (CCT); a descriptive theory of the cognitive psychology that illustrates how decision and judgement situations or tasks relate to cognition. Hammond's theory recognised that different challenges require different approaches to thinking. Hammond confirmed that a decision and judgement is a joint function of task properties and cognitive processes (Hammond, 2000). Hammond offer an explanation about the relationship between the concepts of cognition and task and the mode of cognition used is based on the nature of the task. He suggested that decision-making has six broad modes based on a continuum between cognition and judgement task structure.

According to CCT, the task structure ranges from well to ill-structured and the cognitive continuum ranges from intuition to analysis. The more ill-structured the task is, the more intuition induced decision is made, and the more well-structured the task the more analytical induced decision is made (Hammond, 1996). The cognitive approaches at one end are the most intuitive mode where individual opinion is justified by their clinical experience and authority, while at the other end is the most analytical mode. Different tasks dictate or trigger the use of different modes of decision making ranging from intuition to analysis (Lauri et al, 2001). Bjork and Hamilton (2011) conducted a cross-sectional survey of 2095 nurses in four hospital in Norway using a 24-items Nursing Decision Making Instrument (NDM) scale and reported that nurses mainly use quasi-rationale approach to decision making. However, they used a self- report instrument, developed by Lauri et al (2001) based on CCT, that may have a low validity to differentiate between the different styles of reasoning as correlation coefficients are not reported (Hutchins and Glenn, 2011).

O'Neill and Dluhy (1997) proposed a cognitive maturation framework that describes how nurses develop critical thinking from using rule-based reasoning as students to mainly using pure intuitive reasoning as experienced nurse. Cioffi (2000) conducted an explorative descriptive study in emergency department and found nurses referring to their gut feeling and previous experience as a way to deal with complex clinical situations. However, caution should be taken as individuals often recall those incidents where decisions had positive outcomes and this could affect the quality of decision-making. Furthermore, evidence from cognitive psychology and nursing research suggests that if intuition is used in a more complex situation, the more likelihood for the person to rely on heuristics (Cioffi, 1997) and for errors to occur (Evans and Stanovich, 2013b). Evans and Stanovich (2013b) also reported that when participants are given a novel and complex task they tend to use the analytical approach of reasoning to solve the task not necessary rely on their intuition reasoning.

2.4.5. <u>The dual process theory (DPT)</u>

A variety of paradigms exist to explain the decision making itself and these theories tend to focus on either the analytical or the intuitive approaches as separate methods to CDM. In the last two decades, recent developments in cognitive psychology research have seen the emergence and acceptance of a DPT that rejects the dichotomous view of analysis and intuition. A theory that considered the experienced and novice practitioners jointly uses the non-analytical (type 1) and the analytical (type 2) approaches to CDM (Croskerry, 2009a; Evans and Stanovich, 2013b; Osman, 2013). The differences between the CCT and DPT is in the CCT assumption that the analytical and non-analytical approaches are different systems and both types of CDM are placed on a different side of a cognition continuum. In contrast, the DPT suggested that the two types are parallel and there is continuous switch between the two, so a nurse may use both types to solve the same task.

The DPT suggests that clinical decision-making is achieved through a combination of two types of thinking with distinctive features (Croskerry and Nimmo, 2011). The movement is less linear as both types can override each other at different stages in the decision-making process, which could better reflects the complexity of CDM process. There are many different names that have been used in the literature to describe these types such as modes or systems of thinking (Evans, 2008). Many authors initially believed that the existence of two systems (system 1 and 2) operate in an independent and interactive manner and together they contribute to the individual behaviour (Kahneman and Frederick, 2002). However, there is a recent agreement that there is one system (Figure 2.1) with two different types of decision making including type 1 that uses experiential information and pattern recognition in the decision-making process and type 2 refers to as an analytical approach to decision making (Croskerry and Nimmo, 2011; Kahneman, 2011; Evans and Stanovich 2013a, 2013b; Osman, 2013).

These types of CDM and reasoning have been extensively studied in the cognitive psychology research and recently received interest in the medical and nursing field with an increased focused on patients' safety and clinical errors (Croskerry, 2009a; Dowding et al, 2011; Pirret, 2013). DPT could be applied to potentially demonstrate how theory can be used to improve real-world decision making and it could be used as an eclectic and teachable approach because it considered both types of decision making, the analytical and intuitive (Croskerry, 2009a).

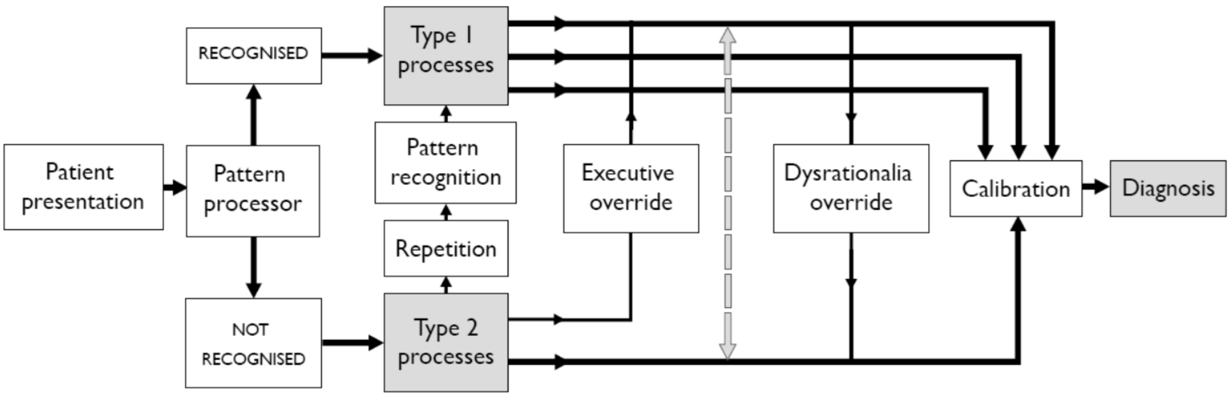

Figure 2.1. The Dual process theory

Source: Croskerry and Nimmo, 2011

The DPT model above flows from left to right. The patients or the clinical situation initially present with signs and symptoms, cues, of a particular clinical situation to the observer. If these are immediately recognised by the observer, it is highly likely that type 1 will engage in a very fast process to make decisions about the presented situation. Whereas, if it was not immediately recognised, type 2 will engage in a slow and more systematic process to make decisions (Croskerry, 2009a). Repetitive processing using type 2 leads to pattern formation that gets integrated into the memory structure and for future retrieval by type 1 using pattern recognition.

Type 2 can override type 1 using executive control or metacognition; when the person finds that type1 might be mistaken or an issue needs further exploration. Type 1 also can override type 2 despite being aware of the best option to lead to irrational actions. Croskerry (2009a) suggest that there is a tendency to assume type 1 as a default mode in an effort to spare cognitive effort. The dotted line suggests that there is a continuous switch function between the two types. The calibration refers to a feedback mechanism that assesses the effectiveness of the actions to the resolution of the patient condition, in a situation when a patient deteriorates further the practitioner thinking could switch to a different type of CDM; commonly to type 2 (Croskerry and Nimmo, 2011).

Pirret (2013) used a mixed method approach to compare 30 nurse practitioners to 16 medical registrars. Pirret (2013) considered system 1 and 2 and used CCT as theoretical framework, nurses diagnostic reasoning reflected analytical- intuitive style and had a mean score of 10.30 for correct diagnosis compared to registrars who mainly used analytical style with mean score of 10.88, both used styles of decision making and the mean score of correct diagnosis were not statistically significant. The researcher briefly discussed the DPT but the identification of the different types of CDM in her study was based on CCT and without considerations of the key differences between the two types of decision that have been clarified recently.

Dual-process theories in both cognitive and social psychology discussed many features that described different types of decision making. This led to criticism about the multiple and vague definitions of DPT clustered attributes, the lack of alignment between the features of the types of decision making and the lack of convincing evidence about dual theory and the use of two systems (Osman, 2004). Evans and Stanovich (2013a) detailed this critical criticism and clarified the debated issues by articulating the defining features and the typical correlates of each type of decision making. This critical discussion of the types of thinking detailed in Evans and Stanovich (2013b) and Osman (2013) and the confirmation by neurological studies provided about the activation of different regions in the brain with a different type of decision making (Lieberman, 2003; Banks and Hope, 2014). This added more clarity about DPT and led to an agreement between the experts in this field.

The DPT provides a pluralistic and integrated approach that considered both types of CDM that other theories in CDM do not offer. DPT is also based on consensus of experts in the field of cognitive psychology with neurological evidence to support it. Therefore, it is an appropriate theoretical framework to examine nursing CDM and may lead to more depth of understanding of CDM in nursing for both expert and novice. For that reason, it has been selected as a theoretical framework for this study.

There are key defining features, key correlating features and other associated features for each type (see Table 2.3). The key defining features are the core identifiers that differentiate between the two types. The correlating features are commonly seen in a particular type but the associated features are incidental correlation and may not necessarily co-occur with the defining features (Rolison et al, 2012).

Table 2.3. Clinical decision-making types and features

	Type 1 of CDM	Type 2 of CDM
Key (core) defining features	• Autonomous processing, high automaticity (automatic) • Doesn't require working memory	• Hypothetico-deductive thinking, cognitive decoupling, deliberative • Load heavily on working memory
Key correlated features	• Fast execution and processing • High capacity • Reflexive	• Slow execution processing • Low capacity • Reflective actions
Typical associated features	• Reasoning style: heuristic, associative, intuitive • Low awareness (unconscious or preconscious), lack attention • Highly depended on the context) • Implicit or tacit • Effortless decision • The default thinking, prototypical • Prone to errors and bias • Affective(emotional) valence is common	• Reasoning style: analytical, normative • High awareness (conscious) • Low automaticity (controlled) • Low dependency on context • Explicit and deliberate • Effortful decision and sequential • Inhibitory thinking • Less prone to errors and bias • Affective(emotional) valence is rare
Sources: (Evans, 2008; Evans and Stanovich 2013b; Osman, 2013)		

2.5. Features that differentiate between the types of CDM

The key features that differentiate between type 1 and 2 are; the level of automaticity, consciousness, the usage of working and mental decoupling (Evans and Stanovich, 2013b). It is worth briefly discussing these key features to comprehend how they could be used to support the study design and data analysis.

2.5.1. Automaticity of the decision-making

The automaticity is a key feature and core identifier of type 1 CDM. This describes an autonomous process in making decisions that do not even engage with the working memory (Rolison et al, 2012). LaBerge and Samuel (1974) considered automaticity as the ability to process information while attention is directed elsewhere. Bargh and Furgenson (2000) suggested an automatic process needed to satisfy any of the following criteria; being effortless, occurring without awareness or occurs without explicit intentions. Chaiken and Trope (1999) described the automatic processes have been automated from those were once conscious and more controlled via type 2. Observing the duration of time that participants take for each decision they make, might give an indication of the type of decisions they use at different points in their performance or the immediate action after perception of information.

2.5.2 Consciousness in the decision-making

Consciousness is a distinctive feature that could differentiate whether the decision is processed using type 1 or 2. Type 2 CDM is a conscious and controlled process whereas type 1 is an unconscious or lack of control. A central principle of the DPT theory is that behaviour is determined by the interplay of automatic and controlled processes. Sigmund Freud and colleagues introduced the idea of the unconscious mind that motivates human behaviour early in Twentieth century suggesting that the conscious mind is prone to self-deception (Evans, 2008). Behaviourists such as Watson, Hull and Skinner focused on how associative and instrumental learning could occur without consciousness (Evans, 2008). More recently the computational theory of mind describes the brain's ability to conduct complex information processing without conscious awareness and they called this form of processing "cognitive unconscious" (Uleman, 2005). Conscious thinking requires access to a central working memory system that has a limited capacity and our awareness at a given time is represented in this working memory, through which conscious thinking flows in a linear and sequential manner (Evans, 2008).

2.5.3 <u>The role of working memory in decision-making</u>

Evans and Stanovich (2013b) considered the use of working memory as another defining feature for type 2 in the dual process theory which is in contrast to type 1 that does not use the working memory. Working memory can be defined as the cognitive system or mechanism capability to temporarily retain and manipulate a small amount of information in an active state for use in ongoing cognitive tasks during the performance (Baddeley, 2002). Feldman-Barret, Tugade and Engle (2004) operationally defined the working memory capacity (WMC) as the number of items that can be recalled during a complex working memory task. Baddeley (2002) suggested that the working memory system is not only responsible for the simultaneous storage and processing of information but also has the mechanism for cognitive control and attention; this was called the 'central executive'.

Engle (2002) suggested that the most important aspect in the working memory is cognitive and attention control, especially in the context of complex situations and competing demands. This may reflect that individuals have differences in their working memory capacity and attention control. Engle (2002) linked the capacity of working memory and ability to individual performance and found that high cognition skills such as reasoning and comprehension were significantly better with those who had higher WMC by assessing the individual's attention span and attention control abilities.

Working memory processes receive information in a sequential way to recall prior knowledge and, as discussed above, it has a role in temporary storage and manipulation of data while performing the task. This is a slow and time-consuming activity, which can be linked more to type 2 of decision making. On the other hand, type 1 does not utilise the working memory, which reduces the time required for information processing, so this would agree that this type is fast and impulsive compared to type 2. If the working memory gets overloaded this would negatively affect cue recall and data integration.

2.5.4. <u>The role of mental decoupling in decision making</u>

Mental decoupling processes enable individuals to distance themselves from their own tendencies to represent the world so that they can be reflected on and potentially improved (Evans and Stanovich, 2013a). It supports one of the most important mental functions: hypothetico- deductive thinking, where reasoning involves representing possible states of the world rather than the actual state of affairs. It was linked to the attention control in Baddeley and Hitch (1974). This cognitive property produces the ability to override type 1 processes by interrupting its input and execute a new process; a functionality is well recognised as a defining feature of type 2 (Croskerry and Nimmo, 2011).

While the interruption is caused by the reflective mind, the newly executed process will take place within the algorithmic mind. The reflective and algorithmic mind can be different based on the measurement of an individual's cognitive ability and thinking dispositions. The cognitive ability is concerned with the capacity of the algorithmic mind to sustain the inhibitory and stimulatory representation, while the thinking dispositions reflect the different state of reflective mind and higher ordered thinking such as information processing before making decisions (Evans and Stanovich, 2013a). This indicates the importance of reflection and self-evaluation after any experience or educational activity to support the development of attention control and enhance the cognitive decoupling ability of the learners.

2.6. Factors that affect the clinical decision-making process

Oliver and Butler (2004) suggested that the influence of the contextual variables on the nursing decision is dependent on nurses' ability to evaluate the importance and relevance of these factors. Rashotte and Carnevale (2004) also suggested that clinical decision-making is not an exclusively cognitive function but includes significant social, psychological, cultural and contextual influences. Nurses' decision can be influenced by work practices, nurse-patient – related aspect of care and environmental factors. Smith (2013) used a grounded theory research design to explore the CDM in realistic acute care settings produced similar themes but also considered the importance of culture, complexity and uncertainty of the environment on nurses' decisions. Currey and Botti (2003) confirmed that there are three broad factors that affect decision-making; factors associated with decision makers, with the task with the clinical environment. These factors have been also discussed by many authors in the field of clinical decision making (Croskerry, 2009a; Dowding, et al, 2011; Smith, 2013; Johansen and O'Brien, 2015). They are linked to theories of decision-making and how they influence the decision-making process. The following discussion summarises key factors (Figure 2.2).

2.6.1. <u>Factors related to the decision maker</u>

The person's level of knowledge, experience, critical thinking, the dominant type of decision they usually use, their biases and situational awareness are some of the factors that have been identified to affect the decision maker (Thompson et al, 2004; Croskerry, 2009a; Andersson, Klang, Petersson, 2012; Johansen and O'Brien, 2015). The following discussion considered the key factors in more details.

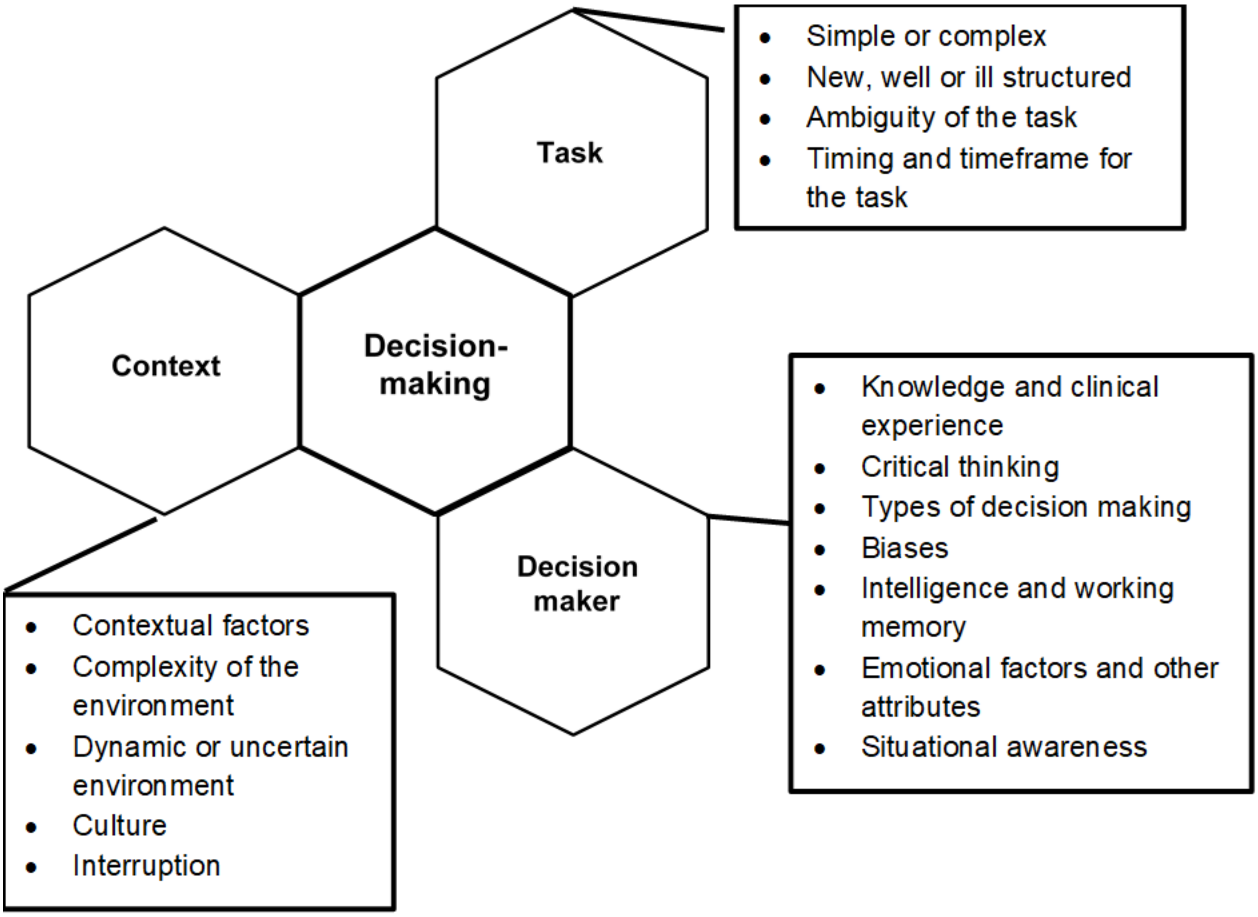

Figure 2.2. Key factors that influence the clinical decision-making process

2.6.1a. Decision maker's knowledge and experience

The appropriate level of knowledge and the accurate information are essentials for effective judgement and clinical decision making and therefore safe and effective practice (Thompson et al, 2004). A strong knowledge base in conjunction with experience results in more accurate information processing, cue weighting and diagnostic accuracy (Thompson et al, 2005; Coskerry, 2009a). It is important to understand the type and sources of knowledge that the nurses have and ensure they have received or been trained to base their decision on accurate information.

Several authors have attempted to define or discuss what constitutes nursing knowledge and what sort of knowledge nurses have to deliver nursing care. Historically nursing knowledge was described as knowing what patients need before they ask and knowing of the heart (Johansen and O'Brien, 2015). Benner (1984) suggested nursing knowledge is "embedded in practice". In Benner's model, the focus was on tacit knowledge, the intuitive knowing, with lack of discussion about theoretical and procedural knowledge. Dreyfus and Dreyfus (1986) was the first model emphasising the concept of informal learning and the development of tacit knowledge that comes in three forms; situational understanding through experience, then becoming more intuitive decision-maker by using pattern recognition and finally the development of routine procedures through competency. Eraut (1994) discussed the importance of tacit knowledge in developing situational understanding and considered it as the most important aspect for the professional to develop. Eruat (1994) described the types of learning into trajectories to address all aspects of knowledge relevant for professional work such: task performance, ability to learn from experience, academic knowledge, decision making and judgement. He emphasised on the importance of developing modes of decision making for different situations and the ability to develop self-evaluation and meta-cognition.

Nursing knowledge is multifaceted, as nurses often use knowledge from biological science, social science and psychology to ensure holistic care is delivered to their patients, which makes it even more difficult to precisely define exactly what nursing knowledge is. It is also important to differentiate between theoretical, “know” and “know that”, from practical or clinical knowledge “know how” (Miller, 1995; Thompson, 1999). The art of nursing is the practical knowledge that is gained via personal experience, socialisation or experiential learning (Eraut, 1994), it is embedded and contextualised knowledge that differentiates between the novice and expert. The theoretical knowledge that is acquired via research is considered the science of nursing, the decontextualised nature of nursing knowledge. The focus of nursing research in the field of CDM has been on examining the role of practical knowledge and intuition. More focus is needed about the importance of theoretical knowledge role in the decision-making process. Both types of knowledge are equally important to produce an evidence-based and holistic practice that is based on sound knowledge, scientific rationale and considers the patient as a holistic being (Thompson et al, 2004).

Elstein, Schulman and Sprafka (1978) also described the contextualised knowledge when he referred to expert decision makers as using a domain-specific knowledge. The organisation of knowledge in this way, allows them to be more efficient in recall and retrieval, this would enhance their abilities to match and recognise patterns and subsequently enhance their anticipation, forward planning and reasoning skills (Thompson and Dowding, 2003). Many nursing scholars found that experienced nurses have more knowledge than the novice does and this knowledge is refined through clinical practice (Lauri et al, 2001; Whyte, Ward and Eccles, 2009)

In nursing research, the theoretical knowledge is often assumed rather than measured before a nursing inquiry, criterion judgements are not usually established and accuracy of decisions described are not usually measured. Theoretical knowledge is considered essential for appropriate observation, accurate interpretation and effective weighting of clinical cues in the presented clinical situation (Banning, 2008). The ability to assign significant value to cues in a decision-making task represents a combination between the decision maker's theoretical knowledge relative to the task, experience or familiarity with the task, personal belief and the context within which the decision must be made (Whyte, Ward and Eccles, 2009). They found that amongst 22 critical care nurses in a simulated task, experts have superior knowledge to inexperienced nurses about clinical symptoms.

Thompson et al (2009) found that nurses do not make the right judgement of a given situation, even when they all receive the same clinical data. The relative values assigned to cues by nurses are variable with a tendency to rely on intuition. Thompson (2002) suggested that heuristics and experiential knowledge are important but not a sufficient basis for clinical decision-making. Nursing knowledge is becoming very complex and is continuously evolving so nurses need to ensure that they are regularly evaluating their theoretical and clinical knowledge through scientific inquiry and by the reflection in and on their clinical experience.

2.6.1b. Decision maker's critical thinking

Critical thinking is a fundamental component of developing clinical reasoning abilities and it is the foundation for sound clinical decision making in nursing practice. Many scholars considered critical thinking as an essential component of competent nursing practice (Walsh, 2010). According to Paul (1984), "without the ability to reason dialectically, individuals are intellectually, emotionally, and morally incomplete" (p. 4). Socrates questioning was a learner-centred approach that aimed to improve learners' thinking by challenging their thoughts. Critical thinking is linked to John Dewey's work on experiential learning and reflection that focused on learning the process and how to develop critical thinking abilities. Dewey (1933) defined critical thinking as "reflective thought" to suspend judgment, maintain a healthy scepticism, and exercise an open mind. Dewey's definition suggests that critical thinking has both an intellectual and an emotional component.

Watson and Glaser (1980) developed the Watson-Glaser Critical Thinking Appraisal (WGCTA) as a generic test to measure critical thinking abilities and this has been used in nursing literature. Brookfield (1987) thought about critical thinking as a process rather than an outcome that involves individuals recognising the assumptions that underlie beliefs and behaviours and then justify their actions or ideas and attempts to judge the rationality of their justification. They also considered four key components of critical thinking: the ability to identify and challenge assumptions, the importance of context, exploring alternatives and scepticism through reflection.

The American Philosophical Association chaired by Facione defined critical thinking as 'purposeful, self-regulatory judgement' that uses cognitive tools such as interpretation, analysis, evaluation, inference, and explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations on which judgement is based (Facione, 1990). Based on this definition Facione, Facione and Sandchez (1994) developed the California Critical Thinking Skills Test (CCTST) to measure critical thinking abilities and the California Critical Thinking Disposition Inventory (CCTDI) as a method to measure clinical judgement. Both tests are widely used in nursing research that examined critical thinking. These measures are generic and not field specific and recently the same group of researchers have developed the Health Sciences Reasoning Test (HSRT), which is more specific to healthcare disciplines that measure concepts of critical thinking and clinical reasoning (Insight Assessment, 2016).

In nursing, there is a couple of definitions noted for critical thinking, which slightly differ. Bittner and Tobin (1998) explained critical thinking as being "influenced by knowledge and experience, using strategies such as reflective thinking as a part of learning to identify the issues and opportunities, and holistically synthesise the information in nursing practice" (p 268). The National League for Nursing Accreditation Commission (NLNAC) defined critical thinking as: "the deliberate nonlinear process of collecting, interpreting, analysing, drawing conclusions, presenting, and evaluating information that is both factually and belief based (NLNAC, 2004). Critical thinking is considered as the induction phase for clinical reasoning and decision making where the information is processed and analysed, where a transaction between the environment, memory and the cognitive processes to form a meaning until the nature of the problem is known. It is the mental process where knowledge, experience, and situational information support a metacognitive processing to reach problem identification. The nurse's level of critical thinking will influence their clinical reasoning and decision-making processes.

2.6.1c. Decision maker's cognitive biases

Cognitive error are tendencies commonly used to process information by filtering it through individual's experience and beliefs. People develop these biases for many reasons, they are frequently a result of a system of heuristics processes that help the brain to process information quickly and reach a quick judgement (Kahneman, 2011). Although under conditions of complexity and uncertainty, heuristics can produce systematic cognitive errors (Elstein, 1999). Heuristics are learned through practice and from experiential learning as “rules of thumb”, heuristics have been described as less precise but practical, faster and adequate for the majority of the cases. When they succeed, they have been described as economical, resourceful and effective and when they fail, we refer to them as cognitive biases (Croskerry, 2002). Cognition participates in human behaviour; from performing a basic-skill task (e.g., giving an injection) to higher order rule-based task (e.g., performing resuscitation) to a more complex cognitive knowledge-based task (e.g., interpretation of data and making decisions) (Reason, 1990).

Cognitive errors could occur at any level or type of the tasks described above. They usually occur at the knowledge base due to the level of complexity required to handle the task. Cognitive biases have been described phenomenologically in a wide range of experimental studies (Tversky and Kahneman, 1974). Some cognitive biases appear very powerful and cause a negative impact on the clinical decision-making process. Biases have been found in longitudinal studies in medicine to cause an unintentional delay in diagnosing clinical conditions, wrong or missed identification, delay in referral or management, particularly in the emergency department and medical wards (Kachalia et al, 2007). The different types of decision-making (type 1 and 2) have different operating properties that expose them to biases in a different way. Most of the cognitive errors and biases are frequently occurring with type 1, in contrast, different errors occur with type 2 but infrequently and usually caused by lack of information or time constraints (Harbison, 2001).

Tversky and Kahneman (1974) described three frequently occurring biases in human decision-making; representativeness, availability and anchoring. Other researchers identified other commonly used errors (Elstein, 1999). In particular, Croskerry and her colleagues extensively reported about the use of bias in emergency medicine (Croskerry, 2002; Stanovich, 2009; Sinclair and Croskerry, 2010; Ely, Graber and Croskerry, 2011). More recently, Stiegler et al, (2012) identified the most common cognitive errors in anaesthesiology using Delphi method with experts and a survey of academic faculty to produce a catalogue which was then followed by an observational study of 32 junior medical staff during simulated airway emergencies. They identified nine different biases that affected the participants in acute care settings, which included the three biases described by Tversky and Kahneman (1974).

O'Neill (1994) examined the use of representativeness heuristic among 214 community nurses and compared the use of heuristics between novices and experts. They found that novices and experts frequently used representativeness to make judgements. O'Neill (1994) developed paper-based scenarios and used the survey to collect data that was used in later research. Similar findings in Cioffi and Markham (1997), who investigated the CDM of 30 midwives and explored the use of heuristics. Each midwife was given two paper-based simulated patient assessment situations with high and low complexity; uncomplicated labour and antepartum haemorrhage. There was an increased usage of heuristics particularly representativeness during a more complex situation with a statistical difference from the low complexity scenarios ($t\ (29) = -2.93$, $p<0.01$). The increased uncertainty due to the complexity of the clinical situation led the midwives to rely more on heuristic to limit the search for cues and reduce the situation complexity.

Ferrario (2003) investigated the use of representativeness among experienced and inexperienced nurses and recruited 217 nurses working in the emergency department. They used paper-based scenarios and found that both experienced and inexperienced nurses frequently applied representativeness. Similarly, Brannon and Carson (2003) also used a paper-based simulated scenario with 182 emergency nurses during a triage situation. They tested the association between the presented clinical and contextual information and the best diagnosis nurses make about the presented condition. Twenty-six percent of the nurses who managed scenario 1 and 27 % of the nurses who managed scenario 2 attributed the patients' symptoms to less serious diagnoses utilising representativeness.

Riva et al (2011) investigated the effect of anchoring as cognitive bias on clinicians' clinical judgement about pain. A relatively large sample size of 423 that included physicians, nursing staff, medical students and nursing students was considered from three different cities in Italy. The participants were asked to evaluate the severity of pain before and after knowing patient rating and observed if the first impression served as an anchor for the clinician's judgement after knowing the patient rating. The investigators used 16 vignettes featuring fictitious patients reporting a headache. They found that participants had a tendency to anchor their pain judgement on their first impression. Many nursing researchers have acknowledged the role of cognitive biases on the nursing decision-making (Mannion and Thompson, 2014) but nursing research in this field is limited and only focused on the classic biases.

There are more than 100 different cognitive and affective biases that have been identified in the literature, mainly in the field of psychology and recently the common biases that affect medical staff in emergency and anaesthesia have been examined (see Table 2.4) (Jenicek, Croskerry and Hitchcock, 2011). More nursing research is required about their effects on the quality of CDM in different simulated and clinical settings.

Table 2.4. Examples of common cognitive biases

Sources of cognitive error	**Examples**
Cognitive biases	Premature Closure
	Order effects
	Searching satisficing
	Confirmation bias
	Anchoring
	Overconfidence
	Availability
	Representativeness
Affective influences	Environmental irritation or interruption
	Sleep deprivation
	Stress
	Fatigue
Sources: adapted from	Croskerry 2002; 2003

2.6.2. The task and context of decision-making

Human beings have a tendency to contextualise information, to add meaning to the received information or maybe to conserve cognitive energy. The task and context are closely linked together and are considered as major constraints that could affect the decision-making process and the outcome of our decisions (Croskerry, 2009b). The context can influence our perception of information such as influencing the meaning, shape or size of the perceived data based on the context where they placed. One of the ways to understand the effect of context is what Swets, Tanner and Birdsall (1961) discussed in their Signal Detection Theory. It suggested that the context could be treated as the "background noise". To perceive data accurately, their actual meaning or to distinguish critical signals from background noise, we need to treat or exclude the context, to reduce the background noise as they may produce different meaning or reveal unrecognised data. The background noise in nursing could be caused by multiple variables such as the degree of overlap between clinical conditions, so if a situation is unambiguous, simple or certain, the background noise is minimal. This may increase the likelihood of making the right decision. Similarly, problems can occur if the nurse's decision is influenced by distracting cues from the patients, relatives and other healthcare professionals.

Context is described as the social nature of the clinical situation (Lewis, 1997). He created a model to describe task complexity as having two components; content and context. The task content referred to the clinical data required for the decision making such as patient behaviour, signs and symptoms. The context of the task referred to social and physical characteristics surrounding decision maker. Social characteristics such as other people like relatives, other health care providers and physical environment such climate, culture, setting or policies (Tanner, 1987). Mann et al (1997) identified some of the contextual factors as individual or client specific such as personality characteristics, stress, anxiety, decision-making style and ability to process information and this is more linked to the decision maker's factors discussed above. Goransson et al (2008) considered these factors as situation-specific such as the volume of patients, time, personal capacity, fear of missing a case.

An expert nurse is described as very experienced in particular clinical situations. Moreover, experts are considered more skilful in contextualising information, selecting valid cues and good in judging the relevance of the collected cue in particular context (Dreyfus and Dreyfus, 1986; Benner and Tanner, 1987). Novice nurses rely on a rules-based decision and the decision is context-free, in contrast, to the experts. Tversky and Simonson (2000) discussed the importance of context in making decisions in their Context Depended-Preference model, they suggested that individuals use the context to identify the most attractive choice over the values of the available choices or cues and the possibility of error of context-based decisions. Therefore, it would be important for nursing staff to refine their clinical experience through continuous reflective practice to reduce the risk of these errors.

The complexity of task increases the demand on the decision maker's information processing and affects the efficiency and effectiveness of the decision-making process (Lewis, 1997). Time pressure is found to constrain the decision maker to use time efficient but potentially less accurate strategies. According to DPT increasing the complexity or novelty of the clinical situation engages the analytical type of decision making to process the solution, compared to a simple or familiar task that could be resolved and handled automatically by type 1 (Croskerry and Nimmo, 2011). This affected both novice and experienced emergency nurses, who reverted to the more analytical decision-making process as task uncertainty increased (Cioffi, 1998). Hicks et al. (2003) compared the decision-making consistency in solving tasks that have different levels of complexity among 54 critical care nurses. They found reduced CDM consistency in the accuracy of interventions used with more complex tasks. Those with greater years of experience in critical care nursing increased the likelihood of decision-making consistency. Perhaps type 1 engagement with simple and routine tasks leads to better consistency in CDM. Overall, the clinical context and the complexity of the task could have significant impact on the nurses' ability to effectively process the clinical cues and make decisions.

2.7. Summary

- Many studies applied the information process theory, social judgement theory or intuitive theory of CDM with a limited discussion about the use of an integrated approach for examining CDM in nursing that considers both types of CDM. The DPT was selected as a pluralistic theoretical framework for this study to better explore the clinical decision making process and the different types of CDM.

- The identified studies tend to use a single research method such as think aloud, observations or self-report interviews. The use of single research method might not fully capture the complexity of CDM process and therefore, there is a need of mixed and multiple methods research designs in this field to add more depth of understanding to the nursing CDM using DPT.

- Most of those studies discussed the ways how decisions are made but provided limited research about the effects of cognitive biases on the quality of the decisions made.

- Many studies that explored CDM in natural settings often selected critical care units or emergency departments with little emphasis on acute wards and nursing students. Other studies used low fidelity paper-based simulated scenarios and mainly studied registered nurse. More research is needed to investigate how nursing students make decisions using high fidelity simulation (HFS) and how HFS affect students' CDM. Chapter three provide a detailed discussion about the effects of HFS on students' CDM skills.

CHAPTER 3
SIMULATION BACKGROUND AND LITERATURE REVIEW

3.1 Introduction

In the last two decades, there has been a proliferation of nursing studies that examined the use of clinical simulation in nursing education. It is important to familiarise oneself with the existing literature related to the research subject but equally important to think broadly about the keywords and subject heading that could be related to the topic of interest. Using appropriate keyword to assist in identifying key relevant literature on the topic. However, as suggested by Chatburn (2011) it is rarely possible for a computerised search to identify all the relevant studies and additional hand search of key publications would be valuable. Different types of clinical simulation have been used in nursing research such as low-fidelity simulation, high-fidelity simulation, games, role-play and virtual reality, therefore it is important to discuss the concept of clinical simulation and its background. Nursing research in the field of simulation is not restricted to pre-registration nursing education but also includes post-registration and post-graduate students. This study was concerned with pre-registration students and this literature review mainly focuses on studies of clinical simulation using high fidelity manikin-based simulator and clinical decision-making in pre-registration nursing education. Gaps in the evidence base will be highlighted to inform the rationale of this study.

The aims of this chapter are to:

1. Review the background and concepts of clinical simulation
2. Review the literature about the impact of high fidelity simulation on clinical reasoning and decision-making.
3. Critically discuss the strengths and weakness of the identified literature.
4. Identify how the gaps in simulation literature justify the study research questions and methodology in chapter 4.
5. Review how the teaching and learning principles of high fidelity simulation support the development of CDM skills.

3.1.1. <u>Definition of simulation</u>

There are many definitions of simulation in the nursing and medical literature; however, there are three shared attributes. First, simulation is a technique, a teaching and learning strategy (Gaba, 2004; Maran and Glavin, 2003), that encompasses a diversity of approaches such as role-playing, virtual reality, human actors and the use of manikins. Second, the focus of simulation is in recreating the whole or parts of a clinical situation that students could recognise in the real world of practice. Replicating the clinical situation or being proximal to reality is an important attribute as it can stimulate students' engagement by ensuring the relevance of the activity to practice and increases the possibility of applying the acquired knowledge and skills into clinical practice. Third, simulation is an active learning strategy that supports learning by doing that require students' active engagement and reflection on action.

For this study, clinical simulation is defined as an active learning strategy that utilises different modalities (such as manikins, virtual reality or role-playing) to replicate parts or the whole of clinical situations and require students to actively participate in the learning process by doing and reflecting on their experience. The Table below (Table 3.1) demonstrate the different classification of simulation modalities and the appropriate application to match the educational context. For this study, the researcher used a full body high fidelity manikin-based simulator and created a bed space an environment proximal to the real world of clinical practice.

3.1.2 Simulation fidelity

Simulation fidelity refers to its' similarity to the simulated situation or clinical situation. The extent to which the appearance and behaviours produced by the simulation match the appearance and behaviours of the simulated system (Maran and Glavin, 2003, p. 23). The fidelity is related to "how closely it replicates the selected domain and is determined by the number of elements that are replicated as well as the error between each element and real world" (Gaba, 2004, page. 8). Maran and Glavin (2003) described two types of fidelity based on Miller (1953); the physical fidelity and psychological fidelity. The physical fidelity refers to the extent to which the physical features of the simulation model replicate the real situation or task. The psychological or the functional fidelity refers to the degree to which the skills in the real world are captured by the simulated task, and this type appears to have more impact of the transfer of learning to practice (Marvan and Glavin, 2003). Forrest, Mckimm and Edgar, (2013) produced a similar classification that distinguishes between different dimensions to explain fidelity. They described physical features, semantic and phenomenal fidelity.

Nehring and Lashley (2010) described three levels of simulation from the nursing literature based on simulator functionality and appearance. Low fidelity simulators provide simple movement and are usually used for psychomotor skills. Medium fidelity simulators allow students to feel the pulse and listen to heart and breathing sounds without visible movement. A high fidelity simulator is a computerised full body manikin with real-time physiological and pharmacological parameters for different conditions.

Table 3.1. Simulation classification

	Appearance	Interaction with learner	Educational context
Human part trainer	Realistic, but of single body part	Realistic but limited response	Repetitive practice of isolated skill
Full body (High fidelity human patient simulator)	Realistic body with physiological modelling	Allow examination (e.g., pulse), realistic interaction	Practice whole scenarios
Screen simulator	2D image of patient, equipment, staff	Realistic response, input via keyboard, mouse	Cognitive exploration in a variety of situations
Virtual reality	3D image of patient, equipment, staff	Realistic response, input via a variety of methods	Practice variety of clinical skills
Real people	Real people acting	Verbal and non-verbal interaction	Practice a variety of skills
Hybrid simulation	Any combination of the above	Verbal, non-verbal communication and interaction	Realistic practice
Simulated environment	An entire clinical environment	Full interaction with patient and team	Realistic practice and team training `
		Adapted from: Forrest, Mckimm and Edgar, (2013)	

Forrest, Mckimm and Edgar (2013) argued that optimising the fidelity relates to the educational value and applying a simple or unrealistic simulation might have a better educational effect. They provided an example of slowing the pacing of clinical deterioration of a patient, so students can grasp the situation and give them time to react.

3.1.3 History of simulation in healthcare

The origin of simulation was difficult to identify in the literature, but Forrest, McKimm and Edgar (2013) discussed that the French midwife Madame du Coudray 1600 used the early models of simulation to describe the stages of childbirth using manikin made from leather. In the nursing literature, the use of mechanical dummy and models of limbs to learn bandage was initially mentioned in Lee's handbook in 1874 (Nehring and Lashley, 2010).

The second phase of simulation development came from two discoveries; the discovery of the cardiac massage and mouth-to-mouth resuscitation and the discovery of mouldable plastic in the 1950s this led to the development of the resuscitation manikins. The focus of the design was on the physical appearance of the manikin to enhance the fidelity of the simulator but had limited functionality. In the early 1960's, new developments were made in advancing the design of the simulator to enhance the fidelity and functionality of the manikin by using electronic and electromechanical devices to mimic the sounds produced by the cardiovascular system (Ewy et al, 1987). The advancement in the simulation in the 1960's led to use of computer screen based simulation of video recorded cases and the development of the first full human body interactive simulator that was controlled by a computer. The use of role-plays and games part of the nursing education appeared in the nursing literature in the 1970's and the computer-assisted instructions merged in the early 1980's (Nehring and Lashley, 2010).

Gaba and DeAnda (1988) were the first to develop a full realistic simulated environment using human patient simulators, teams and fully equipped operation theatre. This brought the technological advancement and the psychological fidelity of the clinical environment together to optimise the realism of the simulation. The purpose was not only to enhance learning but also to understand human behaviour during the performance. Gaba and DeAnda (1988) recognised and integrated the Crew Resource Management (CRM) techniques, a training of crisis management and risk elimination in training anaesthetists and then developed for other healthcare professionals. In 1989, virtual reality emerged from a group of NASA researchers using a three-dimensional representation of body muscles, which led to the era of using virtual reality in surgery. The Laerdal Virtual IV system for learning intravenous catheterization was the first application in nursing (Phillips, 1993).

In early 1990, the simulation development saw the creation of simulation centres across the world and the recognition of the importance of simulated practice in enhancing students' knowledge and skills by professional and regulatory bodies. The high-fidelity simulation emerged after Gaba and DeAnda (1988) work but nurses provided input that influenced the proliferation of these models for almost the last 15 years. The principles and technique of CRM have influenced the introduction of simulation to healthcare education. Interests for simulation in the fields of anaesthesia, emergency and critical care did not only focus on technical skills but also non-technical skills.

3.2 Drivers for simulation in nursing education

The major drivers that influenced the use of simulation in the current nursing education and practice include the increased demand on high quality and safe practice, the advancement in simulation technology, the shortage in the nursing task force and limited availability of clinical placement (Nehring and Lashley, 2010).

3.2.1 Reducing human errors

The use of simulation has been encouraged in many key government papers worldwide. The increased focus on patient safety and the recognition of the effects of human errors in healthcare by USA government report "To Err is Human" (Kohn, Corrigan and Donaldson, 2000) and the UK government publication of "An organisation with a memory" (DH, 2000). Both reports identified that number of fatalities are due to medical errors and recognised that humans are fallible and medical errors are inevitable. The Department of Health (2001) recommended integrating training about human factors into both undergraduate and postgraduate education and part of the actions stated in the report was "enhancing the role of simulation laboratories to expose staff to risk situations with no actual patients involved", (DH, 2001, p. 55).

The Department of Health (2011) White paper argued that innovative educational technologies such as simulation provide real opportunities for healthcare students and staff to acquire and develop knowledge, skills and behaviours and provided a framework for the National Health Services, commissioning bodies and Higher Education Institutions for technology-enhanced healthcare education. As a response to (DH, 2011) framework, Health East of England (HEE) commissioned the Association for Simulated Practice in Healthcare (ASPiH) to scope the existing simulation capacity in England which resulted in the publication of Standard for Simulation-Based Education to ensure the quality of training and the effectiveness of simulation as an educational technique (ASPiH, 2016). Subsequently, HEE (2016) released their strategy to improve patient safety through education and training with the focus on how simulation could enhance patient safety.

3.2.2 Fitness to practice and competency

Nurses and other healthcare professionals are under a great deal of scrutiny to provide safe and effective care. Likewise, nursing programmes are under similar scrutiny to produce graduates who have the capacity to provide safe practice. The Nursing and Midwifery Council (2005) carried out research and used focus groups of stakeholders to explore how to improve “Fitness to Practice”. One of the themes identified by the focus groups was the use of simulation and practice for rehearsal and testing of skills throughout the nursing course (NMC, 2005) to ensure Fitness to Practice at the point of registration.

The Simulation in Practice Learning Project (NMC, 2007) was initially a response to the concern raised by the Council of Deans and Nurse Directors Associations about the increased number of nursing students with the reduced number of quality clinical placement and qualified mentors to support students’ learning and assessment. Furthermore, the limited availability of appropriate clinical areas that have the capacity to accommodate students is adding more pressure on the higher education institutions and placement providers to explore how to ensure nursing students are “Fitness to Practice” at the point of registration (Traynor et al, 2010). Nursing and Midwifery Council (2010) endorsed the use of simulated practice to substitute 300 clinical practice hours out of 2300 of clinical hours in the Standard of pre-registration Nursing and Midwifery Education. In March 2018, the NMC decided to lift the cap on simulation hours and allowed universities to increase clinical simulation hours to substitute up to half of the 2,300 hours of the practical hours. This supports the great interest in simulation and the need to support evidence-based simulation practice.

3.2.3 Ethical considerations

The consensus about the ethical implications of using real patient as a primary mode for technical and psychomotor skill acquisition through “trial and error” or “training commodities (Berndt, 2010). Decker (2007) suggested that students need to inform the patient that they have never performed a procedure on a real patient before. Ziv et al (2003) argued the ethical responsibility of Healthcare provider and Education Institutions is to invest in simulation laboratories and prepare students in a controlled environment to reduce the risk on patient safety. The concern about the lack of quality of clinical placements to ensure that students have the necessary exposure to develop clinical skills and the potential benefits of simulation to re-create situations infrequently occurring in practice are drivers for the increased use of this technique in the recent years. There are evidence that cognitive and psychomotor skills can be improved by using high fidelity simulation (Levett-Jones et al, 2011a; Kim, Park and Shin, 2016) and learned skills in the simulation laboratories could be transferrable to clinical practice.

3.3 <u>Simulation literature review</u>

The following section will present the search strategy and the identified key themes.

3.3.1 <u>Search strategy</u>

A literature search was initially conducted prior to designing and conducting the research in 2013 and during the data collection and analysis stage and repeated in December 2018 to identify any recent publication. To ensure the effectiveness of the literature review in retrieving the most relevant evidence a few strategies were followed that includes: using a defined review question, selecting relevant databases, structure the alternative keywords using population, intervention, comparison and outcome (PICO) framework (Schardt et al, 2007) and the use of subject heading such as Medical Subject Headings (MeSH). The literature review aimed to answer the following question: does manikin based high-fidelity simulation improve pre-registration nursing students clinical reasoning and decision-making skills?

The intervention of interest was the use of manikin-based high-fidelity simulation, the population of interest was undergraduate nursing students, and outcome measures include clinical decision making, clinical reasoning and clinical judgement. Table (3.2) summaries the inclusion and exclusion criteria used in this review.

Table 3.2 Inclusion and exclusion criteria

Inclusion criteria	**Exclusion criteria**
• Manikin based high-fidelity simulation • Pre-registration or undergraduate nursing students. • Adult nursing • Clinical decision making, clinical reasoning, clinical judgement • Primary research • Experimental and interventional studies focused on outcome measures and process of CDM	• Low- or medium-fidelity simulation, human actors, not a manikin-based simulation • Post-registration, post-graduate nursing students, registered nurse • Midwifery, mental health and paediatric • Not primary outcome measure • Secondary literature • Correlational studies

The initial literature search was conducted using three main online databases related to nursing included CINAHL/EBSCO, British Nursing Index (BNI) and MEDLINE/ Pubmed. The initial searches were performed using the keywords that are structured under the PICO framework and was limited to the date of publication between January 2005 to December 2018 for all the three databases.

The first keyword searched was related to the population of interest and the following keywords were used in this search: ‘pre-registration nursing students’, ‘pre-registration nursing education’, pre-registration nurse education and ‘undergraduate nursing education’. The Boolean operator OR was then used for these keywords to bool all the results for the hits that reflect the population of interest. The second keyword searched was related to the educational intervention and the following keywords were used: ‘simulat*’, ‘high fidelity simulation’, ‘human patient simulation’. The Boolean operator OR was used for the keywords that reflect the intervention to pool all the results. The keywords that reflect outcome measure were then used which include ‘clinical decision making’, ‘clinical reasoning’, ‘clinical judgement’ and ‘decision making’. Again the Boolean operator OR was used to bool all the results related to the outcome measure.

The results produce by the application of Boolean operator OR described above were then combined using the Boolean operator AND to retrieved articles that focused on the review question (Appendix 1). To refine the results the search was limited to English language and full text. Due to the large number of hits in the BNI additional limitations were used see (Appendix 2).

The search was repeated using subject headings in both CINAHL/EBSCO and MEDLINE/PubMed to ensure that key studies were not missed. For CINAHL the keywords under PICO were searched using subject headings and the following major concept were identified. “Student, nursing and baccalaureate”, “education, nursing, baccalaureate” and “students, college” were identified as major concepts to reflect the population of interest. “Patient simulation” and “simulation” were identified as major concepts to reflect the intervention of interest. “Decision making, clinical” was identified as major concept to reflect the outcome measure of interest. When keywords were search using Medical Subject Heading (MeSH) in MEDLINE/PubMed the following key concepts were identified “education, nursing,”, “simulation training” and “clinical decision making”. The search strategy and the application of the Boolean operators OR and then AND described above was repeated using subject headings identified in both CINAHL and MEDLINE databases (Appendix 2).

A PRISMA flow chart below summarises the number of hits identified in this review (Figure 3.1). The data from each study was extracted and a summary is provided in appendix 4. The summary focused on the studies used method and design, selected participants, description of the intervention, findings and quality assessment of the studies. Joanna Briggs Institute (JBI) critical appraisal tools were used to assess the quality of primary studies (Aromataris and Munn, 2017). Different checklists were used for randomised control trials and non-randomised quasi-experimental studies (Appendix 3). Due to the nature of the studies under view, some of the criteria such as concealing the intervention group and blinding, were not practical. Therefore, any study that met at least 7 out of 13 for RCT criteria, 5 out of 9 for quasi-experimental criteria and 5 out of 10 for qualitative criteria was included. No studies have been excluded based on these criteria. Lapkin et al, (2010) and Mok (2016) suggested that critical thinking, clinical competency, self-confidence and knowledge acquisition are precursors to clinical reasoning. They considered those areas as outcome measures to assess clinical reasoning in the simulation studies. Studies that referred to the outcome measures identified by Lapkin et al (2010) and Mok (2016) were included in this review.

Sixty-seven articles were identified by CINAHL database, 163 were found in MEDLINE and BNI identified 771 articles; the initial electronic search generated 1002 articles and eight articles were identified through hand search of the reference list and two relevant systematic reviews were found. After removal of the duplicates, many studies were excluded based on the title and abstract as judged irrelevant to this research. Results were restricted to English language only and availability of full text and inclusion and exclusion criteria were applied to refine the results (Table 3.2). Studies that referred to high fidelity simulation but used actors, standard patient (SP) actors or role-plays instead of manikin-based simulation were excluded. Twenty-eight studies were found to be relevant (see Figure 3.1). The electronic search that used subject headings produced seventeen hits in CINAHL and seven hits identified in MEDLINE. All of these 24 articles were either already identified by the first search or did not meet the inclusion and exclusion criteria described above.

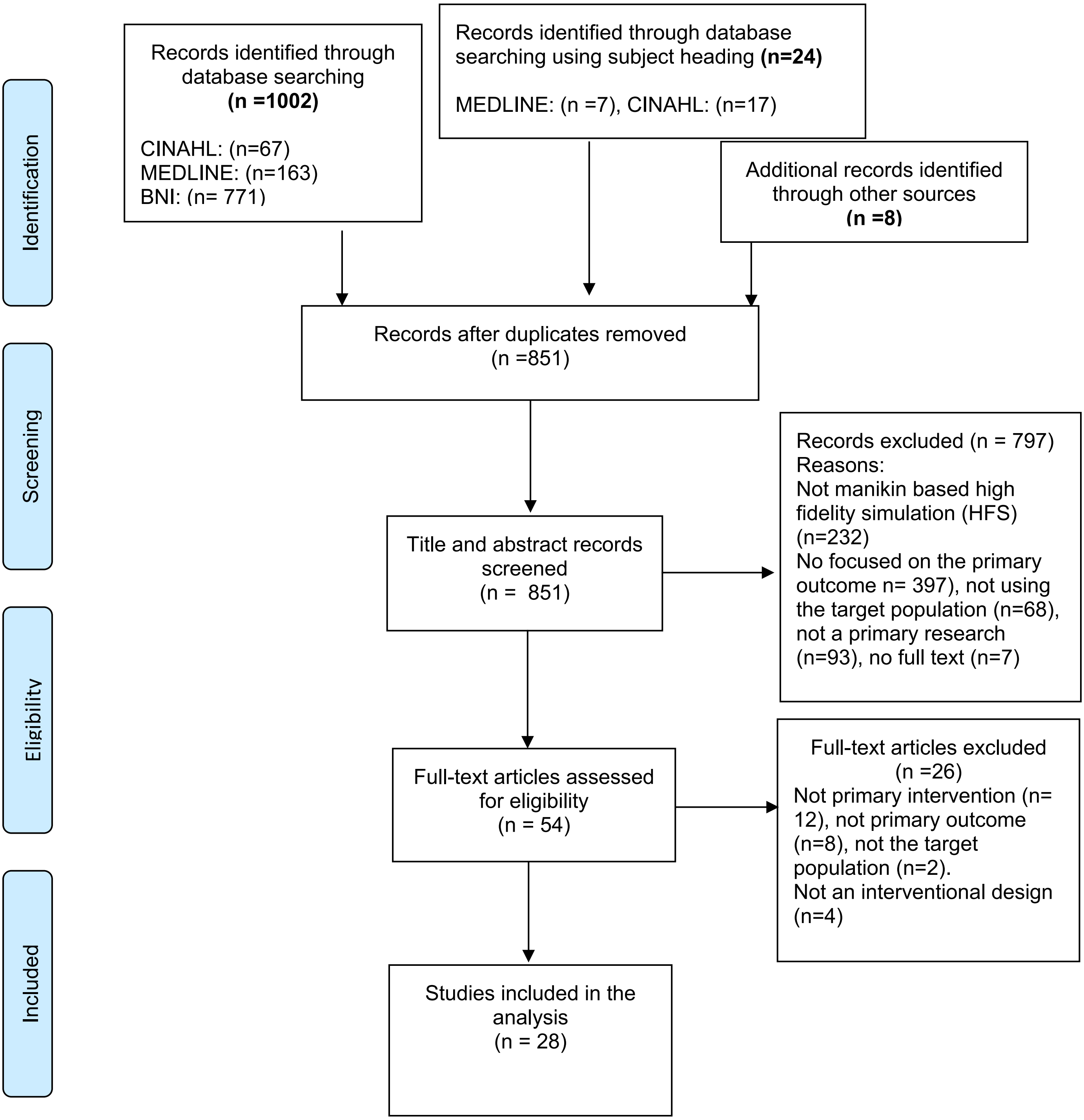

Figure 3.1 Inclusion and exclusion using PRISMA flow chart (adapted from Moher et al, 2009)

3.3.2 <u>Description of studies and methodological quality</u>

Of the 28 studies, 16 studies were from the United States, three studies were from Australia, two were from UK and the remaining studies were from other parts of the world. The majority of the studies were carried out in USA and comparatively limited publications on the simulation studies carried out in the UK. Perhaps the different nursing curricula in the UK, where 50% of the curriculum is clinical placement, has an important role for the reduction in research output in the UK or the late endorsement of the use of simulation in nursing education which was only published by the NMC in 2010.

Most of the identified studies in clinical decision making in simulation setting used quantitative design (26 out of 28).There are limited qualitative studies focusing on clinical reasoning, and decision-making using manikin-based high-fidelity patient simulation (HFS), with only three studies that provided thematic analysis or focused on the process of decision making (Endacott et al 2010; Walsh, 2010; Ashley and Stamp, 2014). The review identified 22 peer-reviewed journal papers and six dissertations. Sample size ranged from 13 to 403 for individual studies with an average sample size of 90. The experimental pre/post design or repeated measure designs were the most common approaches. The identified studies mainly used non-probability sample from nursing courses with varied approaches for control and randomisation. The participants' year of study in nursing is heterogeneous as many studies used junior and others used senior students (Appendix 4).

3.3.2a Methodological quality

Critical appraisal is important to assess the quality of research studies but there are a number of tools available that are used to guide the appraisal of a specific methodology. Whilst these tools are very useful, the different focus of each tool makes difficult when evaluating heterogeneous sample. JBI tools were was used to assess the quality the identified studies based on their methodology (Appendix 3). All the identified studies had good quality assessment that ensured the credibility of evidence, and increased the confidence in their findings. However, a few limitations were identified.

One of the limitations of the identified RCTs is the lack of allocation concealment which could potentially increase the likelihood of selection bias during recruitment and randomization. Only one study from eight RCTs (Merriman, Stayt and Rickett, 2014) mentioned allocation concealment. The second limitation is the lack of blinding in applying the intervention, blinding the participants and the assessment of outcome, subsequently increasing the likelihood of performance and ascertainment bias after randomisation.

Therefore, the cause-effect relationship cannot be certainly inferred. The absence of blinding the participants to the studies' intervention may have an effect on the participants' behaviour to the intervention of interest. Furthermore, despite studies have mentioned the use of random allocation there is a lack of description of the method of randomisation.

A major limitation of all of the identified RCTs and quasi-experimental studies is the use of convenience sampling and small sample size. Although convenience sampling is a popular approach to recruit undergraduate students, the use of non-probability sampling can increase the risk of sampling error due to selection bias. In addition, it can lead to lack of representation of the population of interest and subsequently reduce the generalisability of the findings (Bettany-Saltikov and McSherry, 2016). The small sample size usually suffers from insufficient statistical power to demonstrate adequate effect which has been identified in most of the found studies in this review.

Many of the quasi-experimental design studies, nine out of 18, did not have comparisons and seven out 18 did not have control groups (Appendix 4). This will negatively affect the internal validity of the findings and the researcher cannot certainly infer the conclusions due to the possibility of confounding bias. A few studies used a locally developed tests however some of these studies did not describe the validity of the used test (Howard, 2007; Radhakrishn, Roche and Cunninghum, 2007; Brown and Chronister, 2009; Cobbett and Snelgrove- Clarke, 2016). Young and Jung (2015) repeated the testing immediately after cross-over between the interventions, this approach can increase participants' familiarity with test, which can add threats to the validity of the findings. Most the identified studies relied on self-reporting tools to measure students' confidence, clinical performance and CDM, which is subjective in nature and can be affected by social desirability bias and the reliability of the collected data.

Four studies (Hoffmann, O'Donnell and Kim, 2007; Young and Jung, 2015; Fawaz and Hamdan-Mansour, 2016; Knoesel, 2017) did not provide baseline data about the participants which limits comparability between the groups and does not provide an insight of the effect of demographical variables on the measured outcomes. Two studies reported heterogeneity in the participants' demographic between the control and intervention group (Lee et al, 2016; Knoesel, 2017) and overall there is a heterogeneity in the type of students used in the identified studies with a few studies using either junior or senior nurses without clear justification for this selection. Finally, the qualitative studies (Endacott et al, 2010; Ashley and Stamp, 2014) had good quality assessment and the only issue was the lack of description of the influence of researchers on the research and their relationship with the participants.

The findings of this review are consistent with results of other reviews that evaluated the effectiveness of manikin-based HFS in teaching nursing students clinical reasoning (Lapkin et al, 2010; Mok et al, 2016). Both Lapkin et al (2010) and Mok (2016) were critical of the current evidence with inconclusive results, weak methodologies and sampling techniques and both reach the same conclusion about lack of strong empirical evidence to support the use of simulation in teaching pre-registration nursing students clinical reasoning skills. These results are also in agreement with other reviewed published work about the effectiveness of simulation in nursing education in general that considered both nursing students and registered nurses (Yaun et al, 2012; Lee and Oh, 2015; Cant and Cooper, 2017).

3.3.3 <u>Review findings</u>

The main outcome measures including clinical reasoning, clinical judgment and CDM will now be discussed. Clinical confidence, critical thinking, knowledge acquisition and clinical performance are considered attributes and precursors to clinical reasoning (Lapkin et al, 2010; Mok, 2016) each of these are also discussed below.

3.3.3a Critical thinking

Six studies (Howard, 2007; Ravert, 2008; Brown and Chronister, 2009; Walsh, 2010; Wood and Toronto 2012; Knoesel, 2017) examined the effectiveness of using HFS to develop critical thinking abilities in undergraduate nursing students. All the studies identified in this review were from the USA and no studies have been identified in the UK or Europe.

Ravert (2008) had three groups, namely, HFS, a control and a comparison group without HFS. The HFS group (n=12) participated in a simulation with enrichment session, comparison group (n= 13) had regular education and enrichment and the control had only a regular education. Ravert (2008) used the California Critical Thinking Skills Test (CCTST), a valid and reliable test for critical thinking but not specific to the healthcare domain. The researcher reported moderate to large effect size improvement among the three groups which did not reach statistical significance. Wood and Toronto (2012) used the similar scale, California Critical Thinking Disposition Inventory (CCTDI), to measure critical thinking among 85 second year nursing students. They used quasi-experimental design assigned participants to an interventional group (n=42) and control group (n=43). They compared the effect of a 2-hour simulated session with SimMan to traditional practice. The simulation session included a debriefing session and students performing individually and observing peer performing same skills. Although they found improvement in CCTDI score for the intervention group (mean difference = 6.54, t = 2.26, df = 38, $p < 0.05$), this difference was not statistically significant between the control and intervention groups. Perhaps the sample size in Ravert (2008) and Wood and Toronto (2012) was too small and inadequate to demonstrate significant difference.

Brown and Chronister (2009) recruited 140 senior students and compared weekly didactic session and HFS combined with a didactic session on student critical thinking measure using a commercially available test developed by experts for Elsevier. Each group had 70 students randomly allocated to either the intervention or comparison group. The author reported no significant difference in the critical thinking means score between the groups using the customised test. Similar results in Walsh (2010) study who compared the used of pattern recognition and HFS on junior nursing students critical thinking using Health Education Systems Incorporated (HESI) exam. A sample of 54 students was randomly allocated in pairs to one of three groups; 9 pairs of think aloud control group, 9 pairs of typical HFS using think aloud and Pattern-HFS using think aloud. Walsh (2010) reported no statistically significant difference in the CT score between groups. Knoesel (2017) also used HESI to examine the effect of HFS among 218 nursing students attending two different pathways, an accelerated course (n=103) and traditional course (n=115). One hundred and twelve students attended a simulation session regardless of their pathway compared to a control group of 106 students. Although they found higher scores in critical thinking in the simulation group, the difference between the intervention and control group was not statistically significant ($t(202.8) = 1.68$, $p=0.09$). This study lacked baseline assessment of the participants therefore it is difficult to infer effects students' demographic factors on the HESI score and so limits the generalizability of the findings.

Howard (2007) is the only study that found significant difference when they evaluated the effectiveness of simulation by comparing it to an interactive case study. They recruited 49 both diploma and BSc students in two different universities. The author measured CT using HESI multiple choice questions and found a marginally significant difference in critical thinking score for the simulation group ($p = 0.051$; Howard, 2007).

In summary, the impact of HFS on critical thinking demonstrated no significant difference between simulation and control; with five studies reported that HFS did not have any significant improvement on critical thinking score and one study reported a significant effect.

3.3.3b Knowledge acquisition and retention

Twelve studies examined the effect of HFS on knowledge acquisition and retention (Jeffries and Rizzolo, 2006; Hoffmann, O'Donnell and Kim, 2007; Howard, 2007; Brannan, White, and Bezanson, 2008; Ackermann, 2009; Kardong-Edgren et al, 2009; Shepherd et al, 2010; Levett- Jones, et al 2011b; Akhu-Zheya et al 2013; White et al 2013; Young and Jung, 2015; Cobbett and Snelgrove- Clarke, 2016). The findings are mixed about the effect of HFS knowledge acquisition with six studies reporting significant positive effect (Jeffries and Rizzolo, 2006 Hoffmann, O'Donnell and Kim, 2007; Howard, 2007; Brannan, White, and Bezanson, 2008; Ackermann, 2009; Young and Jung, 2015) while six more recent studies did not find significant effects on students' knowledge (Kardong-Edgren et al, 2009; Shepherd et al, 2010; Levett- Jones, et al 2011b; Akhu-Zheya et al 2013; White et al 2013; Cobbett and Snelgrove- Clarke, 2016).

Jeffries and Rizzolo, (2006) recruited 403 junior nursing students from eight different sites and compared the effect of simulation on the intervention group compared to a group of paper-pencil case study and a group of static simulation. Students were randomly allocated to study groups and were given the same scenario to work in small teams of four students. The difference was measured using Educational Practices in Simulation Scale (EPSS) and the Simulation Design Scale (SDS) that showed significant improvement of knowledge among all the groups. However, their published report does not provide an adequate statistical analysis of the findings. Hoffmann, O'Donnell and Kim (2007) used pre- and post-test repeated measure designs to compared knowledge acquisition and retention of 29 senior students in an educational programme that included 7 weeks of traditional teaching combined with 7 weeks of HFS. The author measured the knowledge attainment using Basic Knowledge Assessment Tool (BKAT-6), a 100-item paper-pencil test that examines basic knowledge recall and application. The findings indicated a significant improvement in the overall score ($p < 0.05$) after three months of the simulation experience.

Howard (2007) randomly allocated students in two sites to either HFS group or a control case study group. The author used HESI exam to assess the differences between the groups and found statistical difference ($p = .037$) favouring the simulation group. Brannan, White, and Bezanson, (2008) reported the effect of simulation by comparing two groups junior nursing student; HFS (group 1, n =53) and traditional lecture (group 2, n=54) using Acute Myocardial Infarction Questionnaire. The findings indicated statistically significant ($p = 0.002$) knowledge gain for the simulation group. Ackermann (2009) examined the effect of HFS among 65 junior nursing student cardio-pulmonary knowledge and skills acquisition and retention. They evaluated the effect of HFS compared to algorithm and DVD review using AHA MCQ and skills evaluation form pre- and post- intervention and after 3 months. Findings indicated significant improvement in knowledge acquisition (post-test 1, p = .015) and retention (post-test 2, p=.002). Young and Jung (2015) used quasi-experimental with cross design and examined first year nursing student knowledge using a locally validated MCQ test. Group A (n=48) initially undertook a didactic session for four weeks plus a 2-hour simulation session, then another four weeks of didactic session. Group B (n=46) had a didactic session for 4 weeks followed by another a didactic session plus simulation for another four weeks. They had three assessment at baseline, cross over at week 6 and at week 12. They found significant improvement in the knowledge when simulation was used (t=2.55, p =.012).

Recently, a number of studies did not find a significant effect of the simulation on knowledge acquisition. Shepherd et al (2010) used a longitudinal quasi-experimental comparative design to investigate third year adult nursing students (n=28) cognitive skills that included knowledge and decision making. They had two sites and two phases for their study. Site A (n=18) standard patient role play simulation compared to site B (n= 10) HFS for phase one and then a follow up interview after 6 months. No significant difference between the two sites in terms of knowledge and CDM. This study is under powered due to the size and the unequal sample size of the two sites. Levett- Jones et al (2011b) compared the effect of medium-fidelity MegaCode (VitalSim) to high-fidelity-HFS (SimMan3G) on students' knowledge acquisition and found no significant difference between the effects of the two types of simulation. The author used two equal-sized groups of 42 students in each group, paired students using clinical reasoning score and assessed the difference use TestGen-MCQ. Kardong-Edgren et al, (2009) had a similar result and they used three-factorial repeated-measure design and measured the difference in knowledge using 15-items multiple choice question (MCQ) from the American Heart Association (AHA) at 2 weeks and 6 months post-intervention. They found a significant difference between pre- and post-test 1 but no differences at 6 months.

White et al (2013) compared HFS and traditional classroom on knowledge acquisition among 54 senior nursing students; allocated to two group (group 1 =16) for HFS and (group 2 = 38) for a traditional class. The findings demonstrated no statistically significant difference between the pre- and post-test but groups in the traditional group had significant improvement in test score (p<0.03, White et al, 2013) compared to HFS group. Akhu-Zaheya et al (2013) evaluated the effect of HFS on knowledge acquisition and retention compared to traditional basic life support (BLS) training among second years nursing students. Students were allocated to two groups; a group of traditional BLS combined simulation (n= 52) and another group (n= 58) of traditional BLS only. Findings indicated no statistical difference in both knowledge acquisition and retention (p =0.1, p =.97 retrospective, Akhu-Zaheya et al, 2013). Cobbett and Snelgrove- Clarke (2016) in their RCT, examined third year nursing students' (n=56) knowledge by comparing two types of simulation; virtual clinical simulation (VCS) and face to face (F2F) manikin simulation. Initially, Group 1 (n=27) attended VCS and Group 2 (n =28) received F2F simulation. The groups then swap by attend the other type of simulation. Students had higher score when attended F2F simulation session compared to VCS but the difference in mean score was not significant. The study does not clearly discuss the validity of the used knowledge test and students never had experience before with either type of the used simulation which negatively affected students' anxiety level and the findings.

In summary, the findings demonstrated an inconclusive effect of high fidelity simulation on knowledge acquisition and retention. There is a lack of consistency between the studies and the positive effect does not reach statistical significance. This also supported by a recent review in nursing education in general (Cant and Cooper, 2017).

3.3.3c. Self-reported confidence

Ten studies (Jeffries and Rizzolo, 2006; Brannan, White, and Bezanson, 2008; Brown and Chronister, 2009; Shepherd et al, 2010; and White et al, 2013; Kelly et al 2014; Merriman, Stayt and Ricketts, 2014; Young and Jung, 2015; Cobbett and Snelgrove- Clarke, 2016; Woda et al, 2017) that examined self-reported levels of confidence after working with HFS. Seven studies (Brannan, White, and Bezanson, 2008; Shepherd et al, 2010; White et al, 2013; Merriman, Stayt and Ricketts, 2014; Young and Jung, 2015; Cobbett and Snelgrove-Clarke, 2016; Woda et al, 2017) reported that HFS- based intervention did not have statistically significant effects on measures of self-perceived confidence compared to traditional teaching using and three studies found significant improvement in confidence (Jeffries and Rizzolo, 2006 and Brown and Chronister, 2009; Kelly et al 2014).

Brannan, White, and Bezanson, (2008) used a Likert-type scale developed by (Madorin and Iwasiw (1999)) to assess students' self-reported levels of confidence by comparing the effect of two educational interventions; a two-hour lecture in the control group and case study with HFS. Both groups reported improvement in their confidence level, but the difference did not reach statistical significance (p= .09). Shepherd et al (2010) compare standard patient role play compared to manikin-based simulation and found no significant difference between the groups (F (1, 24) = 0.03, P=0.863).

White et al (2013) used the same scale (Madorin and Iwasiw (1999)) and compared the differences between the HFS group score and traditional classroom score and found no statistical difference in the level of confidence between the two groups (p=.71). They carried paired sample t-testing of the pre- and post-test for the subscales score both groups had significant improvement in their perceived confidence (p<.001). Young and Jung et al (2015) found no difference in self-confidence between the control and intervention group (t= -0.81, p =.418) which concurs with the findings of White et al (2013). Merriman, Stayt and Ricketts (2014) carried out a pilot study and used a single centre randomised control trial (RCT) design to investigate HFS effect on students' confidence and clinical performance. They recruited first-year nursing students (n=34) and compared HFS in the intervention group (n=19) to conventional teaching (n=15). The simulation experience included a 2-hour session with an initial demonstration by the facilitator followed by multiple individual practices with feedback compared to 1-hour classroom lecture. They used General Perceived Self Efficacy and Self-Reported Competency Scores (GPSEC) and reported no statistical difference between the groups and no significant association between confidence and clinical performance.

Cobbett and Snelgrove- Clarke (2016) used the Nursing Anxiety and Self-Confidence with Clinical Decision-Making Scale (NASC-CDM) and found no significant difference in students' clinical confidence when they compared virtual-based simulation to manikin-based simulation. Woda et al (2017) used a quasi-experimental crossover design and examined third-year students' (n=117) reported clinical confidence. They divided the sample to two groups. Group 1 had seven weeks simulation and after crossover to another seven weeks of hospital placement. Group 2 had seven weeks of hospital placement and then seven weeks of simulation. Each student participated in three simulated scenarios that lasted four hours. Woda et al (2017) used NASC-CDM to measure the clinical confidence and found no statistical difference between and within the groups. The used of crossover design without mid-point measurement or control makes it difficult to infer the true effect of either the simulation or the clinical placement on outcome measured.

Jeffries and Rizzolo (2006) reported significant improvement in students' confidence in their ability to care for patients compared to a paper-pencil case study group. Brown and Chronister (2009) examined the effect of HFS in combination with didactic instruction to only didactic instructions on students' confidence level. The researcher developed a confidence level scale for this study that had five statements rated on a 5-point Likert scale. Findings indicate a significant improvement in the students' perceived self-confidence favouring the simulation group (p<.05). The authors acknowledge the limitation of their scale in terms of contract validity and reported that reliability of the scale using Cronbach's alpha of 0.89 for all the five items for 133 participants' post-intervention, which is a good level of reliability. Kelly et al (2014) had similar results and they used a descriptive pre- and post-test design to examine the first exposure of simulation on nursing students' confidence (n=57). They found significant improvement in students' confidence in communicating and approach other healthcare professionals but do not provide a statistical difference.

In summary, most of the studies showed that HFS did not produce a significant positive effect on clinical confidence. Clinical confidence could have important effects on gathering the right cue to inform clinical decision and execute actions in a timely manner.

3.3.3d Clinical skills performance

Four studies (Radhakrishnan, Roche and Cunninghum, 2007; Ackermann, 2009; Merriman, Stayt and Ricketts, 2014; Lee et al, 2016) examined the effects of HFS on students' clinical skills performance. Ackermann (2009) evaluated the effect of HFS compared to algorithm and DVD review using AHA skills evaluation form pre- and post-intervention and after 3 months. Findings indicated significant improvement in skill acquisition (post-test1 = $p < .001$) and retention (post-test 2, $p < .001$). Radhakrishnan, Roche and Cunninghum (2007) compared the effect of HFS and usual training to only usual training using Clinical Simulation Evaluation Tool (CSET). CEST was developed by the researcher using clinical practice assessment parameters that include: safety, basic assessment, focused assessment, intervention, delegation and communication skills. The study found significant improvement in safety category ($p = .001$) and assessing vital signs category ($p = .009$). Kelly et al (2014) used a descriptive pre and post-test design and found a significant improvement in students' perception of their ability to recognised and respond to patient clinical deterioration ($p < 0.01$).

Merriman, Stayt and Ricketts (2014) also examined the effect of HFS on students' competency in responding to deteriorating patient scenarios. They used objective structured clinical examination (OSCE) to evaluate students' performance and found significant improvement post-simulation ($p < 0.05$) of clinical performance of the intervention group. Similar findings in Lee et al (2016) study, who recruited forty-nine senior nursing students in a clinical reasoning course using high fidelity simulation and measured their competency and problem-solving. They found significant improvement on the score of core competency ($p = 0.008$) but no difference in problem solving between the groups. They used a locally validated measure, but the groups were heterogeneous, the course was an elective course, and they provided a limited discussion about the validity of the used scenarios. Overall, from the identified studies HFS appear to have positive effect on students' clinical performance and problem solving.

3.3.3e Clinical reasoning and decision making

Dreifuerst (2010) investigated the impact of a debriefing strategy after high fidelity simulation on students' clinical reasoning using Health Science Reasoning Tool (HSRT). The study followed an exploratory quasi-experimental pre- and post-test design and recruited adult nursing students from multiple cohorts (n=238). The researcher used HFS for both intervention and control group, but the difference was in the use debrief approach. The intervention group used Debriefing Meaningful Learning developed for the study compared to usual debriefing. The study reported a statistically significant difference in HSRT mean score for the intervention group ($F (1, 237) = 28.55$, $p = <.05$). The author reported that not all the nursing cohorts were invited increasing the risk of selection bias. It was a single centre and focused on the debriefing and did not clearly discuss the content or the simulation design.

Yuan, Williams and Man (2014) examined the effects of HFS on clinical judgement score among 113 second- and third-year nursing students and found that HFS significantly improved students' clinical judgment score. They used a quasi-experimental design without control and utilised Lancaster's Clinical Judgment Rubric (LCJR). This corroborates with the Pierce (2011) study, which had repeated measure design used a self-reported survey to assess students' perception of their clinical judgement. Pierce (2011) recruited 50 senior nursing students and used three simulated scenarios without control or comparison. They found an increase in students' perception of their clinical judgement between two scenarios out of three. Fawaz and Hamdan-Mansour (2016) only used a post-test a quasi-experimental design in two sites with first year nursing students (n= 56), divided into two groups. Group A were assigned to a traditional lecture-based course (n =26) and group B (n= 30) was assigned to HFS. They used Lasater's Clinical Judgment Rubric and found a significant difference between the groups ($t = 5.23$, $p= 0.001$) with higher improvement in the intervention group. Young and Jung (2015) also found significant improvement in students' clinical reasoning score which was significantly better compared to the control group. However, they used a locally validated tool based on the nursing process, but their tool lacks reliability as only one member carried the assessment and no reliability test was carried out. Walsh (2010) conducted a qualitative analysis to their post simulation interview and reported that students perceived positive effect of HFS on students' clinical reasoning

Shepherd et al (2010), Cobbett and Snelgrove- Clarke (2016) and Woda et al (2017) also examined the effect of manikin- based HFS on clinical decision making but they used different measures. Shepherd et al (2010) used a locally validated tool for cognitive skills, Cobbett and Snelgrove- Clarke (2016) used the NASC-CDM and Woda et al (2017) used the NASC-CDM and Clinical Decision Making in Nursing Scale (CDMNS). Both NASC-CDM and CDMNS are valid and reliable tools but they apply a self-report survey approach. Although the CDM score for the manikin-based simulation was higher in comparison to the control or the alternative interventions (virtual reality, lecture or traditional practice), there was no significant difference between the groups for the three studies. Overall, the findings about the effect of HFS on CDM and clinical reasoning are positive but inconclusive.

Two studies explored how students make decision and response to acutely ill patient Endacott et al, 2010; Ashely and Satmp,2014). Endacott et al (2010) conducted an observation and explorative study that investigated the processes used by final-year nursing students (n=51) to recognise and act on signs and symptoms of clinical deterioration. Endacott et al (2010) assessed students' knowledge and observed the recognised cues and the missed cues. The simulation design included working with manikin-based simulation for 1.5 hours in managing two scenarios followed by video-assisted reflective session. The study does not report a specific score about participants' knowledge differences. Endacott et al (2010) used dimensional analysis of the observational and interview data and reported significant differences in the processes used by students in their identification of cues that have four aspects; initial response, differential recognition of cues, accumulation of signs and diversionary activity. They found delay in students' initial response to notice critical cues that led to in accurate action and when cues were recognised, students did not always execute appropriate actions or delayed action until an accumulation of multiple signs.

Ashely and Stamp (2014) had similar findings when explored clinical judgement among 48 junior nursing students and 56 senior nursing students. Students attend 15-20 simulation session followed by video-assisted debriefing. In their analysis the found junior and senior students differ in the way they think, assess and utilised clinical cue. They identified that students failed to carry key assessment and delay cue recognition especially senior students who did not consider the initial cues. Junior students were more systematic and analytical in their approach, considered the initially cues more than senior students and actively listened patients' symptoms. Both types of students felt sense of urgency to look for answers to solve the problem, but junior students were quicker is solving the problem.

3.3.3g Review summary

High Fidelity Simulation appears to have a small positive effect on clinical reasoning, CDM, knowledge acquisition, clinical confidence and critical thinking however the positive improvement found in the reviewed studies was not statistically significant most of the times. The findings demonstrate that HFS has a more consistent positive effect on clinical competency compared to the other outcome measures. There is more focus on measuring knowledge acquisition and confidence but with contradicting results. There are many methodological limitations of the identified studies (section 3.3.2) that may have contributed to these inconclusive findings. The simulation designs in most of the nursing studies discussed above do not clearly describe the activities included in the simulation session such as briefing, performance and debriefing. There was limited discussion about follow-up, retention of skills and knowledge and the role of debriefing after the simulation experience.

There was inconsistency in the type of tests to use between the studies and most of the identified studies did not directly measure clinical reasoning and CDM. There was a limited number of studies that were specifically designed to evaluate or explore the effectiveness of manikin-based HFS on clinical reasoning and clinical decision making. It was also identified the lack of studies that investigated both the decision-making process and the outcome of the CDM using manikin-based HFS. Therefore, more research on the impact of HFS on students clinical reasoning, how nursing students make decision using HFS and how HFS affect students' CDM.

3.4. Simulation: a learning and teaching strategy

To develop an understanding of how clinical simulation could potentially influence nurses' clinical decision. It would be important to discuss how people learn through simulation. The follow sections discuss the pedagogical basis of clinical simulation.

Learning occurs in a variety of ways. Learning from people's experience is a natural result of life and it occurs in different environments or contextual frameworks. A simulation that includes the use of clinical scenarios and debriefing to reflect on performance, is a teaching and learning method that fits well with many theories in teaching and learning (Hughes and Quinn, 2013). Simulation is aligned with experiential learning theory (Kolb, 2015) that recognises the importance of learning through experience and reflection on experience. Kolb (1984, p38) explained that "learning is the process whereby knowledge is created through a transformation of experience". Tailoring the experience during a performance, facilitating abstraction and generalisation from examples during the debriefing, and explaining concepts supports learners to reflect on action and generating insights that go beyond the concrete scenario to have relevance to the clinical world of practice.

Many nursing researchers considered experiential learning and situated learning as the theoretical origins of simulation (Bland, Topping, Wood, 2010; Buykx et al, 2011). Others considered constructivism (Decker, 2007) as the theoretical underpinning of simulation. Constructivism focuses on the way people acquire new knowledge and skills and the way existing knowledge and skills are modified (Hughes and Quinn, 2013). It originates from the work of Piaget and Vygotsky (Vygotsky, 1986). They described that meaning is constructed by the learner from their experience and social interaction with others. Learning through engagement in activities that are perceived as authentic and contextually embedded resonant with the Situated Learning Theory (Lave and Wenger, 1991). A large body of knowledge in both medical and nursing literature found that debriefing is a key component in learning from simulation experience with many structured and valid tools have been constructed to support and maintain the quality for the debriefing session (Dreifuerst, 2010; Buykx et al, 2011; Jaye, Thomas and Reedy, 2015; Ahmed et al, 2013). Lestander, Lehto and Engstrom (2016) conducted a reflection model post-simulation using individual written reflective text followed by group debrief and found that the simulation promoted thoughtfulness and enhanced self-awareness among nursing students. Similar findings in Sedgwick, Grigg and Dersch (2014) study who reported that participants using self-correction and improved their self-awareness.

Clinical simulation provides an environment that is fully attentive to learners' needs and creates opportunities for repetitive practice. It allows the demonstration of behaviours and competencies with instructors' reinforcement through debriefing and feedback which is linked to the principles of behaviourism (Olson and Hergenhahn, 2009). Simulation allows gradual exposure to more complex clinical situations. Breaking the complex tasks into smaller parts may also enhance scaffolding based on the "Zone of Proximal" development described by Vygotsky (Vygotsky (1978). If appropriately designed, it can facilitate the activation of prior knowledge, the actual developmental level, and the use of a structural way to learning new knowledge or achieve the potential development level. Therefore, simulation has the potential to enhance information processing through effective information clustering and pattern formation in the working memory. Subsequently, this facilitates patterns integration within the long-term memory, optimising storage and retrieval of information based on the principles of cognitive learning theory (Newell and Simon, 1972). Simulation is considered a compatible, relevant and appropriate teaching and learning strategy for adult learners if appropriately designed. Simulation has pedagogical advantages in healthcare education as it provides a relatively safe or a non-threatening environment for students to learn and practice without harming patients.

Problem-based learning is a teaching and learning strategy in which clinical problems are presented to a student, and the learning results from the process of working towards an understanding or solution of the problem (Barrows, 1986). A clinical simulation that uses high fidelity simulators is an active learning strategy which applies the principles of PBL method by actively engaging students in the learning process to solve a clinical problem through searching for key information, analysing and weighing the clinical cues, identifying the problem and appropriate solutions (Barrow and Feltovich, 1987). It places learners at the centre of the learning process and the educators act as facilitators for learning. The use of scenario-based simulation stimulates deep learning and support the use of critical thinking and development of clinical reasoning (Richardson and Trudeau, 2003).

In the methodology of problem-based learning, Barrows (1986) described that importance of introducing the student to the patient case study in the similar way the student would encounter it in clinical practice and without prior preparation. The students then work through the patient case study, practising critical thinking and reasoning skills to develop new knowledge and skills. The information needed is identified in the process of working through the patient case study. Barrows (1986) suggested that learning occurred during the work with the problem or the patient case study gets integrated into student's repertoire of knowledge and skills.

3.4.1 Simulation: a learning context

Simulation-based training in the healthcare context refers to performing a range of tasks, i.e. technical, procedural, and cognitive, decision making, problem solving or social interaction. Task performance and clinical decision making are dependent on contextual factors in which the task is performed for example the uncertainty and stability of the situation, the complexity of the tasks and the individual's abilities. Forrest, Mckimm and Egar (2013) suggested that three main factors that affect students' learning; the task, the context and the person performing the task, these factors are similar factors to those that affect people in decision making literature as discussed in section 2.7.1. It would be important to recognise and consider that novice learners can only cognitively process a limited amount of data and a complex task may need to be broken to sub-tasks to reduce the complexity level of the learning situation (Forrest, Mckimm and Egar, 2013). Simulated scenarios must reflect reality to ensure its effectiveness and can be used as a tool for authentic education of clinical problems as they present in a different environment. The learner's action unfolds in the interaction between the learner and the surrounding environment. The context provides meaning to the interactions between people and the environment.

Simulation can support learning, even though some aspects of the simulation situation are not identical to the actual clinical situation. However, similar patterns may actually underlie both situations so the appearance of a situation may be different while the underlying structure of the situation is similar or even identical (Dieckmann and Ringsted, 2013). Therefore, simulators may appear unrealistic in physical terms but allow the learner to construct a consistent meaning of the situation and experience it as relevant. Authentic education learning could occur when approaches are used that allow conceptual knowledge to develop contextually in settings that reflect reality. Simulation if properly designed could provide an appropriate contextual environment that facilitates authentic learning.

3.4.1a Simulation: a context for exploring CDM process

Nursing studies that explored clinical reasoning and decision-making processes focused more on using paper-based simulation or used recorded videos (Jones, 1989; Fonteyn, Kuipers and Grobe, 1993; Funkesson, Anbacken and Ek, 2007; Fossum et al 2011) with only limited studies that used manikin-based HFS to explore students' clinical reasoning and decision making (Walsh, 2010). There is a limited nursing studies that explored the effect of cognitive biases on nursing students' clinical reasoning and decision-making skills (O'Neill, 1994; Mullenback, 2007). All of the identified studies that explored the effect of cognitive biases on CR and CDM are based on paper-based scenarios without the use of HFS. The impact of cognitive bias and heuristic on nursing students' clinical reasoning and decision making is lacking evidence. The effect and usefulness of HFS on investigating biases require further research. Cognitive biases and heuristics can significantly affect the quality CDM (Croskerry, 2002; Mannion and Thompson, 2014) and this effect requires further exploration.

High fidelity simulation (HFS) that include scenario-based task management, facilitator support and guided reflection, may have positive effects on students' high order cognitive skills such as analysis, evaluation, deduction and induction (Bloom et al, 1956). These components of clinical reasoning and clinical decision-making skills. HFS could enhance students' decision making, the conscious type of decision making, by enhancing pattern formation through more effective information processing and reflection. In addition, the debriefing could help in increasing students' awareness of their unconscious type of decision and the associated biases. HFS could be used to understand humans' behaviour and decision making during their performance, a principle used by (Gaba and DeAnda, 1988).

3.5. Summary

- The finding of the review is inconclusive about the impact of HFS on clinical reasoning and decision making for undergraduate nursing students. The small positive effect on clinical reasoning, CDM and the used attributes was not always statistically significant.
- The identified studies mainly used a single method and had many methodological limitations that affected the overall findings.
- There was limited research on how nursing students make decisions using HFS.
- The identified studies gave little emphasis on the importance of debriefing as part of HFS and how debrief impacts on CDM.
- There was limited follow-up assessment about the effects of used HFS on students' CDM in the real world of practice.
- There was no discussion in the identified studies about the effect of cognitive biases on the quality of CDM among nursing students when HFS is used.
- This study has adopted a mixed methods multiple phase design to investigate the outcome and the process of CDM using manikin-based HFS. It also explores the cognitive biases that could affect the quality of CDM. The study also followed-up students after weeks of clinical practice to explore the how students perceived its benefits in their clinical practice. This approach will be discussed in details in chapter 4.

CHAPTER 4
METHODOLOGY

4.1. Introduction

This chapter presents the research methodology and methods for my study. The personal and philosophical overviews which influenced the choice of a mixed-methods approach to the study are discussed. In the chapter, the aim and objectives of the study are outlined. The chapter also includes discussion of the procedure and methods of the data collection, the tool construction, sampling and limitations.

The study's primary focus was on examining the types of clinical decision making (CDM) used by third-year pre-registration nursing students during a manikin-based High Fidelity Patient Simulation (HFS) experience and how this experience affected their CDM skills. This was assessed by measuring pre- and post-experiment clinical reasoning (CR) scores, observing students' behaviours and actions following the designed stages in the CDM process and by analysing their thought processes using think aloud during the experiment and debrief. A secondary focus of the study was to identify students' cognitive biases during the experiment that could be used to develop a tool to support students in their learning about cognitive biases.

4.1.1 Aim and objectives

The study main aim was to evaluate and explore clinical decision making among third-year pre-registration nursing students using HFS. Specifically, the objectives included:

1. Evaluate how a HFS experience affects CDM of nursing students.
2. Explore the types of CDM commonly used by nursing students.
3. Explore and identify cognitive biases used by students during the experiment and how it affects their decisions.
4. Explore nursing students' perceptions of the usefulness and transferability of the simulated experience to the clinical practice.

4.1.2 Research questions

The study was guided by four research questions:

RQ1: Is there a difference in clinical reasoning (CR) and clinical decision making (CDM) measures for students after having HFS experience?

RQ2: What are the CR and CDM types used and cognitive errors made by the third-year nursing students in managing acutely deteriorating patients using HFS experience?
RQ3: Do students who use mainly the non-analytical mode (type1) of clinical decision making in HFS experience perform differently on measures of CR and CDM to those who mainly use the analytical model (type 2)?
RQ4: How do students perceive the usefulness of HFS experience on their clinical practice?

4.2. Methodology and Methods (philosophical rationale for the research)

Selection of appropriate methodology and methods of inquiry is essential to answer the research questions. The direction the research takes in terms of the topic, methods, presentation and utilisation of the results is largely influenced by personal values, beliefs and assumptions about truth and knowledge (Guba and Lincoln, 2005). In order to select appropriate research methods for this study, it was first necessary to consider my personal and philosophical position in relation to research and knowledge. The consistency between the research objective, question and the selected methods and personal philosophy of the researcher is a fundamental consideration in any research project (Halcomb and Hickman, 2015). Easterby-Smith, Thorpe and Jackson (2012) supports this view and argues that the reasons for this are: to enable the researcher to select the most appropriate methodology to conduct the inquiry, to allow the evaluation of other methodologies helping to avoid any inappropriate selection or unnecessary work, and finally to help the researcher to develop their research experience and try new approaches.

Burrell and Morgan (1979) suggest that to develop philosophical perspectives requires the researcher to make several assumptions concerning two main dimensions: the nature of society and nature of science. The sociological dimension considered the choice between a radical change view of society and the regulatory view of society. The science dimension is about considering the objective or subjective approach to research. These philosophical approaches are defined by several assumptions concerning the ontology, epistemology, human nature and methodology. These assumptions are consequential to each other, and that the researcher's view of ontology or reality affects his/her knowledge or epistemological persuasion which, in turn, affects his/her view of human nature and their relationship with the surrounding environment. Consequently, the choice of methodology logically follows the assumptions the researcher has already made (Burrell and Morgan 1979; Holden and Lynch, 2004). Therefore, it is important to acknowledge worldviews and the underlying assumptions that guide the choice of methods in this study (Carter and Little, 2007).

Giddings and Grant (2006) advise researchers to consider the environmental and personal factors before placing the research within a particular paradigm.

For this study, I have to consider factors related to my personal biases and values and the dominant traditions in the medical and nursing disciplines and in higher education. I am a nurse academic specialised in acute and critical care nursing and required a paradigm accepting my inability to be totally objective and value-free. For this research to contribute to future nursing education and clinical practice in acute care settings, the study required data collection, analysis and reporting methods acceptable to medical, nursing and educational bodies responsible for clinical education and staff development. Having considered my personal and environmental factors, this chapter will discuss the postpositivist, the interpretivist and pragmatist philosophical points of view and will demonstrate a rationale for the adopted views, methodology and methods.

4.2.1 Positivism and postpositivism

Positivism emerged in the 18th century, the period of Enlightenment, as a response to acquiring accurate scientific knowledge about the universe. Positivism was conceived as the philosophical underpinning of the scientific method by Auguste Comte. He used methods, such as experiment and observations to describe scientific principles of social and natural science and argued that all the meaningful knowledge should be borne by the observed objective reality (Hansen, 2004). Positivism aimed to eradicate speculation and focused on objectivity and scientific methods of verification based on the belief that single objective reality exists, independent of human behaviour (Giddings and Grant, 2007). For this position, fundamental scientific laws were formed, hypotheses generated, tested and generalised. This philosophical realism adhered closely to the hypothetico-deductive and quantitative methods (Mill, 1906; Guba and Linclon, 2005) and the verification and objectivity led to the philosophical assumption of determinism and reductionism. Giddings and Grants (2007) explained that reductionism means that experience can be reduced to concepts for describing and testing, and determinism means all the effects have determinable causes and actions have predictable outcomes. Positivism has been the dominant force for science for the last 150 years. In fact, it is often described as the “received view” (Guba and Linclon, 2005). Belief in objectivity continues to dominate the current approaches in medical research, whilst social and nursing sciences have embraced other concepts particularly in recent times. The evidence-based medicine still considers randomised control trial as the golden standard for research evidence, consequently placing the quantitative research at the top of the hierarchy of evidence that attracts more funding and research output more than the qualitative research (Andrew and Halcomb, 2009).

Postpositivism emerged as a moderated form of positivism and retained many of the positivism philosophical assumptions, and is viewed by many an extension of the traditional scientific paradigm (Tashakkori and Teddlie, 2010). It arose out of the dissatisfaction with some aspect of the positivism stance. Rather than accepting objective and comprehensible reality, postpositivism acknowledges objective reality but only as imperfectly comprehendible. Postpositivism moved away from the deterministic assumption that only assumed a linear relationship between cause and effect to an assumption that considered more complex causative factors that interacted to influence the outcome.

Positivist stresses theory verification or confirmation to confirm a hypothesis and postpositivism uses theory falsification to support hypotheses (Giddings and Grant, 2007). Despite the differences, they share both the same goal to an explanation that leads to prediction and control of phenomena that can be studied, identified and generalised and both advocate objectivity and a detached researcher role. However, they disregard the fact that many human decisions are made throughout the quantitative research process including what to study, developing the instruments that are believed to measure what the researcher views as being the target, making score interpretation, statistical probability, drawing conclusions and interpretation based on the collected data and then deciding what is practically useful (Johnson and Onwuegbuzie, 2004). It is a process full of decisions made by humans, whose decision is prone to subjectivity, so this raises a question as to whether full objectivity and value-free research are practically achievable and possible?

Postpositivism also acknowledges that phenomena themselves often cannot be measured precisely and may be subjected to the influence of unmeasurable factors, therefore, science is subjected to change when new knowledge becomes available. This perspective is relevant to the current study as clinical decision making is a complex process subject to the influence of many factors that would be difficult to control and measure by using one measurement and using one method of data collection. This discussed further under section 4.2.4.

4.2.2 <u>Constructivism and interpretive</u>

Thomas Khun (1922-1996) opposed the positivist assumption of objectivity. He postulated that a paradigm, which determines the researchers' methodological approaches, may prevent them from being objective (Crotty, 1998). He described quantitative methodology as part of the human affairs, with researcher interest, value and fallibilities and foibles (Crotty, 1998, p. 36). He suggested a scientific revolution and proposed a new way of viewing reality, beyond what could be observed and measured. He discussed individual perception and cognitive processing, allowing new epistemology to emerge that is based on subjectivity, relativity and the researcher influence in the generation of knowledge, concepts that oppose the objectivist stance. Historically, Kant's (1749) work cited in Ponterotto (2005) led to the evolution of qualitative thinking and the development of the interpretive paradigm. Interpretive researchers believe that reality or meaning of phenomena, formed from people's subjective views and experiences of the external world. When people provided their account, they spoke of the meanings formed by social interactions with others and their own understanding. Interpretive researchers observe and collect information about events, while interpretation is to make meaning of the collected data by drawing inferences to make sense of the meaning (Denzin and Lincoln, 2005).

Weber (1949) argued there is no single objective reality and that the study of social observation is subjected to the interpretation of the individual who can never be truly objective. The interpretation is a singular point in time and influenced by our prior experience, knowledge and culture, so it is merely a social construct (Denzin and Lincolin, 2005). Qualitative methodology is rooted in the constructivism and subjectivism paradigm, aims to develop an in-depth understanding of the phenomena under investigation. It is a value-laden approach with inherent biases that require the researcher to interact with the subjects being observed, understanding the meaning and contextual influencing factors through induction (Hughes and Sharrock, 2016). However, this has its own limitation as strong relativism and constructivism in qualitative research could reach multiple, contradictory, but equally valid accounts of the same phenomenon, as people vary in their subjective states and opinions, consequently producing multiple subjective realities that limit theories commensurability. Connell and Nord (1996) argued that if reality is external and unknown to humans, how can we accumulate knowledge about it? And if we are accumulating knowledge about it, how do we know that we are doing it? Qualitative and quantitative researchers are beginning to reach agreement on several points of philosophical dissonance (Johnson and Onwuegbuzie, 2004).

4.2.3 Pragmatism

Pragmatism has been proposed as the theoretical underpinning for mixed methods research. Mixed methods research is defined as "research which collects both qualitative and quantitative data in the one study and integrates these data at some stage of the research process" (Andrew and Halcomb, 2009, p. 9). A range of philosophical approaches may be used in mixed methods research. Creswell and Plano Clark (2011) advocated four stances on using worldviews in mixed methods research; (1) a single worldview such as pragmatism or transformative, (2) the multiple world views that depend on how the researcher understands the social world, (3) multiple worldviews combined and finally (4) depend on the shared belief of the scholar community. Pragmatism is a philosophy that seeks to encompass the insights provided by qualitative and quantitative research into a workable solution. It has been found to be the most frequently used approach in mixed methods research as suggested by Tashakkori and Teddlie (2003).

Pragmatism emerged from the work and discussion of classical pragmatists, for example, John Dewey, William James and Charles Sanders Pierce (Johnson and Onwuegbuzie, 2004). It is an approach evolved to help researchers understand how to mix different methods to find a workable solution, to produce fruitful results and advance the knowledge (Hoshmand, 2003). Peirce and Dewey suggest that when judging ideas, concepts or statements we need to understand the practical consequences and effects of these ideas (Halcomb and Hickman, 2015). Pragmatists view the research problem as the most important issue, valuing both subjective and objective observations to reveal the answers and claim that the concepts of metaphysics and the dichotomy between the constructivism and postpositivism should be abandoned (Tashakkori and Teddlie, 2010; Creswell and Plano Clark, 2011; Halcomb and Hickman, 2015).

Combing the philosophical frameworks remains one of the most contested aspects of mixed method research (Greene, 2008; Andrew and Halcomb, 2009). The dichotomy between the qualitative and quantitative research presents an obstacle and barrier for good research design. Assumptions on adopting mixed methods for the current study are summarised in Table 4.1.

Table 4.1 Philosophical assumptions (based on Creswell and Plano Clark 2011)

Worldview element	Post-positivist	Constructivist	Pragmatist (This study)
Ontology (nature of reality)	Objective reality which is single and concrete	Assumes the existence of multiple realities. Reality is socially constructed.	Singular and multiple realities. A quantitative method is testing a hypothesis, prediction and making associations. Qualitative methods exploring different perspectives/aspects of the decision-making process
Epistemology (what is account as knowledge?)	Distance and impartiality (e.g. objectively collecting data by instruments) the knower and the known are independent	Closeness (e.g., visit participants on their site to collect data) the knower participates in the known.	Practicality (e.g., collect data by "what works" at the time to address specific research questions). Adopting an approach that is realistic, practical and better than the other approaches in answering particular questions.
Axiology (what is the role of value?)	Unbiased (e.g., researcher uses checks and control to eliminate bias, beliefs and interest) value-free	Biased (driven by researcher's beliefs, interest and researcher continuously talk about their bias) Value-laden	Multiple stance (researcher include both biased and unbiased perspectives). Value neutral. The values of anything is determined by its usefulness in achieving some end.
Methodology	Deductive instrumentally predict or describe reality. Hypothesis and theory testing.	Inductive, emergent and shaped by the researcher experience	Combining both deductive and inductive methods. Apply multiple methods to collect data that best answer the research question, with focus on practical implications of the research

4.2.4 <u>Mixed methods</u>

Mixed methods have been evolving in the last few decades as a new methodology. Mixed method research was considered as a suitable approach for this study, as identified above. Greene et al, (1989) suggests mixed method approach combines the inquiry paradigms, Tashakkori and Teddlie described in the 1990's as a mixed methodology; a combination of quantitative and qualitative approaches in the methodology of the study. Many other researchers have given it different names such as multi-strategy (Bryman, 2004) or mixed methods (Tashakkori and Teddlie 2003). Greene (2008) stated that it is multiple ways of hearing, seeing and making sense of the social world. Creswell and Tashakkori (2007) described it as when a researcher collects, analyses data, integrate finding and draws inferences using both qualitative and quantitative approaches and methods in a single study.

Creswell and Plano Clark (2011) suggested that mixed method research is a research designed with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis and the mixture of quantitative and qualitative approaches in many phases of the research process. As a method, it focuses on collecting, analysing, and combining both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches, in combination, providing a better understanding of research problems than one approach alone. The need for scholarly research using both qualitative and quantitative methods was first voiced in the late 1950's. Mixed method research strongly emerged in the late 1980's as qualitative research became more accepted and researchers started to combine both qualitative and quantitative methods with a single study (Bazeley, 2009; Creswell and Plano Clark, 2011).

Creswell and Plano Clark (2011) explained that the evolution of mixed methods had five distinct periods: the formative period, the paradigm debate period, the procedural development period, the advocacy and reflective period. The formative period described the late 1950's and early 1980's trends of gathering, integrating and analysing different types of data by scholars in psychology and sociology. Well- known quantitative researchers advocated the use of qualitative data in experimental design such as Cronbach (1975). The paradigm debate period developed in the 1970's and 1980's, as qualitative scholars started to debate whether or not qualitative and quantitative data could be combined, as each belonged to distinctively different paradigms and philosophical assumptions (Guba and Lincoln, 2005). This debate led to a further debate on combining different data or methods, and combining paradigms, and resulted in the embracing of pragmatism as the best philosophical foundation for mixed methods research (Tashakkori and Teddlie, 2010; Creswell and Plano Clark, 2011). The procedural development period evolved when procedures and techniques of collecting and analysing data began to emerge in order to conduct a fruitful mixed method research (Creswell and Plano Clark, 2011).

After this period researchers from different disciplines, including nursing, education and public health, proposed multiple types of mixed method designs, each with distinct procedures (Greene 1989; Bryman 2004; Creswell and Plano Clark, 2011). This led to the advocacy period with the acknowledgement of mixed methods research as separate methodology, method or approach in the late 1990's (Creswell and Plano Clark, 2011). The reflective period started after 2003, this period focused on the criticism of how mixed methods research developed, its current state, and how it needs to develop further in future.

4.2.5 Adopted approach and methodology for this research study

Clinical decision making and reasoning are complex processes and many nursing studies focused on examining CDM and CR either by using a quantitative or qualitative method. I believe there is a complex array of causative factors that interact with each other to affect the process of clinical decision, as described in chapter 2 (section 2.7), and that one type of data or single method might not adequately address this complexity (Mesel, 2013). My study explores how nursing students made their decisions using scenario-based HFS and will apply multiple tools to carry out this examination to raise confidence in the findings. Whilst being embedded in medical, nursing and academic culture, nowadays there is understanding and acceptance that the generation of knowledge requires both qualitative and quantitative approaches. Both are essential to inform and develop clinical practice and education and as such produce knowledge which has practical applications and is, therefore, valuable.

Based on the discussion above (section 4.2.1 to 4.2.3), quantitative research primarily presumes some sort of permanence about the world which allows generalisations to be made. It is not always possible to make generalisations when studying human beings, given their uniqueness and ever-changing environment. Whilst quantitative research concentrates on validity and reliability, qualitative research concentrates on trustworthiness and authenticity (Bryman, 2016). My personal philosophy in life is always to use a dynamic flexible approach that answers my practical question and since both the qualitative and quantitative approaches have strengths and limitations. A pragmatic approach was adopted and a mixed methods research design was deemed the most suitable methodology to meet the study aim and research questions. Pragmatism found to be appropriate for this study as it has been considered as a middle ground between the two classical philosophical stances, subjectivism and objectivism, a position that aimed to find a workable solution (Tashakkori and Teddlie, 2010; Creswell and Plano Clark, 2011).

This approach considered both worldviews; a post-positivism worldview to answer particular research questions based on established theories in CDM and an interpretive worldview to observe students' actions and discuss their experience of the same phenomena. Finally, a follow-up interpretive approach answers different research question related to students learning experience in the real world of practice. This design provides broader focus, collects more comprehensive data about the problem, adds breadth to the findings to adequately address the phenomena under investigation and to compensate for the limitations of a single type of findings. It provides flexibility and a dynamic approach that focuses on consequences of learning from HFS on practice. Mesel (2013) suggested that complexity in the healthcare system require methodological pluralism that utilises the strength of both qualitative and quantitative approaches. This also will bring value to the research process if the findings are contradictory, it may reveal particular assumptions, constraints and biases in measuring or interpreting the findings (Giddings and Grant, 2006). Pragmatism offer practicality, pluralistic and a problem-centred approach for investigating clinical decision making, examining of consequences of students' actions and usefulness of HFS for the participants (Creswell and Plano Clarke, 2011).

4.3 Research design

To achieve the current research aims and objectives, a multiphase research design was used in two phases (see Figure 4.1): a pragmatist approach was adopted to construct a mixed methods design for this study. Creswell and Plano Clark (2011) describe a multiphase research design that combines both sequential and concurrent strands over a period of time. They suggested that this design is usually used in program evaluation, where a mixed quantitative and qualitative approaches are used over a period of time to develop or adopt particular interventions. This design suits the aim and objectives of this study outlined in this chapter introduction (section 4.1), as exploratory and evaluation study.

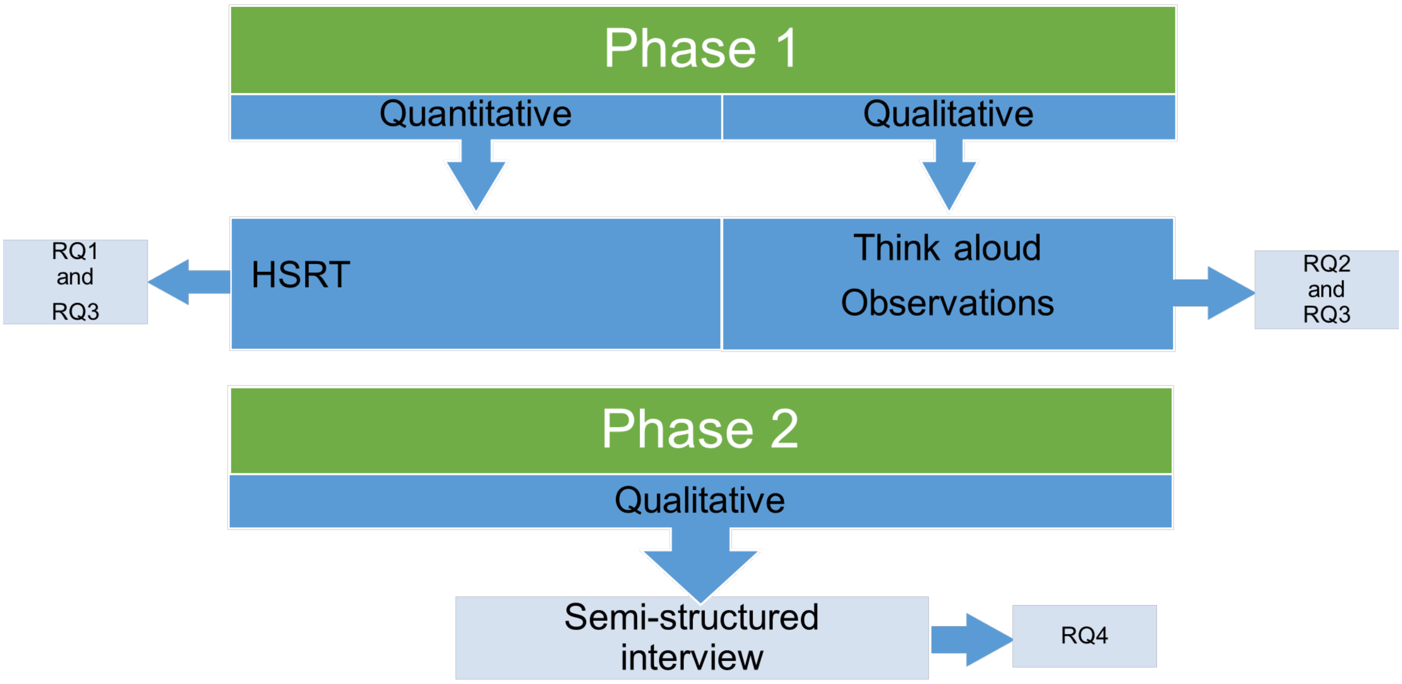

Figure 4.1 Multiphase research design

Four methods have been used: thinking aloud, observation, Health Science Reasoning Test (HSRT), and a semi-structured interview. HSRT is a valid and reliable test to assess measures for clinical reasoning (CR). The study has two phases that are described below.

4.3.1 <u>Phase one</u>

This is the main phase of the study and it utilised a mixed methodology and different ways of collecting and analysing data in a parallel manner. This design is described as 'convergent parallel' by Creswell and Plano Clark (2011) and 'simultaneous' by Tashakkori and Teddlie (2010). The researcher collected both types of data (qualitative and quantitative) and gave both types of data equal emphasis and priority. The phase followed a quasi-experimental approach with an interventional group, without a comparator group, a pre- and post-design and used a convenience sample of 23 pre-registration nursing students (Polit and Beck, 2014).

The data was quantitatively collected using instruments that assess measures of CR and CDM. The qualitative explorative data was collected using thinking aloud and observation and through which the researcher sought to understand students' actions via think aloud but also to expand on the cognitive errors that affected their decisions. The rationale for this approach of combining different methods is to correlate and corroborate the data and provide more breadth and depth of understanding of the decision-making process and to answer the research questions (Creswell and Plano Clark, 2011). This part of the study examined the impact of simulation on third-year nursing students' decision making and reasoning score. It also examined the type of decision making, operators and cognitive biases used by students' nurses in simulation settings. The types of decision making, cognitive biases and operators used in the process of decision making were correlated to the quantitative tests and literature. The collected data was used to answer the research questions 1-3 and to help in developing observational tools for nursing students about their type of CDM and associated cognitive biases.

4.3.2 <u>Phase two</u>

Phase two was a complementary and sequential phase that provided insight about the transferability and the perceived benefits of the simulated experience to the clinical practice. An interpretive approach was used to collect and analyse the data in this phase to complement the data from phase one and to explore any new issues or themes. It explored the students' feedback about the transferability and usefulness of this experience in their clinical practice in the real world and whether a particular type of bias and decision making is more common than others. The data was collected using short individual semi-structured interviews after four to six weeks of clinical practice.

4.4 Sampling, sample size and setting

Nursing students in the pre-registration adult branch at one university were the target population for this study. A convenience sample of self-selected, nursing students enrolled in a baccalaureate degree nursing program at one university in the south of England were recruited for this study. The sample was recruited from third-year pre-registration nursing students in the last six months of their course. This population was selected because they had prior experience with high fidelity simulation and had prerequisite knowledge of the clinical context of the simulation experience.

The BSc adult nursing curriculum has 9 modules; module 1, 2, 4, 5 and 9 are theory modules, module 3, 6 and 8 are practice modules and finally, module 7, the acute care module, is a theory and practice module (Table 4.2). All the students had successfully completed their acute care module, (module 7) before enrolment in this study, this is to ensure that the prerequisite clinical knowledge for this study has been attained in order to examine the decision-making processes. This sampling method was used as it was easier to access the subject of the study, and because the study is aimed to explore CDM and the effects of simulation on CDM, to help in developing tools that optimise the nursing students' decision-making skills.

Table 4.2 BSc Adult nursing curriculum

Year	**Module**	**Module description and focus**	**Simulation input** Not part of clinical hours
1	One: theory Two: theory Three: practice	Bioscience and fundamentals of nursing. Research process and fundamentals of nursing. Medical and surgical placement wards (primary to tertiary care settings).	Low to medium fidelity simulation
2	Four: theory Five: theory Six: practice	Public health module. Nursing theories and models. Long-term conditions, clinical placement in medical and surgical areas.	Range of simulated practice: low- high fidelity, manikin based or actors based simulation.
3	Seven: theory and practice Eight: practice Nine: theory	Acute care module: 7 weeks of theory and 7 weeks of practice. Placement in acute wards and acute care units. Six months, focus on clinical management, students' clinical placement in medical and surgical placement Degree dissertation module	Usual manikin based HFS frequently used but not based on theories of CDM. <u>Recruitment for this study after module 7</u> Limited simulation input at the end of the module, as this module is a practice module. <u>This study phase 1 data collection within the first 2 weeks of module 8. Phase 2 data collection after 4-6 weeks of clinical practice</u>

High fidelity human patient simulation is an existing component in this course and all the students were involved with similar simulation experience in managing acutely ill patients one to two months before the study commenced. The students were recruited from two subsequent cohorts to increase the sample size for demonstrate adequate effect of the intervention on outcome measure. Students who are under direct supervision or personal tutees and those who could be assessed by the researcher were excluded from this study, to ensure and maintain power balance and reduce any potential research bias (see Table 4.3). Participation in this study was voluntary and students completed a consent form.

Table 4.3 Selection criteria for the study students

Final year pre-registration nursing students
In their last 6 months of their nursing degree course
Passed the acute care module and before they started clinical practice in module 8
Researcher did not have direct tutoring, assessment or academic support
Adult branch

This study adopted mixed method design with a quantitative and qualitative methodology. There is little prior data reported on this as no similar study has been carried out using the same design and settings. A small sample size is common in studies using think aloud (TA) (Aitken, 2003; Hoffman, 2007), as data collection will provide a large amount of data for each student which can be investigated in depth. Twenty-three students completed the two phases of the study. For phase 2, all the participants were invited to participate in both phases at the beginning of the study as part of the voluntary participation. The study considered a short follow-up interview so gathering more views will increase the richness of the data as every participant might perceive the benefits of simulation experience in a different way. All the 23 participants attended the second phase follow-up interview and this generated a rich amount of data about how students perceived the benefits of HFS to their clinical practice.

4.4.1 Procedure

Prior to the study, the course leader was approached, the study was discussed and permission sought to conduct the study in the cohorts that meet the study inclusion criteria. The module leaders and students' personal tutors were approached and the study was discussed with them with a view to accessing the cohorts. Permission was granted from all involved and the study was then explained to the target cohort by the researcher at the end of a scheduled session, 95% of the student cohort being present. The students were provided with Participant Information Sheet (PIS) and researcher contact details. Students interested in the study provided the researcher with their contact details and were happy to be contacted, and other students contacted the researcher at a later date. During subsequent sessions, those interested were approached and after answering all of their questions, informed consent was obtained (more details under section 4.6).

The decision-making examined in the study was based on an acutely ill patient with physiological signs and symptoms of clinical deterioration. This study aimed to examine the CDM during the simulated experience and therefore a control group was not used. A control group could be used for comparative purposes; a group of students that is similar to the interventional group, except that they are not exposed to the intervention (Polit and Beck, 2014). The absence of a control group in this study makes it difficult to infer that the post-test differences in HSRT were as a result of the intervention. However, the simulation was the only educational intervention used between the pre- and post-test. One criterion for causality is the existence of a relationship between variables but it is risky and more difficult to infer causal relationship without the use of randomisation and control (Polit and Beck, 2014).

4.4.2. Settings and simulation design

The simulated session was structured in four stages (Figure 4.2). The simulation initially started with an introductory session that included reminding students of the airway, breathing, circulation, disability and exposure (ABCDE) approach, practising thinking aloud session and orientation to the simulated environment, equipment, manikin and the role of the facilitator. In the second stage, students were given a clinical scenario, patient's records including past medical history and drug charts and were asked to think aloud and respond to patient's needs (section 4.4.2a). At this stage, students reviewed the paperwork and immersed in the simulated experience in their clinical assessment and management of the patient's symptoms.

The third stage was the debriefing and reflection on practice. In the debriefing stage students initially reviewed the recorded videos of their performance and then a structured debrief session was carried out using an adapted SHARP debriefing tool (Ahmed et al, 2013) and tailored questions were used to seek clarification on students' actions during performance and concurrent think aloud (TA) (Appendix 5). The focus of the debriefing session was on the collected cues, how it had been related, problem identification and decisions made. In the final stage, the facilitator introduced students to cognitive biases to increase their awareness about the potential effects of biases on the quality of their clinical decision making. The facilitator gave them a list of different biases with a definition and example for each bias and asked them to identify the biases that affected their decisions in the simulated scenario (Appendix 6). Finally, a list of biases and key debiasing strategies identified from the literature were given to students, so they could reflect on future clinical practice (Appendix 7). This is an approach that aimed to increase students' awareness and attempt to reduce their cognitive biases (Croskerry, 2002; Croskerry, 2003).

The simulation design was aimed to enhance student clinical decision-making skills, with the orientation on the use of ABCDE as a systematic approach for data collection and intervention, reflection on their actions and debriefing about their approaches to decision making. Nursing students interacted with HFS, collected data, analysed the collected cues and intervened based upon the patient's situation. The HFS was programmed to respond appropriately to the students' interventions, whether it was correct or incorrect.

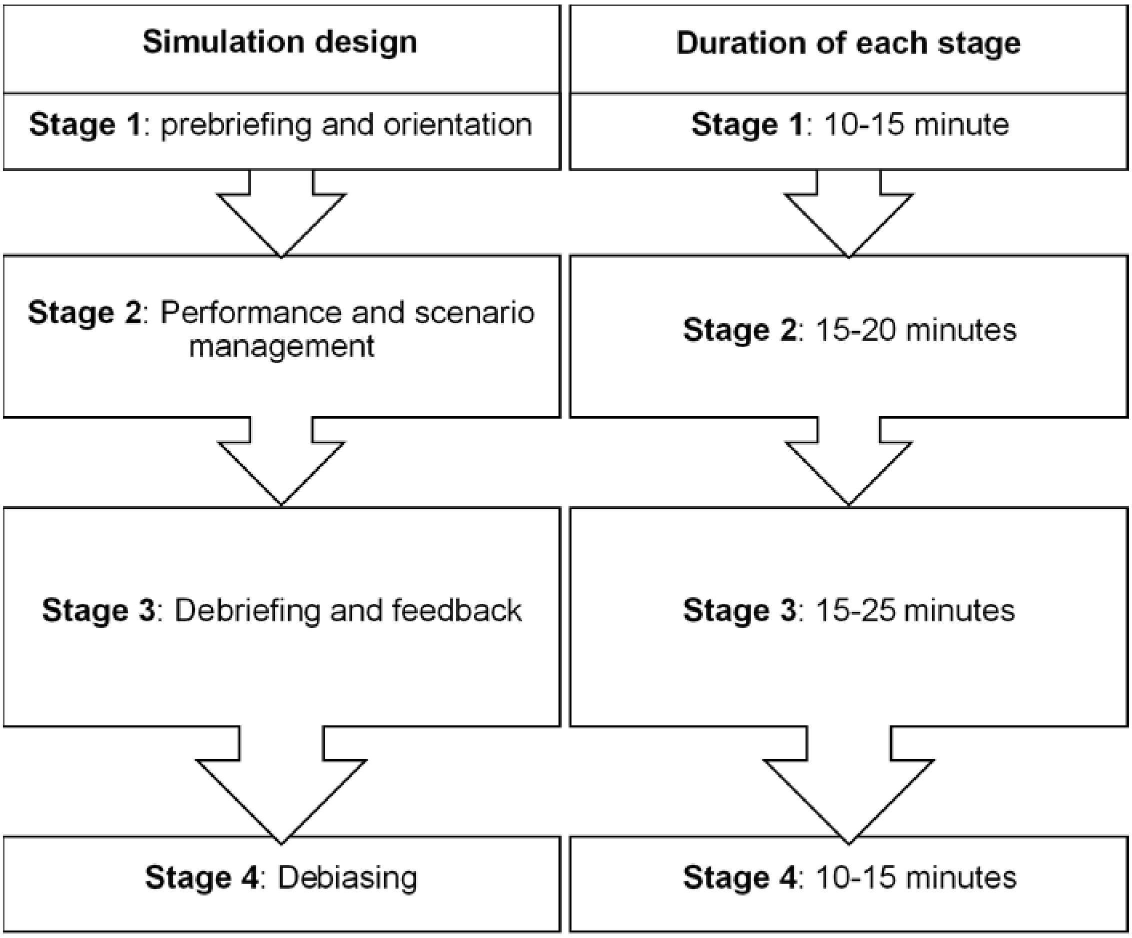

Figure 4.2. Simulation session flow chart

To increase the likelihood of similar conditions for all students, the same clinical scenario was used and a similar simulation environment was created such as placing the patient in a surgical ward, attaching related equipment that represents a surgical ward (Appendix 8). All the students worked individually and followed the four stages of simulation design described in Figure 4.2 with same time limits and same rooms. Students' performance was video recorded using SMOTS (Scotia Medical Observation and Training System), which has cameras attached to the laboratory ceiling and away from students' visual field. The recorded videos were used to support the debriefing and debiasing stages by stimulating their memory recall. They were also used as forms of data record to support the data analysis. The scenario was stopped if the students asked for it to stop or if they managed to identify a range of clinical problems and stopped the blood transfusion and if they reached 20 minutes or called for help or emergency or cardiac arrest. This procedure was followed to increase the external validity of the collected data.

4.4.2a. Clinical scenario

The simulation scenario was based on a previous patient record encountered in clinical practice from clinical experience of the author. The scenario was reviewed by a panel that includes one critical care practitioner experienced in the post-operative care and a senior academic experienced in acute care and simulated practice. This approach was used to enhance the validity and believability of the scenario. The two experts scrutinized the scenario, realism, relevancy, progression and design to maximize the fidelity of simulation experience to meet three conditions: little information was provided at the outset, students could investigate freely, and additional data was made available as the simulation progressed and based on students' questions, an approach outlined by (Barrows and Feltovich, 1987; Buykx et al, 2011). A limited amount of data is given to students to ensure they gradually process the initial cues and the patient situation is gradually increased in complexity to allow the exploration of CDM and associated biases.

The scenario design considered the analysis of the factors that may affect the clinical decision-making process such as the task, person and the context. For example, patient's previous history, the number and type of cues, the complexity of the tasks, the students' level of knowledge and skills as described in section (2.6.2).

The scenario was about a post-operative patient receiving a blood transfusion and signs and symptoms of hypovolaemia and inflammatory response (Table 4.4, more details in Appendix 9). Most of the students have regularly cared for and practised with similar clinical conditions as evident in their demographics (section 6.2.1). The World Health Organisation (WHO) for International Statistical Classification Diseases (ICD 10th) was used to ensure clarity in the definitions of the relevant differential diagnoses for the presented signs and symptoms and clear presentation of the clinical conditions in the scenario (WHO, 2016). The national and international consensus about the assessment and management of the presented clinical conditions were used to create a checklist about the appropriate treatment for the presented problems and associated clinical symptoms (Appendix 10) (NICE 2007; Dellinger, et al 2013; Serious Hazards of Transfusion, 2014; UK Resuscitation Council, 2015).

Table 4.4: case scenario

Carol Stone 65-year-old female admitted to an acute ward post hip replacement surgery. Carol received 800 millilitres (mls) of Hartmann's solution intra-operatively. Post operatively, her doctor continued the Hartmann's solution at a rate of 50 ml per hour via an infusion pump and she was started on blood transfusion due to low Haemoglobin (Hb) level. She has just arrived in your ward and she has a fast respiratory and heart rate. She is complaining of being breathless and getting anxious. Carol reported to you that she was frequently coughing last week.

The checklist in appendix 10 was used to guide the simulation progression to match the programmed trends in the simulator. This approached was used to increase the likelihood of similar conditions for all students, a similar simulation environment was created and the same clinical scenario, physiological signs, symptoms and trends were used for all the students. This procedure was followed to increase the external validity of the collected data.

4.5 Study methods

A variety of methods were used to collect data in the study of decision making and clinical reasoning in nursing. Some of the previously used techniques include self-reported questionnaires (Pirret, 2013), interviews (Benner, Tanner and Chesla, 1992), grounded theory (Smith, 2013) and verbal protocol analysis (Aitken and Mardegan 2000; Hoffman 2007) and observation combined with think aloud (Aitken et al, 2011) case studies using video simulation or computer simulation (Lauri et al, 2001). All are part of a larger umbrella of cognitive techniques used to gain insight and analyse human thought processes and reasoning. Each technique has its strengths and weakness and it depends on the type of data that is required to answer the research question. Broadly two methods are commonly applied: thinking aloud and observation (Van Someren, Baranard and Sandberg, 1994). Clinical decision making and reasoning are cognitive processes, therefore a process tracing technique such thinking aloud and observations are appropriate methodological approaches to using in this study. A quantitative web-based HSRT, to assess clinical reasoning score, is a useful objective measure. A semi-structured interview to gather data from students about the usefulness of the simulation experience and its impact on their practice is helpful to provide insight into students' experience. The primary phase of data collection in phase one involved the think aloud and observation, HSRT and demographic data set. The second phase data collection involved a follow-up semi-structured interview. All these methods provided different but equally valuable data. Each of the data collection methods is now outlined below (Table 4.5)

Table 4.5 Methods

Phase one		
Methods	**Research question**	**Data**
HSRT	RQ1 and RQ3	Quantitative data
Think aloud	RQ2 and RQ3	Qualitative data
Observations/ video analysis	RQ2 and RQ3	Qualitative
Phase two		
Semi-structured interview	RQ4	Qualitative

4.5.1 Thinking Aloud

Think aloud (TA) is classified as concurrent and retrospective; the concurrent refers to the verbalisation during students' performance and the collection of data while a student is undertaking a task and the retrospective TA refers to the verbalisation after the performance. The study employed both concurrent and retrospective TA protocol to increase the validity of the collected data and allow for a more thorough inspection of decision-making processes used by the students and to identify their cognitive biases.

The case scenario of an acutely ill patient using think-aloud protocol was used in this study to explore students' clinical reasoning, decision making and their biases. The focus of the TA protocol was on the meaning of the verbalisation from the individual (Ericsson and Simon, 1993). One of the primary data collection methods used was concurrent TA for a15-20 minute period of care of an acutely ill patient using Human Patient Simulator (SimMan3G Essential (Laederal) in a simulation laboratory. During this period each student was asked to "think aloud" while assessing and managing the patient. They were specifically asked that they do not need to provide any explanation of their thoughts or actions while undertaking patient care as recommended by (Ericsson and Simon, 1993). Retrospective TA, a debriefing period, was initiated with the students reviewing his/her performance using the recorded videos from the SMOTS system first. Then the researcher used open-ended questions to facilitate the retrospective thinking aloud. This aspect had same duration 15-25 minutes, like the concurrent TA (described in section 4.4.2).

Concurrent TA was video recorded and retrospective TA was audio recorded and aimed to explore decision-making process and cognitive biases and observe students' behaviours during this experiment. Collecting both forms of data allows for a more thorough inspection of decision-making processes, increases the credibility of the collected data and contributes to increasing validity of the findings.

Think-aloud verbalisation was originally described by psychologist Karl Dunker in 1945 as "productive thinking" and a way to understand his subjects' development of thought. However, before him, John Watson had described the strong relationship and correlation between human verbal behaviour and thinking (Watson, 1920). Further development of this technique in the field of information processing was described by Newell and Simon (1972). A well-known research Elstein, Schulman and Sprafka (1978) in medicine used various methods in analysing participants' reasoning processes including recall tasks, simulated patient and verbalisation. Joseph and Patel (1990) in their seminal work used the think-aloud technique combined with verbal protocol analysis (VPA) to examine experts' hypothesis generation. They described how verbal protocol analysis allows examination as to how the problem is solved (more discussion in chapter 4). The results of these studies had a strong influence on health professional education (Elstein and Schwartz, 2002) and it was mainly based on low fidelity simulation. This confirms the suitability of this method to investigate CDM using high fidelity simulation.

Within the framework of the information processing model (section 2.5.3), it is assumed that information recently acquired is kept in the short-term memory (STM), making it readily accessible and available for verbalisation and reporting through concurrent TA (Ericsson and Simon, 1993). The information from the long-term memory (LTM) must first be retrieved by the STM before it can be verbalised. This limits LTM content reported during concurrent TA. Therefore, retrospective TA could be used to seek more explanation or rationale for participants' behaviour and provide more insight into the content of the LTM. In the current study as described above, each student verbalised his/her thoughts during the simulation using concurrent TA, and this was followed up by a retrospective TA. Dual process theory decision, the theoretical framework of this study assumes that information process as part of the reasoning approach to decision making and problem-solving underpinning this theory.

Ericsson and Simon (1993) advocated that the think-aloud method is a valid data collection method to investigate cognitive processes and to examine the subject's short-term memory. TA is described as a process-tracing technique to elicit and explore what is happening in a person's mind while performing a task, solving a problem or making decisions. It reports a step-by-step progression as the participant moves different sets of knowledge towards an outcome (Jones, 1988) and reports the thoughts at the time they are processed (Ericsson and Simon, 1993). It is a qualitative and an open-ended technique that allows continuous verbalisation with little structure imposed on the participants. The continuous verbalisation using TA generates verbal reports about the verbal behaviour of a person performing under instructions, these verbal reports are considered as the participant's account of her/his cognitive processing. Ericsson and Simon (1993) described this verbal behaviour like any other behaviour that could be recorded and analysed and they explained that the cognitive process that generates verbalisation is a part of the cognitive processes that generate any kind behaviour (p. 9).

Katalin (2000) described TA and VPA as the closest possible way to get to the mental processes of a participant compared to other methods. Aitken and Mardegan (2000) agreed with that as they considered TA a method that provides a direct insight into the decision-making processes more than any other methods like observations or self-reports. TA is a useful technique to find out how participants decide and the rationale for their choices and decisions. This does not only allow the examination of the cognitive processes but it could be used to identify faulty reasoning. Verbal protocol analysis with thinking aloud technique has been considered an effective way of analysing observable behaviours and collecting data about problem-solving, critical thinking, clinical reasoning and decision making in nursing (Cioffi, Purcal and Arundell, 2005; Daly, 2001; Twycross and Powls 2006; Simmons et al 2003). Aitken et al (2011) and Hoffman (2007) effectively compared and combined the use of think-aloud protocol and observation in a nature study of expert nurses' decision making in critical care.

4.5.1a Strengths and limitations of the think aloud

The advantage of the TA method is that it allows examination of the working memory (WM) content, the thought process and the verbalisation that take place concurrently with cognitive processes that are independent of the subject interpretation (Van Someren, Baranard and Sandberg, 1994). The limitation of the retrospective approach is that it is not always easy for the participant to remember exactly what they did especially if some time has passed after completion of a task. Another problem is that participants may tend to present their thought processes as more intelligent and coherent than they originally were (Ericsson and Simon, 1993) or present new thoughts they did not have at the time of task performance. The immediate think aloud and the use of video review was used in this study to reduce this effect. In the current study, the observational nature of the experiment and the think-aloud technique compensated for less objective self-reports in decision making and reasoning questionnaires. Observation is commonly used in conjunction with TA protocols to increase the depth and reliability of the collect data (Aitken et al, 2011). The current research employs the think-aloud technique as a data collection method and VPA for the analysis of the collected verbal reports as described below but it is important to acknowledge the methodological limitations of this method before discussion the other methods.

Few studies raise limitations about the TA method; one of the early issues discussed by nursing researchers was whether the think aloud and the limited capacity of the working memory hinder the cognitive processes and thus affecting performance and speed of solving problems (Fonteyn, Kuipers and Grobe (1993). However, Newell and Simon, (1972) and Fonteyn (1998) found in their studies that there was no difference in the path of solving problems or in the speed of performance between groups, and there was no difference in cognition and task performance (Johnson, 1993). Ericsson and Simon (1993) recommended that researchers need to carefully instruct participants to verbalise their thoughts as they come to mind and to avoid explaining their thinking (Aitken and Margedgan, 2000; Taylor and Dionne 2000; Aitken, 2003; Aitken et al, 2011). Insufficient instruction to the participants may result in an inappropriate level of verbalisation

All the students had some experience with thinking aloud during the course and before the current study. At many stages in their nursing course, they were asked to verbalise their approaches while performing clinical procedures or solving a problem. Ericsson and Simon (1993) recommended the use of warming up technique before the thinking aloud and reminders during the TA to ensure that students produce the best possible verbal report. All the students in this study had experience with simulation and the researcher went through a brief rehearsal before the simulation experience (see section 4.4.2). They received instructions about the scenarios and the objectives of the experience immediately before their performance. The researchers are usually available in the research field primarily to monitor the verbalisation by reminding the participants to speak when she/he lapses into silence. In the current study, this was one of the main roles for the researcher but he was also observing students' behaviours and providing verbal responses to student clinical questions to the patient. It is important to monitor the context of the TA to ask for clarification in the retrospective TA. To ensure similarities in the conditions for all the students during simulation, the researcher used a pre-prepared clinical data sheet to response students' questions in a similar way.

Ericsson and Simon (1993) pointed out that the headed traces of TA can be verbalised. As the participants use TA they are able to report data that comes to their attention and awareness. This limits the TA reliability to report automated type 1 processing of making decisions. This is particularly important as some familiar and simple task learned from routine practice might not be headed in the working memory and therefore will not be verbalised. Observation, retrospective think-aloud and video recording have been used to identify cognitive biases associated with type 1 decision making and any automated behaviours that have not been verbalised (Newell and Simon, 1972). A schedule for think aloud and observation was based on the simulation design section 4.4.2 (Appendix 11).

4.5.2 <u>Observation</u>

Observation is a systematic data collection approach. Researchers use all of their senses to examine people's performance in natural or simulation settings or naturally occurring situations. Observation is useful during the thinking aloud protocols and increases the understanding of the performed behaviour. Direct observation of participant's behaviours is a good alternative to self-report, especially if the topic is relatively unexplored or little is known to explain the behaviour of people in a particular setting (Swanwick, 1994). Observing nursing students in the simulation laboratory, to examine their clinical reasoning and decision making has not been used before. Observation has been frequently used in clinical settings and provided good insight into nurses' decision making (Aitken et al, 2008). Observation is a useful method that allows the researcher to observe what the participants actually do, as opposed to what they think they do or would like others to think they do (Caldwell and Atwal, 2005). This is useful as Thompson and Dowding (2009) noted that what nurses recall might not always match what actually happened

An observational method in this study was used to gather information about students' performance, their verbal and non-verbal communication while responding to HFS with acute clinical deterioration. It is a valuable data collection method to gather real-time data about the types of biases made, concepts considered and the different types of decision making used by the students at different points of their performance. It allows the monitoring of data that the students considered and the order and the way of which it is acquired, at which point the researcher can make an evaluation of the cognitive process (Bucknall, 2000). Observation in a specific context can help in interpreting the verbal protocols transcripts and recognising non-verbalised behaviours that may indicate type 1 decision making, a type that the students are usually unaware of and cannot be examined using self-report.

Participant observation is a common technique in qualitative research when the researcher closely follows the participant for a lengthy period of time to study their behaviour in its natural state (Mulhall, 2003), it is commonly utilised in ethnography and phenomenology. In non-participant observation, that applies to in this study, the researcher adopts a more objective approach to data collection and participant observation and is an approach more associated with the quantitative methodology. Although it has great value in capturing action and interaction as it occurs, it is reliant on the selective subjectivity of the observer, who may choose what to observe and record. The use of think aloud protocol transcription reduces the subjectivity of the observer, and as well as a video recording, has potential to overcome this sources subjectivity. Video recording was used in this study and repeatedly reviewed to observe particular actions or interaction and to enhance the consistency of the collected data. An observational checklist was used to guide the observation and considered possible cues and critical actions and the different stages of the reasoning process based on the simulated scenario (Appendix 10). Caldwell and Atwal (2005) suggested that observational studies require the researcher to be able to see, record, interpret and evaluate information.

Video recording has been frequently used as a method to record observations in healthcare and educational settings (Aitken et al, 2011; Thackray and Roberts, 2017) and used as a method to enhance the validity of data by comparing the video recorded data with the think-aloud data. Video recording can capture verbal and non-verbal behaviours and interaction simultaneously, tapes can be reviewed repeatedly allowing more detailed analysis and so it offers a more comprehensive record of events than can be achieved by observation alone. Ethical issues were raised in the previous studies about the use of video recordings in natural settings such as recording real surgery (Hood et al, 1998). This was not an issue in laboratory settings. The camera system is attached to the laboratory ceiling and out of the participants' visual field to reduce the effect of them changing their behaviour. Reviewing the recording performance was part of retrospective think aloud and debriefing.

4.5.3 <u>Health Science Reasoning Test (HSRT)</u>

HSRT measures critical thinking, clinical reasoning and clinical decision-making processes in a healthcare related clinical context. It is therefore found more appropriate to healthcare professional compared to the more generic California Critical Thinking Skills Test (CCTST) (Facione, Facione and Sanchez, 1994). The HSRT is based on a Delphi study and associated with other tools created by Facione and Facione (2006) such as CCTST. CCTST has been frequently used by HFS studies that measured clinical reasoning. Decision making in the context of uncertainty relies on inductive and deductive reasoning. Inductive reasoning moves from specific to general and includes argument based on observation or experience. Deductive reasoning begins with general thinking and ends with specific conclusions (Caine, and Caine, 2006). Ideas can be discovered but not proven by inductive reasoning. But in deductive reasoning arguments are based on laws, rules or other accepted principles that demonstrate a great deal of certainty (Caine and Caine, 2006).

The HSRT measures clinical reasoning and critical thinking by analysing the responses scenarios based 33-items multiple-choice questions that takes approximately 50 minutes to complete using a computer. The HSRT measure five different domains; induction, deduction, analysis, inference and evaluation (Insight Assessment, 2016). The content of the test items is constructed in a way that require the application of the classical reasoning skills to professional and clinical contexts more appropriate to healthcare professionals and provide the require content to allow the application of one's reasoning skills but it does not test a specialised area of knowledge (Insight Assessment, 2016). The test questions require the test taker to analyse the provided data, to make interpretations, to draw inferences and reason the claims and evaluate the quality of different arguments and options. The overall total score gives a measurement to the strengths and limitation of the test taker's skills in making a reasoned judgement about what to believe or what to do (Facione and Facione, 2006, p. 3). Examples of HSRT questions are provided in appendix (12).

Facione and Facione (2006) considered the analysis, evaluation and inference to be the core components of critical thinking. The analysis helps in assessing the individuals' ability to identify claims, assumptions, reasons and examine how different pieces of information relate together to develop arguments. It is the ability to identify alternatives, organise and prioritise variables and their possible consequences (Dexter et al, 1997). The analysis is defined so as to identify the actual inferential relationship between different forms of representations such as concepts, description, statements or questions (p.9.) (Facione and Facione, 2006). Nurses gather different types of information through clinical assessment, investigation and discussion with patients, family and other team members. They try to identify different elements for a given clinical situation and how these elements interact and relate to producing clinical patterns. The ability to analyse accurately and relate variables is depended on the individual's interpretation skills to identify precise cues meaning and the appropriate weight and significance of the different pieces of clinical data in its context.

Evaluation is the process of determining the probable validity, reliability, clarity, relevance, accuracy and applicability of the information to a specific clinical situation (Dexter et al, 1997). The skill is used to assess the credibility of the source of information, the strength of the presented evidence or any biases (Paul, 1990). Subsequently, this allows better categorisation and classification of different types of data and leads to a better analysis of the clinical situation. Evaluation helps in assessing the quality of the analyses and inference made by individuals (Insight Assessment, 2016).

The inference is described as the ability to draw conclusions from reasons and evidence, formulate a hypothesis, conjecture alternatives, and differentiate between the necessary relevant conclusions and merely possible hypothesis, the application of rules of induction and deduction and logic (Dexter et al, 1997; Facione and Facione, 2006). Despite excellent inference skills individuals could reach to the wrong conclusion and recommendation if it was based on wrong information, faulty analysis or biased evaluation.

4.5.3a HSRT validity and reliability

Insight Assessment (2016) measured the internal consistency of the overall HSRT using the Kuder-Richardson 20 (KR) calculation. The KR 20's of more than .70 is considered an evidence of strong internal consistency in non-homogenous measures (Fraenkel et al, 2016). They reported a reliability coefficient range between 0.77-0.83 with an overall internal consistency of .81 (n= 444) (Insight Assessment, 2016), this is a high level of reliability for such an instrument that measures the complex construct. For test-retests reliability, the HSRT was reported to meet or exceed .88 in controlled administration conditions at pre-test and post-test (Insight Assessment, 2016).

Content validity refers to the ability of a tool to measure and capture all the facets of the intended domain or construct. A second criterion, which Nunnally and Bernstein (1994) emphasised is the importance of assuring that sensible methods of test construction are used. The HSRT measures clinical reasoning, critical thinking and clinical decision making. The validity of the HSRT is maintained as it measures specified cognitive domains of critical thinking and clinical reasoning identified and described in a large Delphi study by the American Philosophy Association (Facione, 1990). That provided the experts' agreement and the identification of this domain. Each of the items included in the test was chosen based on its theoretical relationship to the Delphi Reports conceptualization of critical thinking (Facione, Facione and Winterhalter, 2010). Critical thinking as a construct is defined by a number of integrated manoeuvres and cognitive components in the human reasoning such as the analysis, inference and evaluation. The constructs of clinical reasoning are the inductive and deductive reasoning that will directly affect clinical decision making. HSRT measure the described construct of critical thinking and reasoning defined by the Delphi study and the scale can be used to measure these components.

The content validity of the CCTST and HSRT is supported by the choice made by researchers and educators in the field of reasoning (Cazzell and Anderson, 2016). The CCTST has been extensively used in the nursing research to assess clinical reasoning (Walsh, 2010), and recently the HSRT has become frequently used as a customised test for healthcare professionals (Dreifuerst, 2010). Construct validity is typically demonstrated by correlational studies that demonstrated a strong correlation between the CCTST, CCTDI and HSRT score and a variety of other robust examinations for academic achievement (Facione and Facione, 2006; Huhn and Deutsch; 2011). The construct validity was also established by correlating test items to American Philosophical Association Delphi study (Facione, 1990). Correlating the quantitative data from the HSRT with qualitative data from think-aloud protocols and observation was applied in this study to further increase the depth of analysis for the study research question and the credibility of the study findings.

4.5.4 Interview schedule

Interviews are systematic ways of talking and listening to people and a method of collecting data and gaining knowledge from individuals through conversations. Interviews are classified on the basis of their level of structure. At one end of the spectrum is a structured interview which is associated with quantitative research and usually features with close-ended questions, inflexible and generally, the answers are expected to be short. On the other side of the spectrum is unstructured interview and in the middle of the spectrum are the semi-structured interviews. Both semi-structured and unstructured interviews are associated with qualitative research and usually presented with open-ended questions and seek more depth understanding of people experience. Unstructured interviews are based on a limited number of prompts with the emphasis to encourage the participants to talk around the themes of interest and the interviewer can adjust the order of the questions to suit the direction of discussion with interviewee (Bryman, 2016).

Interviewing is a common data collection strategy for qualitative research commonly used in ethnography and grounded theory. Mixed method researchers (Creswell and Plano Clarke, 2011) also regularly use it. Semi-structured interviews range in structure and type of question in order to accommodate the interviewee. Rowley (2012) recommended that for a novice researcher, a semi-structured interview that includes 6-12 well-chosen and wellphrased questions with some adaption to interviewee is a good starting point. She also suggests each question may have prompts to expand the discussion and seek further exploration of the issues raised. Gerrish and Lathlean (2015) suggest that interviews usually aim to seek understanding of people's experience, feeling, opinion and knowledge. They can be conducted face-to-face or by telephone, individual or group interviews. This method would be an appropriate approach to gain a depth of understanding about the benefits and usefulness of the simulated experience to student clinical practice and their clinical decision making. The flexibility of this method is compatible with the pragmatism approach for practicality in using a method that works to answer the research question.

A semi-structured interview allowed the use of key questions to define the areas that need exploration but allowed for persuasion of any idea or response in more details (Gill et al, 2008). It is a flexible approach allowing the elaboration or discovery of information that is important for the students but which the researcher might not have thought about. It provides an opportunity for both parties, interviewer and interviewee, to clarify meaning. Bryman (2016) recommended various aspects to consider before, during and after conducting the interview to ensure the best quality of collected data. It is important to select an appropriate environment for the interview, use appropriate presentation and develop a rapport before conducting the interview. It is equally important to organise and sequence of the interview questions and begin with simple questions (Britten, 1999).

The interview took place in the university campus when the students were coming for other training or for meeting their tutors. Their familiarity of the place helped to put the participants at ease, made them feel comfortable and allowed the time to warm up before the interview (Litosseliti, 2003). The interviews took place in students' tutorial rooms to ensure students' familiarity with the settings, maintain confidentiality and prevent any distractions. Before the interview, the content of the interview was discussed using Participant Information Sheet (PIS). It clarified my role as a researcher and participant's consent for this phase of the study was checked again and confirmed (section 4.6). The interview lasted 10-20 minutes and was audio recorded with the participants' permission. An interview guide was used to help conduct the interview (Appendix 13) but more questions were based on students' responses. Since students' experience is individualised and may vary between participants, a face-to-face individual interview of all 23 students was used to answer this study research question number four.

I transcribed the interviews verbatim and I kept a reflective diary during the interview and part of the data collection and analysis added memos and I was questioning the meaning and direction of the analysis. The transcribed interviews were then loaded to NVivo© software for analysis. Figure 4.3 summarises the different point of data collection before, during and after the simulation.

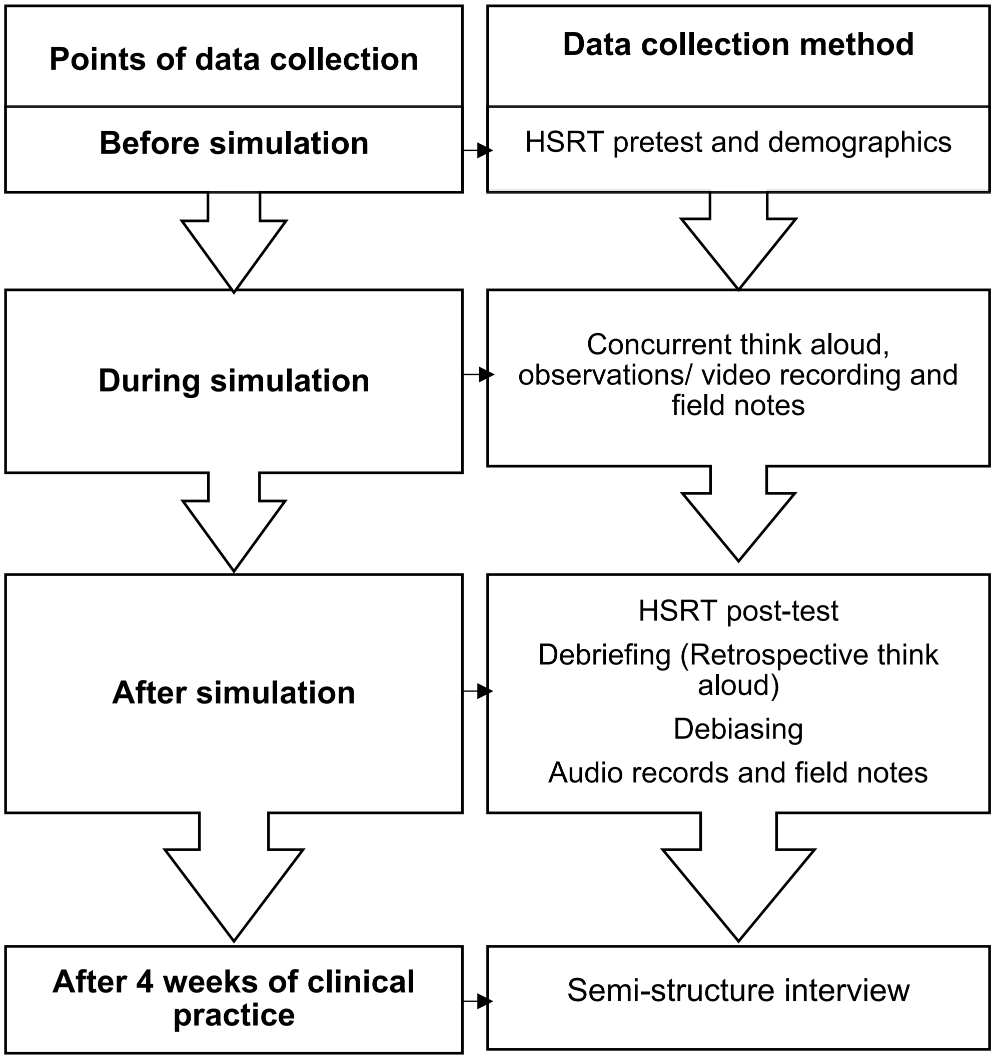

Figure 4.3 points of data collection and methods

4.5.5 Demographics

Demographical variables were collected with demographic data sheet (Appendix 14) to describe the sample and to identify any factors that may influence the nursing students' reasoning, types of decision-making and biases they have. The demographical factors could be considered when explaining the results of this study (see Table 4.6). The list of demographics was based on similar studies in CDM (Hoffman, 2007), simulation (Walsh, 2010), nursing practice (Madaus et al, 2002; Morris and Turnbull, 2006) and factors that increase the likelihood of cognitive errors (Croskerry, Singhal and Mamede, 2012).

Table 4.6 Demographics

Demographics
• Gender • Age • The highest level of education • Ethnicity • Type of previous clinical experience in health care before the course • Number of years of clinical experience • Type of clinical placement during the nursing course • Number of hours of sleep before the experiment and HSRT • Feeling tired and tiredness • Learning difficulties

4.6 Ethical approval

The study conformed to the ethical standards of research inquiry. Prior to the study, ethical approval was gained from Anglia Ruskin University Research Ethics Committee on 16th of July 2015 for a period of three years (approval number SNM/DREP/14-014) (Appendix 15). The research took place within the University skills laboratory and to gain access to the participants this also required permission to be sought from a number of 'gatekeepers' as described in section (4.4.2). The Belmont Report (1974; cited in Polit and Beck, 2014) summarised three basic principles relevant to research involving human subjects as; respect for human dignity, beneficence and justice.

4.6.1. <u>Informed consent</u>

Obtaining informed consent is one of the most fundamental ways to demonstrate respect individual's dignity, autonomy and rights to voluntarily participate in any research or action (Polit and Beck, 2014). This ethical principle considers the individual's right to self-determination and the right to full disclosure. To ensure full disclosure and informed consent is obtained; the researcher explained the study risks and benefits, voluntary participation and the fact that it is the student's right to refuse participation and withdrawal from the study at any time without explanation. The researcher responded to questions provided the students with Participant Information Sheet (PIS) for each phase of this study, so they have time to read and decide (Appendix 16 and 17).

A written consent (Appendix 18 and 19) for each phase of the study was obtained after a one-one meeting, with each student; in this meeting the researcher explained the information in PIS and ensured the student's understanding of the study, the time and travel needed for attending the university laboratory. A fresh verbal consent was sought before the testing and simulation sessions to ensure continued consent and fitness to attend the sessions and before the follow-up interview.

I was a lecturer in the same campus and the study population were students in the nursing degree. In order to ensure power balance and to mitigate for any bias or risk of coercion all students who were under direct supervision or personal tutees and those who could be assessed by the researcher have been excluded from this study. The researcher made efforts to ensure the simulation and interview sessions were scheduled at times to suit the participants.

4.6.2. Beneficence

Beneficence is one of three fundamental ethical principles, which refers to the researcher duty to maximise benefit and minimise harm or risk. The risks and benefits of this study were explained as described above. There are no known personal benefits or risks for taking part in this study as detailed in the PIS, though it could be considered a useful learning experience. For participants, and the study could benefits future students. The following measures were considered if a student became distressed during the simulation: the researcher would stop the scenario immediately; the researcher would only resume the simulation after a break when students felt ready to restart and only after careful considerations that the cause and signs of stress had been resolved.

To further address this potential risk, students were given the University Counselling and Wellbeing services details that provide free and confidential service to students. Fortunately, no student felt distressed and needed to use this service. The study required students travel to the university simulation laboratory, testing and the interview, therefore a £20 gift voucher was given to the participant who completed the study to compensate for travel expenses; this was explicitly explained in the PIS.

4.6.3. Anonymity and confidentiality

The researcher took the following measures to protect students' confidentiality as detailed in the PIS. All student documentation was anonymised and given research codes known only to the researcher. The students' codes and video/audio records were held in a password protected computer accessed only by the researcher. The participants were not identified in the transcript; they were only identified by letters and numbers for example P1 (participant A1) to preserve anonymity.

To maintain confidentiality, the video recordings in SMOTS were downloaded immediately after each session and the system is password protected. Two passwords protected data storage devices (e.g., memory cards) were used for the data management and stored with all the other data sheets in a locked cabinet, within a locked office only accessed by the researcher. This was necessary to ensure the research adhere to Data Protection Act (1998) and the University of Code Practice (Anglia Ruskin University, 2016). The data collected through the HSRT is protected by an administrator account that can only be accessed by the researcher, the account is protected by a username and password. When the documentation of the study findings is complete audio and videos recordings will be destroyed. Transcription will be maintained for further study and analysis with the security measures described.

4.7 Validation strategies

Qualitative and quantitative research have different approaches to validating the quality of the collected data and findings of research. While quantitative researchers focus on validity and reliability, qualitative researchers focus on the validity to determine whether the account provided by the researcher and participants is accurate, can be trusted and credible (Creswell and Plano Clark, 2011). Andrew and Halcomb (2009) recommended that validation should focus more on the dominant paradigm of a mixed method but Creswell and Plano Clark (2011) recommended mixed method researcher to discuss the validity of each method used. Since the validity and reliability of HSRT has been discussed earlier in section 4.5.3a, the following section discusses the rigour of the collected data and findings from the qualitative methods.

4.7.1 Validity of the qualitative data

Trustworthiness or validity of a study relates to whether the findings of the study are worth taking account of, and whether they are credible Lincoln and Guba (1985). There were a number of approaches were used to increase the validity and credibility of the collected data. Creswell and Plano Clark (2007) suggested clear articulation of the research questions to direct the data collection and the analysis process as the first step, this was clearly discussed earlier in section 4.1.

In observational studies, the Hawthorne effect could affect the construct validity; which is defined as the degree to which a test measures what it claims to be measuring (Polit and

Beck, 2014). Hawthorne effect refers to participants altering their behaviours during a study due to their awareness of being observed (McCambridge, Witton and Elbourne, 2014). This was considered by employing a combination of data collection techniques to enhance the construct validity of the study by ensuring that many aspects were audio and video recorded, so data was not missed. The use of different data-collection methods as a triangulation approach also helped in checking the data from different techniques against each other thus enhancing the credibility and validity of the collected data (Creswell and Plano Clark, 2007). The researcher can demonstrate auditability by showing how a coding system using VPA and DPT could be used to establish categories and how these categories linked to the concepts presented in the findings (chapter 5)

The relevance of the current study could be demonstrated by establishing how the findings contribute to the current body of knowledge about the impact of simulation in developing nursing students' clinical reasoning and decision-making skills (chapter 8). My research supervisor reviewed the coding books for the qualitative methods and more than 10% of transcripts for phase 1 and 2 and provided feedback.

Methodological congruence is an important criterion to assess the credibility of the generated data and appropriateness of the data to answer the research question of the study. Researchers identified that even though a small number of participants are usually used in the TA method, it provides extensive, and rich data about cognitive processes for analysis and provides stable results (Aitken, 2000; Aitken, 2003; Hofmman, 2007; Lundgren-Laine and Salantera, 2010; Aitken, 2011; Johnsen, Slettebø and Fossum, 2016). The data was collected and analysed by one researcher and this is believed to enhance the consistency of the data analysis in TA studies.

To enhance the validity of the data further, both concurrent and retrospective verbal protocols were used. The retrospective TA seeks validation and clarification from the participants in this study about their thought process during the concurrent TA. Newell and Simons (1972) believe this will add a different type of data and allow checking the issues raised in the concurrent think-aloud thus increasing the credibility of the data. The use of observation was a useful source of gathering data and increases the credibility by allowing comparing and cross-checking during the data analysis and interoperation of the results. The use of audio and video recordings allowed the frequent review of the situation and compared the students' TA account with the recorded videos thus enhancing the credibility and validity of the collected data.

To reduce the possible bias in the data collected from the students, the retrospective TA sessions immediately followed the simulation experience and the concurrent TA. This allowed more accurate recall of the cognitive processing behind their decisions and prevented the students from reconstructing the accounts of what happened (Johnsen, Slettebø and Fossum, 2016). The same open-ended questions were used to guide the retrospective TA with the freedom to allow the students to explain what happened at different points and their thoughts when they did specific interventions. This stimulated recall of specific issues and provided a more consistent approach for collecting data and improve its reliability. I also acknowledge my biases and subjectivity and the use of multiple methods, referring to my research supervisor, my reflection diary and comments from peer reviews which are used to enhance the credibility of the study data and findings.

Transferability refers to the degree to which the research findings can be generalised or transferred to another setting and that reveals a pattern that is recognisable and useful. This study was conducted in one university in two cohorts, so its findings through TA and semi-structured interviews cannot be generalised to others. Yin (2009) suggested that although it has limited generalisability, the results may be theoretically generalised to produce replication logic. The researcher steps in the researcher process can be traced back throughout the research process from the data collection of each phase by providing detailed documentation, appendices and example of transcripts for each phase of this research study. The findings of the study have been integrated within the literature for verification, through research supervision and peer reviews in conferences.

4.8 Summary:

The focus of this study is to investigate clinical decision making among undergraduate nursing students using high fidelity simulation. The study has explorative and evaluative focus and for that reason; a mixed method multiphase design was adopted. The chapter discussed the philosophical approach to this study and the rationale of each method. The chapter also mapped the research questions against the selected method to ensure methodological congruence is clearly described. The study adopted the following methodology for this study (Table 4.7)

Table 4.7 Summary of the study methodology

Worldview (epistemology and ontology)	practicality and what works to answer research questions
Epistemological approach	pragmatism
Theoretical lens	dual process theory
Methodology	mixed methods- multiphase design
Methods	HSRT test, think aloud, observation and individual semi-structure interviews

To validate study data and findings, the following strategies were used throughout the research process:

- Application of multiple methods to examine clinical reasoning and decision making.
- The finding from concurrent think aloud data was compared to the retrospective data, with participants verifying their thought process and errors.
- The finding from concurrent think aloud data was also compared with observation notes and video analysis of students' performance.
- The results from concurrent TA, retrospective TA and observation were compared to the quantitative results from HSRT.
- Clearly described the research process and simulation design.
- Providing coding schemes and example of coded transcripts and explained methods of analysis in chapter 5.
- Feedback from supervisors, peer and critical reviewer

Having discussed the methodology used in this study, the next chapter describes how data was analysed.

CHAPTER 5

DATA ANALYSIS

5.1. Introduction

This chapter presents the method of data analysis in this study. The data collected by Health Science Reasoning Test (HSRT), think aloud (TA) and observation was analysed in number of ways to build an in-depth, rich description and analysis from a small sample to illustrate how a group of nursing students reason and decide using manikin-based high-fidelity simulation of an acutely ill patient scenario. As phase one of the study contains both quantitative and qualitative data, the statistical analysis will be described first and then qualitative analysis of TA data using verbal protocol analysis (VPA) and the last step for phase one data describe how the data from both methods will be related and compared. Finally, in the second phase the thematic analysis of the interviews will be discussed.

5.2 Quantitative analysis

The quantitative data collected through the HSRT and demographics were added to the data set in Statistical Package for the Social Sciences (SPSS 20) for analysis. The VPA allow the TA data collected in phase one to be transformed and quantified using a qualitative analysis program NVivo 11 (QSR International, 2017) and then calculated frequencies were added to the data set in SPSS. Data from HSRT, think aloud, demographic data sheets and observational data were analysed separately in keeping with the multiphase mixed method design and to allow the result of each method to be discussed separately and then compared and corroborated. The data was reviewed in SPSS for errors and data from each of the methods were firstly subjected to exploratory data analysis using descriptive statistics and graphs (Pallant, 2016).

5.2.1 <u>Descriptive statistics</u>

Descriptive statistics are used to compare the differences in HSRT scores before and after the simulation experience and to calculate the frequencies for types of clinical decision making (CDM). The exploratory data analysis (EDA) such as descriptive statistics, graphics and frequencies are useful approaches to examine and understand the data before deciding whether to use parametric or non-parametrical inferential statistics.

5.2.2. <u>Inferential statistics</u>

Initially, datasets were analysed to check for normal or non-normal distributions, since this has implications for assumptions regarding the data and consequently for the selection of appropriate parametric or non-parametric statistical tests. This study used skewness and kurtosis, visual inspection using histograms and Shapiro-Wilk's test ($p > 0.05$) to assess approximate normality required for parametric tests (Doane and Seward, 2011). The homogeneity of variance was evaluated using Levene's test. The statistical significance for all quantitative analyses was set for an alpha level at $p<0.05$ with 95% confidence interval. The tests for normal distribution identified a satisfactory degree of homogeneity and supported the application of parametric tests.

A dependent t-test (paired t-test) was used to assess the statistical significance of the difference between HSRT pre-test and post-test mean score for one group and to answer the first research question by using the following hypothesis (Table 5.1).

Table 5.1 Hypothesis related to research question 3

Null hypothesis (H0): post- simulation HSRT score for the students will be the same to the pre- simulation HSRT score. Mean score 1 **(μ1) =** mean score 2 **(μ2)** **Alternative hypothesis (H1):** post- simulation HSRT score for the students will be different to the pre- simulation HSRT score. Mean score 1 **(μ1) ≠** mean score 2 **(μ2)**

This study also employed tests to evaluate the correlation between the variables. Pearson product-moment correlation coefficient (*r*) analysis is an appropriate parametric test for interval level variables and was applied to assess any correlation between HSRT scores as a dependent variable and other variables that met parametric assumptions. Spearman's rank order rho (r_s) correlation coefficient test was used to assess the correlation between ordinal and nominal data that did not have a normal distribution and comparative data that failed Pearson' test assumption (Morgan et al, 2013; Pallant, 2016). Linear regression can be used to explore relationship between variables and interrelationship between the dependent and multiple independent variables (predictors) (Pallant, 2016). In this study, the limited data volume meant that it could only be used for explorative reasons to assess the potential relationships between the HSRT and the clinical decision-making processes.

One-way ANOVA between-groups analysis of variance was conducted to explore the effect of type1 and type 2 on the level of clinical decision making, as measured by the HSRT

(Table 5.2). It was also applied to assess whether there is a difference in HSRT mean score for students with different CDM category identified from the TA data (Martin and Bridgmon, 2012). The independent variables are the different types of decision making and the different categories of CDM processes. It can be used if the dependent variable is quantitative and the independent variable is qualitative that meets the need of this study. Each student will be given one type of CDM as a dominant type and therefore this ensures independence. One-way ANOVA was used to answer the following research question (Table 5.2).

Table 5.2 Hypothesis related to research question 3

Null hypothesis (H0): student who mainly use intuitive mode (type1) of CDM during simulation experience will have the similar measures of CR and CDM to those who mainly use the analytical mode (type 2)? Mean score 1 **(μ1) =** mean score 2 **(μ2)** **Alternative hypothesis (H1):** student who mainly use intuitive mode (type1) of CDM during simulation experience will have the different measures of CR and CDM to those who mainly use the analytical mode (type 2)? Mean score 1 **(μ1) ≠** mean score 2 **(μ2)**

5.2.3 Health Science Reasoning Test (HSRT) Score

HSRT is a standardised criterion-reference test that was utilised to measure how well a person has performed in measures of critical thinking and clinical reasoning (Insight Assessment, 2016). The test questions require the test taker to analyse the provided data, to make interpretations, to draw inferences and reason the claims and to evaluate the quality of different arguments and options. The HSRT measures clinical reasoning and critical thinking by analysing the responses to scenarios based to 33-items multiple-choice questions that takes approximately 50 minutes to complete with a total score of 38 points. The HSRT measures five different domains; induction (10 points), deduction (10 points), analysis (6 points), inference (6 points) and evaluation (6 points) (Insight Assessment, 2016). A score for each of the five HSRT domains is produced after the test and an overall HSRT score is also provided for each participant. The results of each domain could be interpreted to their relative strength using Recommended Performance Descriptors recommended in HSRT Manual (Insight Assessment, 2016). Table 5.3 illustrates the scale of interpreting the HSRT five domains.

Table 5.3 HSRT domains score interpretation

HSRT scale Score (33-point version)	HSRT Scale score (Recommended Performance Descriptors)		
	Not Manifested	**Moderate**	**Strong**
Analysis	0-2	3-4	5 or more
Inference	0-2	3-4	5 or more
Evaluation	0-2	3-4	5 or more
Induction	0-4	3-7	8 or more
Deduction	0-4	3-7	8 or more
			Source: Insight Assessment, 2016

The participant overall score could be interpreted as to their relative strength using Recommended Performance Descriptors (Insight Assessment, 2016). The overall total score gives a measurement to the strengths and limitation of the test taker's skills in making a reasoned judgement about what to believe or what to do (Facione and Facione, 2006, p. 3). The HSRT results can be compared to standard "cut score" that have been identified for four levels of performance using the 38-point scale (Table 5.4). An overall score of ≥ 26 out of 38 is designated as "superior", defining a level of performance and critical thinking skills that is far above most of test-takers and corresponds to the ability to participate in more advanced learning. A "strong" score (21-25) reflects the ability for career development and successful educational achievement. A "moderate" score (15-20) suggests the student may have some difficulties with problem-solving and decision making skills. Lastly, "not manifested" (0-14) implies suboptimal" effort when completing the test or possible reading or language comprehension problem that have been associated with poor performance in the workplace (Insight Assessment, 2016). The HSRT results also provide a norm-reference percentile for each student compared to large population in similar study level in Nursing, therefore it allows the evaluation of students' performance relative to the performance of other subjects in external norm group in the same field (Waltz, Strickland and Lenz, 2010).

Table 5.4 HSRT overall score interpretation

HSRT overall score	Category	Description
>26	Superior	Level of performance and critical thinking skills that is far above most of test-takers and corresponds to the ability to participate in more advanced learning
21-25	Strong	The ability for career development and successful educational achievement
15-20	Moderate	Suggests the student may have some difficulties with problem-solving and decision-making skills
0-14	Not manifested	Suboptimal" effort when completing the test or possible reading or language comprehension problem that have been associated with poor performance in the workplace
		Source: Insight Assessment, 2016

The section above discussed the researcher approaches to quantitative data analysis appropriate to the selected methods applied to answer the study research questions one and three.

5.3. Think aloud protocol

The TA protocols can be analysed by three main methods in this field, depending on the focus of the study and the research questions. Few researchers used content or thematic analysis (Aitken et al, 2008; Thompson, Moorely and Barratt, 2016) and other researchers used verbal protocol analysis (Hoffman, 2007) as described by Newell and Simson (1972) and a third group combined the use of content analysis and VPA (Lundgren-Laine ad Salantera, 2010). Many researchers have discussed the similarities between the VPA and content analysis, but other researchers suggested that the methods have a different focus (Lundgren-Laine ad Salantera, 2010). The main target for the content analysis is interpretation and sense making of the phenomena under exploration and observation. The main purpose of the VPA, however, is to describe the thinking path and gain insight into the participants' decision-making process, which suits this study. Qualitative researchers analyse the data by coding, producing themes and constructing categories. With the VPA, the analysis is slightly different as the data analysis and coding consists of three sequential steps to trace the cognitive processes (Lundgren-Laine ad Salantera, 2010) (section 5.4).

Three main approaches have been used to code the content of TA data in nursing studies including the use of concepts map, decision-making tree and VPA that produce Problem

Behaviour Graphs (PBG). The concepts map approach is widely used to represent relationships between different concepts. Aitken (2000) based her research on the Concept-Attainment Theory and used the concepts map to explore the relationships between the concepts used by critical care nurses during a decision-making task. In the current study, the researcher is focusing on tracing the cognitive processes and biases and therefore concept mapping would have limited utility to answer the research questions. The decision-making tree focuses on the risk, frequency and probabilities of the decision in a specific task. Aitken and Mardegan (2000) used this method to describe how expert critical care nurses used the assessment information to direct patient care in natural settings. This approach is an appropriate way for building a search tree using yes or no options to analysis decision-making in a specific task. Therefore it would not adequately analyse the data for the current study and will not adequately fit the adopted theoretical framework in the current research.

5.3.1. <u>Verbal protocol analysis</u>

This study employed the verbal protocol analysis as a method to analysing the verbal data collected by TA, an approach outlined by Newell and Simon (1972) in the information processing and refined by Ericsson and Simon (1993) to examine cognitive processing. VPA has been frequently used in nursing research that explored and examined clinical reasoning and decision-making (Jones, 1989; Greenwood et al 2000). This technique is an appropriate approach for examining the different types of clinical decision making by tracing the cognitive processes and thinking path used by the participants. Hence, it can provide adequate content and an appropriate level of analysis of the data to answer the second and third research questions of the current study. Selecting appropriate methodology that ensures the collection of valid and reliable data, that is consistent with the theoretical framework and research objectives of the study ensures the credibility and validity of study findings (Taylor and Dionne, 2000). Ericsson and Simon (1993) outlined VPA and it started with transcription, then segmenting, followed by three steps of encoding and inferring the verbal content including a problem behaviour graph (PBG) for each participant (section 5.4).

The PBG reflects the state of transition as the participants search through the problem space in their efforts to solve the problem. The three-steps analysis involves constructing schedules of concepts for the referring phrase analysis and schedules of operators for the assertional phrase analysis that can emerge from the data using data-driven approach, or from theory using a concept-driven approach based on the existing literature (Ericsson and Simon, 1993). A final categorisation can be made by analysing the formed patterns in the PBG to produce theoretical explanations about the decision-making process. Coding schedules were constructed for the three steps analysis and the following sections provide discussion about VPA process that was followed in this study, see flowchart (Figure 5.1).

5.3.1a Transcription of tapes

The first step before the analysis was to transcribe all the audio and video files for both the concurrent and retrospective TA, an example is provided in appendix 20. It is important for verbal protocol analysis to transcribe TA in its entirety but the researcher can ignore events that are not relevant or not related to participants' performance under observation (Van Someren, Barnard and Sandberg, 1994). To ensure the consistency of the collected data; the main researcher conducted all the think-aloud sessions and carried out the data analysis. To ensure the validity of the analysis the transcription should be done by someone familiar with the participants' language, the task and the context as suggested by Ericsson and Simon (1993). Therefore, the transcription was also carried out by the same researcher, who is familiar with the task, settings and the used language in the study to increase the consistency of the collected data. The transcribed data was analysed based on a reference frame of a clinical decision-making process.

The audio and videotapes were transcribed verbatim by the researcher and then he re-read the protocol and reviewed the videos again to ensure nothing was missed in the transcription. The video recordings were very useful in allowing multiple rechecking of the analysis throughout the study. The transcripts were given a letter of the alphabet for each participant and identified as concurrent and retrospective. Each participant was given a letter of the alphabet (for example participant 1 was given the letter A, the letter refers to student's code). Also, a number was given beside the letter to distinguish the source of the data whether it was from the concurrent, retrospective or observation data. For example, participant "A" has 3 sources of data, A1: refers to this participant's data from the concurrent TA, A2: refers to this participant's data from the retrospective TA and A3: refers to this participant's data from the observation and so on. When the letters are presented without a number this was used to show combined concurrent and retrospective results and was clearly labelled as combined TA.

5.3.1b. Segmentation

The second step before the analysis was to segment the transcripts to individual meaningful statements (assertions, proposition). Before segmentation, the researcher reviewed all study transcripts to enable familiarity and to identify general impressions from the verbalised data.

Newell and Simon (1972) and Ericsson and Simon (1993) recommended the use of segmentation and tasks analysis to better understand the cognitive processes used to solve each task. Ericsson and Simon (1993) suggested that simple tests could be used to judge the validity of the verbal report, segmentation and whether the verbalisations are pertinent to the solution process. They considered criteria of three components as the necessary conditions to be satisfied with if the verbal data is to be considered to infer the used cognitive processes.

- The relevance criterion: the verbalised data should be relevant to the given task. This was achieved in the current study by assessing whether the participants' verbalisation corresponds with the provided stimulus or the provided cues. This would verify the relevance of the verbalised data to the task and whether it shows plausible steps towards a solution.

- The consistency criterion: the verbalisations to be pertinent, it should be consistent with the verbalisations that just precede them. This was achieved by assessing the consistency of the verbalised data in different segments with the just previously verbalised data. If the verbalisations or segments were not related to each other, then those are independent and random and could not be considered part of the cognitive process towards the solution.

- The memory criterion: a subset of data heeded during task performance should be remembered. This was checked through the presence of previous information in the working memory because of the subsequent demands on this data for the recall and recognition. This was evident during the participant's recalling and reviewing data earlier in the VPA protocol to relate data together and to reach a diagnosis or to take actions.

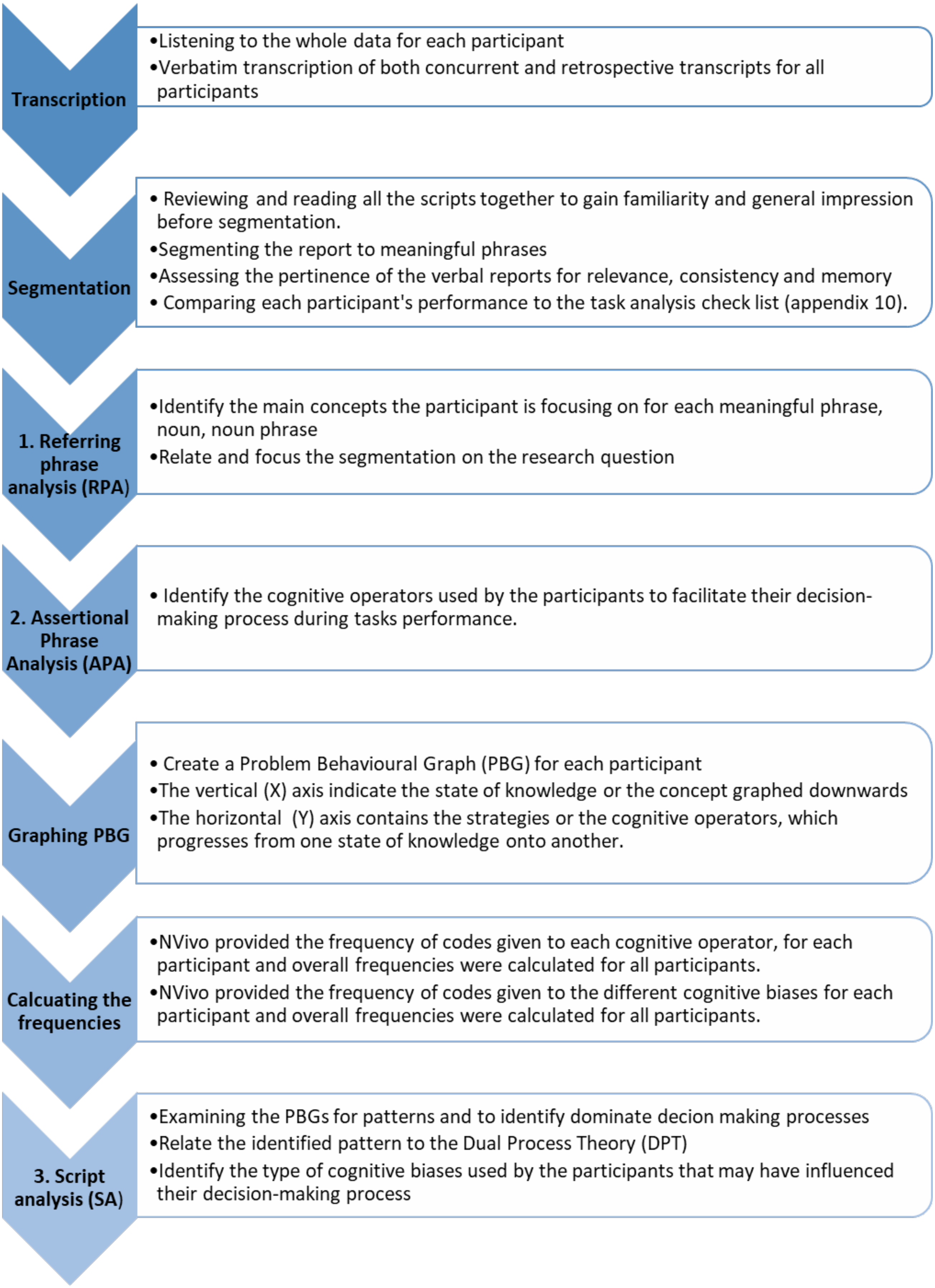

Figure 5.1 Verbal protocol analysis steps

5.4. Verbal Protocol Analysis (VPA) Steps

In the VPA, the verbal data is a step-by-step progression toward a solution of a problem. Each segment will bring the decision maker to a higher state of knowledge (Newell and Simon, 1972). The application of one of the cognitive operators allows the individuals to make this progression and allows them to move to a new state of knowledge. The new state of knowledge must correspond to the additional data yielded by the used cognitive operator. Since it allows the researcher to trace the students' decision-making process, it will yield information about the type of decision making used at different tasks within the scenario, strengths and weaknesses, type of biases and it can also allow the cross-checking the findings with HSRT. The following section discusses the VPA steps for data analysis, initially, it reviews similar nursing literature that used this method of analysis and then it discusses how it informed the developed coding frameworks for this study.

5.4.1. A schedule for referring phrase analysis (RPA)

This step began by encoding and organising the transcribed verbal reports into segments or concepts, each corresponding to one sentence, clause or even a single word that represents as a single thought or the focus of attention (Lundgren-Laine ad Salantera, 2010). A schedule was developed (Table 5.6) to analyse the transcripts for concepts used by students based on previous studies and as a recommended approach to analysing TA data using VPA (Taylor and Dionne, 2000). Concepts refer to clinical nursing concepts (airway, breathing, circulation) that the students were using to make decisions in providing nursing care. The following discussion, therefore, considered a range of nursing studies to support the selection of these clinical concepts as a coding grid.

The RPA stage examines the concepts of care on which the students are focused on. These concepts have been explored in different ways depending on the aim of the study. An area of nursing knowledge which has high relevance to everyday clinical practice in acute care setting was chosen for the simulated scenario in this study. The focus of the scenario was on recognising and responding to the needs of a post-operative patient with a hip replacement who developed hypovolaemia and allergic reaction. Hypovolaemia is a common problem in hip fracture and post-hip replacement surgery (Carpintero et al, 2014) but allergic reactions are not common, though, they are considered to have serious implications (UK Resuscitation Council 2015). This area of nursing knowledge to work towards is not too narrow to limit the data collection about students' reasoning and decision-making processes but is also not too complex to cause confusion or disturb students' thinking. It has been considered to produce sufficient data about students' clinical reasoning and decision making in both simulated

(Jones, 1989; Funkesson, Anbacken and Ek, 2007) and natural settings (Greenwood and King, 1995; Greenwood et al, 2000; Han et al, 2007; Hoffman, 2007). In the current study, students are familiar with the aspects of nursing care in this scenario since all of them passed the theoretical and clinical assessment of the acute care module (section 4.4).

The referring phrase analysis and assertional phrase analysis schedules were based on care concepts initially described by (Jones, 1989) but expanded on by other nursing investigators. To extract a coding schedule, the most frequent concepts used in the nursing literature were identified. Many researchers used concepts that mainly focused on the Activities of Living (Timmins and O'Shea, 2004). The most frequently used concepts of nursing care identified in the literature are breathing, circulation, elimination, hydration or fluid balance (Jones, 1989; Greenwood and King, 1995; Greenwood et al, 2000; Funkesson, Anbacken and Ek, 2007; Han et al, 2007; Hoffman, 2007; Johnsen, Slettebø and Fossum, 2016). Table (5.5) provides an overview of the concepts used or identified in different nursing studies that used the VPA analysis.

These studies are qualitative studies with explorative design that applied concurrent and retrospective TA as data collection methods. Some of the studies applied VPA including PBG (Jones, 1989; Greenwood and King, 1995) for data analysis but others used content analysis as part of the VPA and did not use PBG (Simmons et al, 2003; Funkesson, Anbacken and Ek, 2007; Fossum et al, 2011). Hoffman (2007) used both concurrent and retrospective TA and applied PBG. All the identified studies have a small sample size ranging between (4-13 participants) and most were carried in natural settings and from different clinical specialities. The researchers in the identified literature compared between novice and expert (Hoffman, 2007) or mainly use expert (Simmons et al, 2003; Funkesson, Anbacken and Ek, 2007; Han et al, 2007).

Jones (1989) used eleven nurses and paper-based scenario of an acute medical condition, Greenwood and King (1995) used nine pairs of nurses caring for a total hip replacement patient and Hoffman (2007) used four pairs of critical care nurses caring for a patient with an aortic aneurysm. Simmons et al (2003) explored the clinical decision making of thirteen experienced nursing staff working in medical and surgical units but applied the used of retrospective TA only. Funkesson, Anbacken and Ek (2007) used eleven experienced community nurses to explore their planning and clinical reasoning using paper-based scenarios. Han et al (2007) explored the thinking strategies of five critical care nurses in caring for ten patients. Both Funkesson, Anbacken and Ek (2007) and Han et al (2007) used content analysis instead of VPA. Only two studies focused on novice nurses (Greenwood et al, 2000; Johnsen, Slettebø and Fossum, 2016). Greenwood et al (2000) focused only on exploring clinical decisions of four nurses after they attended a theoretical course but Johnsen, Slettebø and Fossum (2016) used eight community nurses working with three different patients in community settings producing twenty-four interviews.

Table 5.5: Concepts of care used in studies employing VPA

Jones (1989)	Greenwood and King (1995)	Greenwood et al (2000)	Han et al (2007)	Funkesson, Anbacken and Ek, 2007	Hoffman (2007)
Respiration Circulation Pain Anxiety Elimination Hydration Life pattern Temperature Problem area Mobility	Chest infection Observation Pain Home circumstances Appetite Constipation Urinary output Hygiene Temperature Wounds Mobility Pressure areas Deep vein thrombosis	Respiratory status Cardiovascular status Position Psychosocial Gastrointestinal status Fluids Temperature Wounds Medication Blood tests Age Error	Respiratory care Hemodynamic monitoring Positioning Tube feeding Measuring fluid balance IV infusion Recording	Breathing Circulation Wellbeing Nutrition Elimination Skin Activity	Airway Breathing Circulation Pain Comfort measures Nausea Elimination Fluid balance Hygiene Wound Mobility Equipment Family

Similar work in North America mainly conducted in simulated settings (Grobe, Drew and Fonteyn, 1991; Fonteyn, Kuipers and Grobe, 1993; Fonteyn and Fisher, 1995). These studies explored experienced critical care nurses thinking strategies and decision making, and were therefore mainly qualitative explorative designs like the studies discussed earlier. They used paper based simulated case scenarios of critically ill without manikins and applied TA and data collection and VPA as a method of analysis.

The concepts identified in RPA provide a conceptual vocabulary for the next stage of the analysis. Kuipers, Moskowitz and Kassirer (1988) suggest this phase identifies a set of referring noun phrases in a verbal protocol and defines a small universe of underlying conceptual objects. In the current study, the list of concepts was developed from two different type of sources in the literature. It was constructed based mainly on nursing studies that used think aloud and VPA to explore nurses' clinical decision making as discussed above. It was also based on the National consensus on the methods of assessing and responding to acutely ill patient needs (NICE, 2007; UK Resuscitation Council, 2015). The listed concepts in this study (Table 5.6) have been identified as part of the domain of nursing for the delivery of patient care and were used for coding the TA and observational data (see an example in Appendix 21).

Table 5.6: The current study concepts and aspects of care for RPA

Concept	attributes	Examples from this study TA scripts
Airway	Ventilation, chest wall movement, ability to speak, relevant history, airway assessment. Suctioning, drugs, airway interventions manoeuvres.	e.g., "I put her at the best position for her airway"
Breathing	Respiration; rate, pattern, and depth, air entry, effort of breathing, oxygen saturation, arterial blood gas, cyanosis, ability to speak, relevant history. Oxygen therapy, type of masks, monitoring, positioning, drug, any other breathing intervention.	e.g., "I am really concern her sats [O2 saturation] is low"
Circulation	Heart rate, regularity, rhythm, pulse strength, blood pressure, limbs observation, capillary refill time, temperature, input and output, drainage, blood test or any other circulation assessment. Relevant history. Intravenous therapy, hydration, drug, electrolytes management, monitoring, intravenous access	e.g., "Hb 75 is low", "she has high pulse", "she is compensating"
Disability	Consciousness level, neurological assessment, pupil size, anxiety, pain assessment, pain management, glucose level, sedation, limb mobility Previous or current drug, communication, reassurance, compassion, psychological.	e.g., "Disability, what is her blood sugar, she is not diabetic?"
Exposure	Full body examination, wounds, dressing, drainage, skin colour and integrity, comfort, dignity, holding drugs, monitoring, preserving dignity, cooling/warming techniques.	e.g., "I just need to examine your surgery site"

Smith (2003) and the UK Resuscitation Council (2015) recommended the use of airway, breathing, circulation, disability and exposure (ABCDE) as a structured framework for assessing and responding to acutely ill patients. Many nursing researchers also recommend the use of this systematic approach to enhance the recognition of acutely deteriorating patient (Liaw et al, 2011). They used high-fidelity simulation with 31 nursing students in Singapore, and found that the use of ABCDE approach significant improvement in students' performance in reporting deterioration and in assessing and managing the patient for those in the interventional group. The use of a structured approach could significantly impact on the patient care and patient outcome (Carroll, 2004; Munroe et al, 2013).

The context of this study is focused on a patient with acute clinical deterioration and how simulation may enhance students' decision-making skills. It would be difficult to consider holistic care in emergency situations, and therefore, not all the aspects or activities of daily living will be essential at this stage.

5.4.1a Calculating RPA frequencies

The VPA steps allow the TA data to be categorised to meaningful categories. The data can be quantified by transforming the verbal account to codes that can be counted and frequencies can be generated (Young, 2005; Bazeley, 2009).

The frequency of occurrence of different nursing concepts, that represents the RPA step of the VPA, was count based on the focus of students' verbalised thoughts, behaviour or action. A qualitative analysis program NVivo 11 (QSR International, 2017) was used for coding and providing the frequency of occurrence of each nursing concept and the reference statement for each occurrence. The coded transcripts were then exported from NVivo 11 to word documents to check the accuracy of coding, the nursing concepts were tabulated and frequency of occurrence for each nursing concept was rechecked. The frequency of the referral to nursing concepts was counted for each participant first and then the overall frequencies for each concept for the study group was produced by adding the frequency of each concept from all participants. Previous researchers used a similar approach to investigate clinical decision making by calculating the frequency of cognitive operators (Jones, 1989; Fowler, 1997; Hoffman, 2007). Appendix 21 provides an example of coding nursing concepts for one participant and an example of how the frequency of each concept was counted for the provided example.

5.4.2 <u>Assertional Phrase Analysis (APA)</u>

The focus of the assertional analysis is to determine and identify the different types of relationship between the verbalised concepts and the significance of the identified relationships (Farri et al, 2012). It defines a set of relations on objects, connectives and operators on sentences to express the content of the assertions identified by the referring phrase analysis (RPA) (Kuipers, Moskowitz and Kassirer, 1988). In the literature, two main ways have been used to carry out the assertional phrase analysis, by either identifying the operators responsible for moving the reasoning process between the states of knowledge or by describing the relationships between the concepts.

The description of relationships between the concepts was frequently used in nursing research and described how the individuals were forming relationships between the identified concepts. The relationship is usually coded as indicative, connative or casual (Fonteyn, Kuipers and Grobe, 1993). Many nursing researchers used this coding approach in both natural and simulation settings (Greenwood and King, 1995; Funkesson, Anbacken, Ek, 2006; Han et al, 2007; Lundgren-Laine and Salantera, 2010; Johnsen, Slettebø and Fossum, 2016).

The other coding approach was the use of cognitive operators to identify the decision making or reasoning pathway in solving a problem as described by Newell and Simon (1972) and Ericsson and Simon (1993). It had application in medicine and nursing by Kuipers, Moskowitz and Kassirer (1988), Jones (1989), Hoffman (2007) and Taylor-Goh (2015). The operators used may vary depending on the type and field of the study. This approach was mainly used to trace the cognitive processes of reasoning and decision making. It was used in both natural and simulation settings. This approach of coding has been found more relevant to the current study to answer the study objective and research question. The TA protocol does not collect data on the actual reasoning process, only what the subjects verbalise as they reason; therefore, the researcher interprets the change in knowledge states in the form of relationships (Ericsson and Simon, 1993). This means that the coding cannot be totally objective as it depends on researcher inference.

5.4.2a. Developing a coding framework for APA

The coding grid could be developed in two ways: either from the collected data or based on a priori theoretical concepts or theory as recommended by (Ericson and Simon, 1993). Coding categories that are constructed based on a theory are often influenced by the theoretical assumptions but that is sometimes unavoidable but necessary if testing theory by this method (Ericsson and Simon, 1993).

The coding scheme in this study was based on analysis of previous nursing studies with a similar research focus and the theoretical framework of this study, the DPT. In studies that researched cognitive processes, many researchers mainly developed coding grids based on a theory to provide a coding framework for the analysis of new data. The first coding framework within nursing research that focused on cognitive operators was produced by Jones (1989). Subsequently, many investigators in nursing adjusted and expanded Jones (1989) initial coding framework.

Although, there are a range of operators identified in nursing research produced in different parts of the world, and in different nursing specialities and settings, there are clear similarities between these operators with clear expansion on Jones (1989) work. The following section compared the operators identified in the literature to assess similarities and equivalence to develop a coding scheme for APA for this study.   For examples, the operator “collect” is equivalent to operators “choose”, “study”, “review” and “describe”. The operator “diagnose” was found to be equivalent to “conclude” and “synthesis” and it is commonly used in most of the studies. The operators “evaluate” is equivalent to “verify”, the operator “reason”, “rationale” and “explain” are similar. The operators “interpret”, “relate”, “goal” and “plan” are commonly used in most of the studies despite the settings and location. There are other operators identified, but less common, like “predict” and “match”. The operator “act” was mainly noticed in studied that used natural settings. Table (5.7) present the coding frameworks that have been used in nursing studies of clinical reasoning and decision making. Codes which demonstrate similarities or equivalency are placed in the same row.

The identified studies mainly focus on the use of the analytical approach (type 2) of decision making with limited emphasis on type 1. The features of type 1, as being intuitive and unconscious, and the difficulty to observe this process made it difficult for it to be examined in this method. This is because TA relies on students’ verbalising their thoughts, so they need to be aware of what they verbalise, which may not be achievable with type 1. The observation and video analysis provided more information about the use of type 1 and will be discussed in section (4.5.2). The recent development in the DPT suggests key features for this type is the automaticity that can be observed in internalised and routine practices, pattern recognition and as a key feature of intuition. Therefore, the operators associated with type 1 such as “predict” and “match”, are not commonly considered compared to the type 2 operators in previous studies but have been identified as part of pattern recognition and have been used in this study.

Table 5.7: Operators used in studies employing VPA and PBG

Jones (1989)	Fonteyn, Kuipers and Grobe (1993)	Greenwood and King (1995)	Lamond, Crow and Chase (1996)	Fowler (1997)	Higuchi and Donald (2002)	Twycross and Powls (2006)	Han et al (2007)	Hoffman (2007)
				Connecting				
Collect	Study	Collect	Read	Describing	Collect	Collect		Describe
Choose	Choose							Choose
Review		Review			Select		Reviewing	Review
Interpret		Interpret	Interpret		Inference	Interpret		Interpret
Relate		Relate			Relate		Validation	Relate
Diagnose	Conclude	Diagnose			Synthesise			Diagnose
Act						Action	Action	Act
			Goal			Goal		Goal
			Plan	Planning		Plan		Plan
			Evaluate	Evaluating	Verify	Evaluate	Consideration	Evaluation
	Explain		Reason	Explaining		Reason	Rationalization	Rationale
			Predict			Predict		
				Judging		Prior knowledge		
					Match			Match
								Course of action

A preliminary coding framework was designed (Table 5.8) based upon the codes generated by Jones, (1989), Lamond, Crow and Chase (1996), Higuchi and Donald (2002) and Hoffman (2007). Moreover, the following steps were considered in constructing the coding framework. It was based on the DPT as a theoretical framework that considered both types of decision making type intuition and type 2 the analytical and as defined in chapter 2 section (2.5.3). A preliminary analysis was carried out of two selected scripts using the developed framework and adjustment were made to reduce duplication or refine the description. To enhance the consistency of the coding grid and each operator was clearly defined and illustrated with a prototype (Taylor and Dionne, 2000) (see Table 5.9).

Table 5.8: Initial coding schedule

Operator	Description
Plan	Explain what is going to happen
Describe	Describe fact situation or context.
Collect	To acquire cues, examine, measure
Interpret	understanding and the meaning of the collected cues
Relate	Connecting relevant signs and symptoms together
Infer	Make deduction, include relevant and exclude irrelevant cues
Rationale	To provide reasoning for a course of actions
Diagnose	Reach definitive conclusion and identify the patient problem.
Match	Matching cues/patient in the present situation to the previously encountered
Predict	Anticipate or propose how the patient condition would progress,
Goal	Identify the desire outcome or target
Choose	Choose a course of action
Act	Performing action
Evaluate	Verify the effectives of the actions

Initially, the hierarchy was not clear and operator “predict” and “match” were listed after “diagnose” and operator “rationale” was listed before operator “diagnose” but after the examination of the first two scripts and referring to the literature the order of the list was changed. The hierarchy of the cognitive operators is based on previous studies discussed earlier in Table (5.7). This hierarchy was clearly noted in Jones (1989), Higuchi and Donald, (2002), but Hoffman (2007) also considered features the non-analytical method of CDM in her work. The features of type 2 CDM considers the application of the stages of the hypothetico-deductive approach that was defined by Elstein, Schulman and Sprafka (1978). The definition of critical thinking was also considered in the construction of this hierarchy. The operator “describe” was replaced by operator “review” which was found to reflect students’ statements better than “describe”, being broader in meaning and to reduce the use of too many operators with similar meaning. The same approach was applied to replace operator “choose” to “course of action”. The final list of operators applied in this study with their hierarchy are listed in Table 5.9 with examples from the verbal data and this was the final list used to analyse the study data.

Table 5.9: The study cognitive operators for the APA

Operator	Definition	Example from TA data of this study
Plan	Explain what is going to happen	e.g., “I am going to do a set of observations”
Review	Review actions, go over drugs and charts, records and results. Restate, reflect	e.g., “I put her at the best position for her airway and the fluids are running”
Collect	To acquire cues, examine, measure, notice, observe and ask for further details,	e.g., “patient respiratory rate is 23”
Interpret	To demonstrate the understanding and the meaning of the collected cues, signs and symptoms consistent with professional knowledge	e.g., “temperature of 38.9 C is really high maybe she has sepsis”
Relate	Connecting relevant signs and symptoms together, cues clustering to identify new patterns or relationships between signs and symptoms.	e.g., “as having high temperature, high HR, and low BP. All pointing toward sepsis”
Infer	Make deduction, include relevant and exclude irrelevant cues, draw logical conclusions/patterns based on the provided cues.	e.g., “I roll out an allergic reaction to blood”
Match	Cues/patient that activate the recognition of a pattern.	“because of the rash and the temperature, it is reaction, typical signs of reaction”
Predict	Anticipate or propose how the patient condition would progress, declaring in	“and if she keeps continuing like this she will arrest”

	advance, and make prediction about intervention, outcome, situation or response.	
Diagnose	Reach definitive conclusion and identify the patient problem.	e.g., “she either has serious infection or internal bleeding”, “it looks to me; this is infection”
Goal	Identify the desire outcome and achieving a target/aim within a time frame	e.g., “wait until it [SpO2] reaches 94%”
Course of action	Describe, choose or select a course of action/s to manage the identified problem/s. Weighing different alternatives	I need to start sepsis 6 so the first thing is oxygen, next is IV fluid, taking lactate and ABGs, we need antibiotics”
Act	Performing action/s, or a description of what a nurse is doing, or what he/she want the patient to do	e.g., “Try to take nice deep breathing. Checking the site of the surgery again”
Rationale	To provide reasoning for a course of actions/ suggestions, how things works fit, explain events, links or the cause of effect.	e.g., “because no signs that I can see of losing fluid”, “because she is speaking in full sentence”
Evaluate	Verify the effectiveness of the actions	e.g., “Ok Saturation is 88% and is not coming up with O2 therapy”

NVivo 11 provided the frequency of occurrence of each cognitive operator and the reference statement for each occurrence. The coded transcripts were then exported from NVivo 11 to word documents to check the accuracy of coding, the operators were tabulated and frequency of occurrence for each operator was rechecked (Appendix 23). Initially, the frequency of the referral to cognitive operators was counted for each student and overall frequencies for the study group was produced.

5.4.2b Problem behaviour graph (PBG)

Before discussing the script analysis, it is important to introduce the problem behaviour graph. The verbal protocol analysis of the operators used by each student was graphically presented using a PBG. The PBG has been used in a number of nursing studies as a method for script analysis. Newell and Simon (1972) described the concept of a problem space that individuals use to search through this space for a solution for the task at hand. They used the PBG as a graphical representation or a search tree that the individuals use through search in a problem space. They described that each node is characterised by an expression, and each move to a new node in the tree can be characterised by the application of one of the cognitive operators. For this to be accurate, not only the operator must apply to the node but the new state of knowledge must correspond to the additional information yield by that operator. PBG was used as a method to graphically illustrate the thought process as the students think aloud while performing a task. The assumption is that new state of knowledge is built upon the preceded state of knowledge.

PBG is a network of nodes connected vertically and horizontally. The application of operators to a state of knowledge is represented by a horizontal line to the right that results in a new node. A return to the same node or backtrack to the previous node is represented by a node that is connected by a vertical line. The time is to the right and then down; thus, the graph is linearly ordered by time of generation. The value of PBG is its ability to simultaneously illustrate the concepts that the participant is paying attention to, the cognitive processes, the progression in thought process and sequence of events for each VPA. A number of nursing researchers applied the first two steps of VPA and then for the script analysis they applied content or thematic analysis instead of PBG (Twycross and Powls, 2006; Han et al, 2007). A commonly cited rationale for not using PBG, is that is PBG is time-consuming and some suggested that the focus is on the content of the decision-making process.

5.4.3. Script Analysis (SA)

The script analysis was carried twice, the first analysis focused on identifying the type of decision-making used by the students with different tasks and the second analysis focused on identifying the cognitive bias used by the students during their performance.

5.4.3a Script Analysis for the type of CDM

The approach to identifying the type of decision making was based on the literature review and the theoretical framework discussed in chapter 2 and after the preliminary analysis of the first two scripts. The main two types of decision making identified in chapter 2 were type one and type two (Croskerry and Nimmo, 2011). Similar approaches were used by Jones, (1989); Greenwood et al (2000) and Hoffman (2007) but with differences in the theoretical framework used. The following tables were constructed as coding schedules to identify the types of decision making (Table 5.10 and 5.11). The way to identify the types of decision making was identified by tracing the use of cognitive operators and the production of the PBG.

Table 5.10 Type 1 decision making for SPA

Type	**Aspect**	**Brief description**	
Type 1 CDM			
• **Intuition** • Unconscious • Automatic	Reflexive. Fast executed process. High capacity. Many decisions in short time frame.	Effortless. Missing steps, straight to action, diagnosis or solution. automatically appear to know what he/she is doing	
• **Pattern Recognition**	Acquiring specific cues	Immediately recognizing or noticing critical cues that automatically activate the collection of specific to the clinical situation based on experience.	Collect specific cues based on predication to match previous conditions. Predict
	Chunking cues	Chunking the critical cues and rapidly processing and connecting the chunked cue to the LTM.	Interpret, relate and match cues to previous cases, situations or interventions
	Pattern- matching	Rapidly matching the chunked cues with familiar patterns	Predict, Match and diagnose
	Pattern-recognition	Reaching single diagnosis with greatest probability based on experience.	Diagnose
	Evaluation	Chunking new cues and refining and the new pattern	Evaluate

Table 5.11 Type 2 decision making for SPA

Type	**Aspect**	**Brief description**	**Cognitive operators used in this study**
Type 2 CDM			
• **Hypothetico-deductive**	• Cue acquisition	Cue recognition and collection (i.e., sign and symptoms)	Collect, review and plan
	• Cue interpretation	Cue valuation, meaning of the cues, cue clustering.	Interpret, relate, infer, rationale
	• Hypothesis generation	Possible meanings of the generated clusters of cues.	Diagnose, goal, course of action
	• Hypothesis evaluation	Confirming the hypothesis, course or action or return to cue acquisition and start the cycle again.	Evaluate, act
• Load heavily on the working memory	Slow process Low capacity to process many decisions at short period of time.	Limited number of decision within timeframe Time consuming process.	As above
• Cognitive decoupling	Able to test different hypothesis at the same time	Able to focus and maintain attention on different cues while evaluating different hypothesis. Usually require more data.	As above

Type one CDM

Type one was identified through pattern recognition and automaticity in making decisions or taking actions considering the short time frame for the decision-making process. The fast, unconscious, and automated features of this might not be easy to identify through the verbal data that require the student attention. However more data about this type was collected using observing non-verbalised behaviours. The intuition and automaticity have been identified in the literature by recognising missing steps in the reasoning process, the move straight to action and solution from the perception of information or automatically appear to know what he/she is doing (Moors and De Houwer, 2006). There is a slight difference between automaticity and intuition; where intuition is described as a form or knowing and automaticity may have been developed by internalisation of routines and procedures so not always automatic behaviour might not always reflect intuitions (Table 5.12).

Table 5.12 Examples of automated behaviour from TA scripts

Student O1	L001: “Hello Carol, I am x” (act) L002: “how are you feeling?” (collect) *Facilitator: I am a bit short of breath* L003: “ok I am going to do a set of Obs (observations) on you” (plan) L004: “to see how is your blood pressure and temperature” (rationale). (*here despite the patient complained about shortness of breathing, the student went for measuring blood pressure first)* *Although student might be conscious about her/his action and appear to know what she/he is doing but it demonstrates automaticity and internalised routine of practice and a missing step of examining the issue with breathing. This led to delayed examination of the critical cue, shortness of breath, and delayed management.*

The other way of identifying this type is based on the students’ familiarity with the clinical situation. Pattern- matching involving students immediately recognising critical cue in the situation comparing it to their experience and predicting what will happen next (Fonteyn,1995). It has been described as a rapid processing as nurses used cues chunking and rapid connection to the long-term memory (LTM) to activate previously stored patterns with similarities to the current situation. The chunking increases the processing capacity and matching different patterns until you reach a single diagnosis or best match with the highest probability. These features fit with type one decision making as it is fast, automatic and high capacity processing. So, the students may:

- Start by collecting or noticing specific cues or rearranging the collected cues that fit together in a familiar constellation
- Matching the collected or noticed cues to previous experience of conditions, situations or interventions.
- Predicting what may happen next.

The tracing of this process using the following operators:

- “Collect” or “review”, then
- “Match” and/ or “predict”

Then they may or may not use the following operators immediately after the use of “match” or “predict”:

- “Diagnose” or “act” or “evaluate”

Although some of these operators are part of type 2 the difference is the rapid processed decision, many reasoning steps are missing and the use of “match” to match the collected data to previous experience and the immediate identification of the problem or action afterwards (Table 5.13)

Table 5.13 Examples of pattern recognition from TA scripts

Student C1	Exposure: L094: “I need to check for proper exposure” (plan), “excuse me Mrs Stone I just need to examine your surgery site” (act) L095: “Ok she has red rash all over her chest” (match) L096: Ohhhhh, noo.. I am going to stop the blood right away (act) L097: “she is having serious reaction” (diagnose) L098: “and she is very tachycardia…” (interpret) L099: “is going to arrest” (predict) L100: “call for cardiac arrest” (act)
B1 (Concurrent) B2 (Retrospective)	L001: When did that blood transfusion start “when she first arrived, I thought immediately it was blood transfusion reaction” *Researcher: Why?*

	"I do not know but I had similar issues in critical care placement, initially I thought about reaction but then I thought about hypovolaemia but the signs and symptoms pointed more toward sepsis" *The first question the student asked after reviewing the patient scenario, was about the blood transfusion bag, B was immediately focused on blood transfusion. He/she used similarity from experience, a match with similar pattern to include and exclude reaction.*

Type two CDM

Type two was identified by tracing the processes of hypothetico-deductive reasoning and number of decisions made within the specific time frame. The hypothetico-deductive reasoning is usually divided into two types of reasoning: forward and backward reasoning.

The forward reasoning or data-driven method occurs where information is gathered and cues are collected in an inductive way that leads to the generation of a hypothesis (Carneiro, 2003). The backward reasoning or hypothesis-driven reasoning occurs when the students initially identify the problem then collect data to deductively verify and provide a rationale for their conclusion. The hypothetico-deductive approach usually starts with the inductive approach based on limited pieces of patient data then proceeds in a deductive manner to reach a final diagnosis. Jones (1989) suggested that the forward reasoning tends to produce a vertically shaped PBG and the backward reasoning produced more horizontal shaped PBG.

The hypothetico-deductive with a forward reasoning may have operators arranged more or less in the following order

- Start with "plan" and/or "review" and/or "collect", then
- "Interpret" and/or "relate" and/or "infer" and/or "rationale", then
- "Diagnose" and/or "goal", then possible to be followed by
- "Interpret" and/or "relate" or/and "infer" and/or "rationale", then
- "Course of action" and/or "act", then
- "Evaluate" (see Table 5.14 and Figure 5.2 for PBG)

It may not be necessary for all the steps to be available in the verbal data but a more or less very similar path would suggest forward reasoning.

Table 5.14 Example of forward reasoning from TA scripts

Student A1	Circulation: L032: “Hb 75 is low” (interpret) L033: “she has high pulse”, “she is compensating” (interpret) L035: “because of the low Hb” (relate) L036: “she has low blood volume” L037: “so she is suffering from some haemorrhage” (diagnose)

The hypothetico-deductive with backward reasoning may have operators arranged more or less in the following order:

- Start with “diagnose” and/or “review”, then
- “Plan” and/or “collect”
- “Relate” and/or “infer” and/or “rationale” and/or “interpret”, then
- “Course of action” and/or “act”
- “Evaluate” (see Table 5.15 and Figure 5.2 for PBG)

Table 5.15 Example of backward reasoning from TA scripts

Student B1	Circulation: 177: “her temperature was 38.5 c” (review) L178: “it looks to me; this is infection” (diagnose) L179 “So my priority is she is having sepsis” (diagnose) L180: "as having high temperature” L181: “and high HR”, L182: “low BP” (relate) L183: “all pointing toward sepsis” (relate)

The frequency of occurrence of type 2 was based on the number of sections coded pattern recognition, automated behaviour and intuition that was extracted from NVivo and PBG. Likewise, the frequency of occurrence of each type 2 was based on the number of sections coded as forward and backward reasoning that was extracted from NVivo and PBG. Initially, the frequency of occurrence of each type of CDM was counted for each student and then overall frequencies for the study group was then produced.

The previous sections discussed my approach to TA data analysis the use of VPA steps, how coding framework for each VPA step was developed and used in the analysis. The discussion and appendices provided many examples from the study data to allow traceability of the researcher steps.

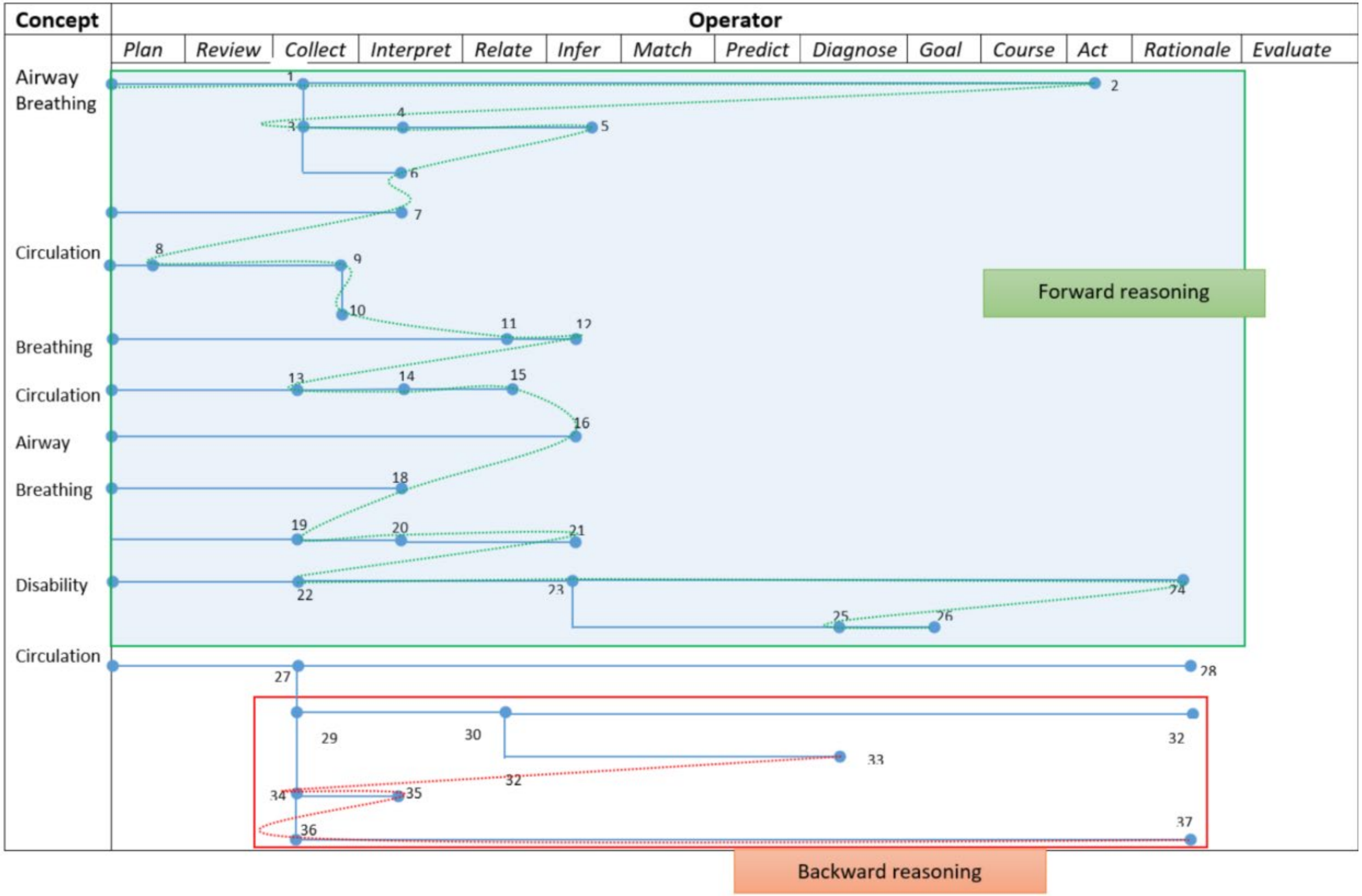

Figure 5.2 An example of a problem behaviour graph (PBG): A1 concurrent TA

5.4.3b. Script analysis of cognitive biases

Tversky and Kahneman (1974) observed that the rational approach to decision making is not consistent with how people make decisions in a real-life situation. They discovered how human judgement under uncertainty regularly departed from rationality. They observed people employing a range of cognitive shortcuts during decision making which were time-saving and generally effective in order to reduce the complexity of the task. However, alongside these advantages, they found that these shortcuts can also lead to systematic biases (section 2.6.1c).

Tversky and Kahneman (1974) focused on three main biases; representativeness, availability and anchoring, Croskerry (2002) identified 30 different biases and Stiegler et al (2012) Delphi study of experts identified 14 biases followed by an academic survey that narrowed it down to 10. Their observational study narrowed it to nine cognitive errors that were used by participants. Although Croskerry focused on emergency medicine and Stiegler focused on anaesthesiology, their work may have application within the wider field of healthcare and decision making and may be relevant particularly to nursing working in acute and critical care settings. While limited research has been identified in nursing that focuses on investigating the use of biases in nursing clinical decision-making process(O'Neill, 1994; Cioffi and Markham, 1997; Ferrario, 2003), based upon the Tversky and Kahneman (1973). It is arguable that they are just as likely to be employed by nursing students. It does not appear to be a profession-specific trait but rather a feature of human decision making.

This study produced a catalogue of cognitive biases based on the above literature (Tversky and Kahneman, 1973; Croskerry, 2002) and what (Stiegler et al, 2012) validate through their Delphi and observational study. A catalogue was produced and used to code statements from the think-aloud protocols and observations (Table 5.16). The coding scheme includes all the classical biases and all those biases that have been identified by (Stiegler et al, 2012) in their observational study. Four other biases were added by the researcher from Croskerry (2002) list as they were found relevant to nursing practice, which included the following biases; order effect, searching satisficing, context error and hindsight.

Stiegler et al (2012) used a similar design to the current research, they used a high-fidelity simulator in a university skill laboratory and they used similar scenarios such as airway problems. Their study was a pilot and did not have a control, blinding or randomisation with a population of 32 residents who were sequentially recruited over a period during an academic course. They did not control the simulated subject matter or script or faculty member and did not control faculty responses from usual simulated practice but the same investigators observed for the biases. Stiegler et al (2012) only collected observational data and the current study used verbal and observational data. The researcher of the current study made notes of cognitive biases during the simulation and those behaviours were subsequently explored during the debriefing and debiasing session.

Table 5.16 schedule of cognitive biases

Bias	Description
Omission	Hesitation to perform intervention worrying about the consequences.
Commission	Deviating from protocol, performing unindicted or tendency to action rather than inaction, due to pressure from other or desperation.
Premature closure	Reaching conclusions before all the information are obtained or accept first plausible diagnosis.
Order effects	Tendency to miss vital and relevant clues due to the order of gathered data.
Searching satisfacing	Tendency to stop searching for alternative once plausible abnormality is identified.
Framing	Fixated on prior decision or labels placed on patient [by previous clinicians/ lay person or patient/family] the tendency for particular diagnosis to become established without adequate evidence.
Representativeness	Tendency to use typical presentation of clinical problem to reach diagnosis without considering possible alternative. Cues indicate a particular condition that the participant has previously encountered. Issues could be missed if atypically presented.
Confirmation	Seeking only data that confirms the desired or suspected problem. Or modifying interpretation of data to fit with initial prediction or selected diagnosis.
Availability	Tendency for things to be judged more frequent if they come readily in mind and insufficient attention to that is not immediately present. Similar conditions come to mind.
Context error	Wrong perception or misinterpretation of critical cues due to background noise or interruption or lack situational awareness.
Anchoring	Fixated on one issue at the expense of understanding the whole situation. Loss of situational awareness. A participant starts from an initial estimate (anchor point) and then adjusts away from this anchor point to arrive at a final estimate.

5.5. Task analysis

During the research process, I felt the need to consider not only how the decisions have been made but also the type of information used by students during the simulated scenario. The concurrent TA scripts and checklist used during the task performance were analysed to identify a number of cues used by students, the accuracy of interpretation, the type of cues, the accuracy of cue clustering and patterns, the identified problems and taken actions. The findings were then related and compared to the type of CDM use and the effects of biases.

5.6. Content analysis of observation and recorded videos

The researcher assumed the role of observer-participant; he was observing students' performance and responding to questions from a structured predesigned sheet for the simulated scenario. The checklist includes the signs and symptoms and trends of clinical deterioration of a patient's condition. The checklist was structured under the nursing concepts (airway, breathing, circulation, disability and exposure) as discussed in chapter 4 (section 4.4.2). The observation and video analysis was focused on stages of hypothetico-deductive approach and to gather data that would help in identifying the type decision making. The checklist collected data about the cues used by students, how they identified the problem, acted on the presented issues and evaluated their findings and action (appendix 10). Any extra cue or action was added on the form during the observation. The content of the used checklist was included in the recorded videos. During the video analysis, these checklists were reviewed at the same time to ensure any important notes written in the checklists were not missed. The content analysis of the observations applied the same coding grids used in TA, nursing concepts, cognitive operator and type of CDM (Tables 5.6, 5.9, 5.10 and 5.11).

The content analysis used the schedules developed and discussed earlier in section 5.4 for the cognitive operators to assess their frequencies and for the identification of the type of decision-making process used by students. Finally, the author identified the cognitive biases in the observational data based on the schedule discussed in appendix six. The objective of analysing the observations was to compare the results from the observations with the results produced from the concurrent TA. The identification of similarities and differences is a recommended approach to enhance the consistency of the data analysis by Aitken et al, (2008). The selected videos were transcribed Verbatim and attached to NVivo11 (QSR International, 2017) for coding the operators, type of CDM and cognitive biases. The frequencies were calculated and tabulated and data was attached to SPSS for descriptive statistics.

5.7. Thematic analysis of the follow-up interview in phase 2

Thematic analysis is a qualitative analytical method for 'identifying, analysing and reporting patterns (themes) within data. It minimally organises and describes your data set in (rich) detail. However, frequently it goes further than this, and interprets various aspects of the research topic' (Braun and Clarke, 2006, p.79). Braun and Clarke (2006) explained that unlike grounded theory or conversation analysis (CA), thematic analysis is not tied to a theoretical or epistemological position. As a method of analysis, it is essentially independent of theory and can, therefore, be applied across a range of theoretical and epistemological approaches. For example, it could be firmly used within the interpretive paradigm for sociologists, thematic analysis is also could be applied by clinical researchers as almost a form of content analysis, with focus on identifying recurring descriptive statements (Ryan and Bernard, 2003).

The reason for selecting thematic analysis was due to its flexibility and freedom from epistemological and theoretical limitations. Its theoretical freedom, the thematic analysis provides a flexible and useful research tool, which can potentially provide a rich and detailed, yet complex, account of data that will adequately answer the study research question. The focus is on the usefulness of the simulated experience on students' clinical decision-making skills and how it affected their clinical practice. It is important to assess what students consider valuable and clinically useful learning for their practice. Thematic analysis aims to identify, describe and analyse patterns about the usefulness of simulation experience to students' clinical practice.

To explore the content of the interviews, an inductive data-driven coding method was undertaken to generate themes within the data (Miles, Huberman, Saldaña, 2014; Bruan and Clarke, 2006). Braun and Clarke suggested taking six phases for thematic analysis (Table 5.17). Although those phases were also recommended by Miles, Huberman and Saldaña (2014) but summarise the key stages as descriptive coding, then categorical coding and finally analytical coding.

The first step was to familiarise and immerse oneself with the depth and breadth of the data content. All the verbal data from the interviews were transcribed by a professional transcriber specialised in the field of healthcare. All the transcripts were then reviewed and checked against the audio recordings by the researcher and corrections were carried out and a few sections were transcribed again by the researcher to maintain the accuracy of the verbal data. This was a useful way to familiarise myself with the set of data. Then all transcripts were read in one session to develop a better sense of the data and notes were written from the initial reading. All the transcripts were then organised and imported into NVivo 11© (QSR International, 2017) to manage the coding process.

Table 5.17 Thematic analysis

1. Familiarizing yourself with your data
2. Generating initial code
3. Searching for themes
4. Reviewing themes
5. Defining and naming themes
6. Producing the report
Source: Braun and Clarke. 2006

The second phase was then followed. All transcripts were coded in a systematic way using NVivo 11 generating the initial code list and each transcript was coded for meaningful features that are relevant to study focus and research question. These codes were described as “descriptive code” by Miles, Huberman and Saldaña (2014). The third phase started by examining and organising the identified codes together to identify meaningful patterns and search for themes. If the codes refer to similar concepts or describe the dimension of the same concept, then they were clustered together to produce a more refined categorical list of codes that represent the initial themes or sub-themes.

The fourth phase was conducted by reviewing the identified patterns. The researcher used NVivo by applying functions such “Explore” and “Comparison” to interrogate the initially coded extracts and the allocated codes and to examine whether those extracts fit the identified sub-themes, belong to different sub-themes or could be constructed to present different relationships. All the collated extracts for each theme were explored using NVivo 11 and read to ensure it formed a coherent pattern. Phase four then started by reviewing the identified themes and their extracts and assessing if each theme had internal homogeneity by fitting together in a meaningful way at the same time as having clear features to be distinguished from the other themes. The configuration or thematic tree of all the sub-themes were then examined and aggregated to illustrate a smaller number of meaningful patterns that were considered the main themes. The entire data for each theme was then reviewed to ensure accurate representation. In phase five, those themes were given names and description. The final phase is writing the results in chapter 7 (Braun and Clarke, 2006; Miles, Huberman and Saldana, 2014).

5.8. Summary

The chapter discusses the use of descriptive statistics to explore the data set and the clinical reasoning scores. Inferential statistics examines the differences, the correlation and evaluates variance between the HSRT and type of decision making. VPA explores the TA data to identify the concepts of care, cognitive operators and the types of decision making and biases and how frequencies are calculated. Content analysis analyses the observational data and thematic analysis identifies the themes from the semi-structured interview. The following figure summaries the chapter methods of analysis and the relationship with the applied method to research questions (RQ) (Figure 5.3)

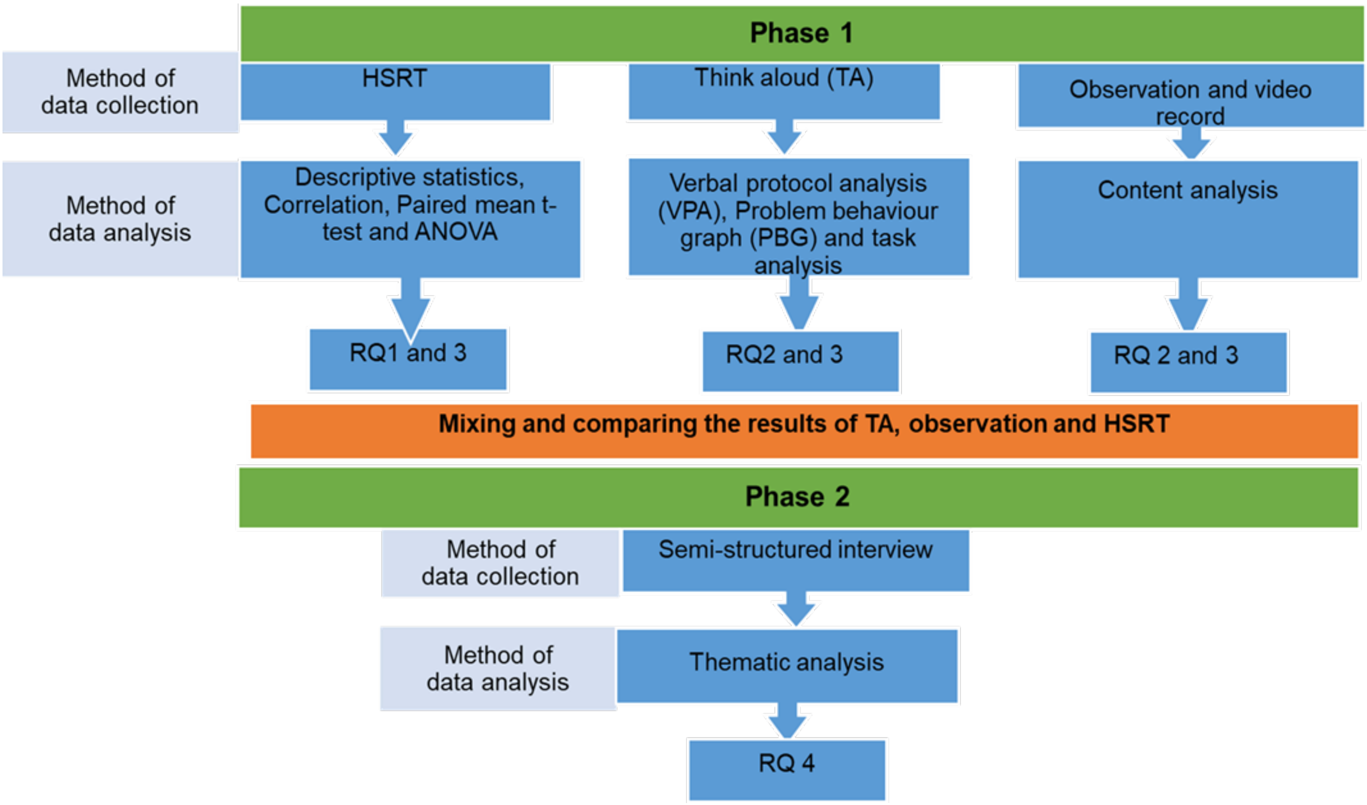

Figure 5.3 summary of data analysis methods

CHAPTER 6
RESULTS OF PHASE 1

6.1. Introduction

The purpose of this study was to investigate nursing students' clinical decision making using high fidelity simulation of a deteriorated patient scenario. This chapter presents the results of the first phase of this investigation that initially focused on quantitative measurement of the simulated experience impact on the clinical reasoning score, then explored the type of clinical decision-making (CDM) and the associated processes and cognitive biases. The data collected by HSRT, think aloud (TA) and observations were analysed in a number of ways to build an in-depth, rich description and analysis from the small sample to illustrate how a group of nursing students reason and decide using a high fidelity manikin-based simulation of a scenario of an acutely ill patient. The demographic characteristics are presented first, then data on the Health Science Reasoning (HSRT) score that includes the result of the overall score and subcategories scores. The data on the cognitive operators used by students are presented next for both concurrent and retrospective TA. The results include the frequency of using different operators in the concurrent and retrospective separately and then from both combined. The results of the processes and types of decision-making are then presented in a similar way. The results of the cognitive biases identified in the TA transcripts are presented next and related to the type of decision making used in the same verbal segments. Observational data about the cognitive operators and types of decision making is then presented and compared to the data from TA. Finally, the data from the TA session was then related and compared to the HSRT pre/post the simulation.

In keeping with the multiphase mixed method design, the result of each method was analysed separately and then compared and corroborated (Onwuegbuzie and Leech, 2005; Creswell and Plano, 2007;). Table 6.1 provides the start and the end dates of the data collection for phase 1.

Table 6.1 Dates of data collection for phase 1

	Cohort 1		Cohort 2	
	Start	Finish	Start	Finish
Phase 1 data collection point	21st September 2015	7th October 2015	11th April 2016	25th April 2016

6.2. Results of the demographics and HSRT

Descriptive and inferential statistics were used to examine three research questions in this study; RQ1, RQ2 and RQ3. Descriptive statistic was used to compare the differences in the HSRT scores. The HSRT was used to quantitatively measure a change in clinical reasoning score of the students in this study.

6.2.1. <u>Demographics</u>

The study consisted of 23 third-year nursing from one School of Nursing and Midwifery in the UK. Students were recruited in the last six months before completing BSc in nursing.
Most of the students were female (87%; *n* = 20). The age of students ranged from 21 to 44 years (*mean (M)* = 28, standard deviation (S*D)* = 6.95) and 52.2% of the age distribution was for students age between 20-25 years old. Most of the students did not hold previous educational qualification before starting their nursing degree. The students had varied clinical placements during their Nursing course with 47% (n=11) in clinical placements in mixed medical-surgical wards without emergency or critical care placement. A small number of students self-reported to have learning difficulties (13%). Most of the students (61%) had less than 2 years of clinical experience as a healthcare assistant (HCA) before commencing the Nursing degree course (Table 6.2).

Table 6.2: Sample characteristics

Gender	Number (%)	Ethnicity	Number (%)
Female Male	20 (87%) 3 (13%)	White Black/African/Caribbean	20 (87%) 3 (13%)
Level Education	**Number (%)**	**Type of clinical placement**	**Number (%)**
Advanced level Bachelor of Science Master of Science	20 (87%) 2 (8.7%) 1 (4.3%)	Mixed (medical and surgical) without ICU or emergency unit Mixed with emergency unit Mixed with ICU Mixed with emergency unit and ICU	11 (47.8%) 6 (26.1) 4 (17.4%) 2 (8.7)
Learning difficulties	**Number (%)**	**Previous healthcare care experience**	**Number (%)**
Has learning difficulties No learning difficulties	20 (87%) 3 (13%)	No experience - < 2 years ≥ 2 - < 4 years ≥ 4 years	14 (61%) 3 (13%) 6 (26%)
Age (years)	**Number (%)**	**Measure**	
20-25 26-30 31-35 36-40 >41	12 (52.2%) 5 (21.7%) 1 (4.3%) 3 (13%) 2 (8.7%)	Mean (S.E) Median Mode Range SD Minimum Maximum	28 25 25 23 6.95 21 44
SE: Standard error of mean, SD: standard deviation, ICU: intensive care unit			

6.2.2. Descriptive statistics of HSRT results

The HSRT overall score has 38 points, the student overall score could be interpreted as to their relative strength using Recommended Performance Descriptors recommended in HSRT Manual (Insight Assessment, 2016). Twenty-three nursing students in their third year took the pre-test (n=23, M= 18.49, SD=4.45) and the same group took the post-test (n= 23, M= 20.52, SD=4.02) (Table 6.3). Overall, there was an increased in the post-test results for the mean of total HSRT and the subscales score except the inference, this demonstrates improvement in students' clinical reasoning and decision-making abilities after the simulation experience compared to their score before the simulation. Based on the mean of the percentiles of this group, the pre-test percentile was 43, which is below the norm reference of nursing students. The post-test percentile was 58, which is above the norm reference for nursing students at the same level of study (Insight Assessment, 2016). The increase in the group overall percentile above norm-reference percentile is a good indicator of the improvement in students' performance after the simulation this study.

Table 6.3: HSRT mean results

HSRT	Mean (SD)	Mean percentile compare to norm-reference score
Pre-test n=23	18.39 (4.45)	43
Post-test n=23	20.52 (4.02)	58

Eighteen students out of 23 (78%) had a suboptimal level of clinical reasoning score before the simulation and only small number of students achieved a good level (22%, n= 5). In the post-test results, there was a reduction in the number of students in the suboptimal performance categories (52%, n=12) and an increased in the number of students in the "strong" level category (48%, N= 11) indicating an improvement in performance for many students (Figure 6.1). A similar trend was observed in most of the HSRT sub-scales scores; with a notable improvement in the deduction score for the post-test. The improvement was not limited to the increased number of students who achieved "strong "category but also in the HSRT score of most of the students including those who stayed in the same category, for example, two students achieved "superior" level in both the pre-test and post-test, but their HSRT was much higher for the post-test.

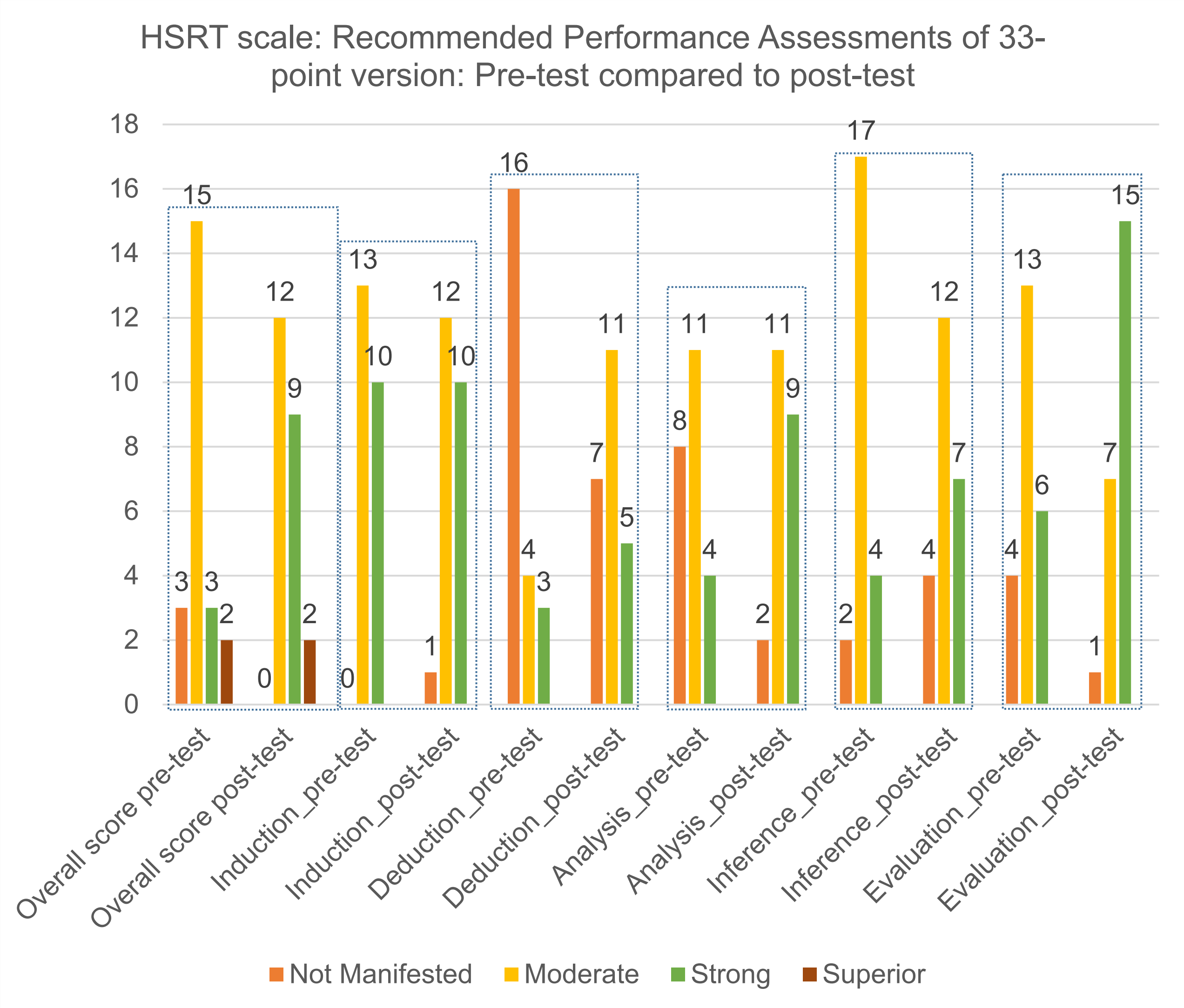

Figure 6.1. Comparison between pre- and post HSRT scale components

The mean overall score of the post-test was 20.52, roughly 21, a score that is classified as strong on the recommended performance scale. In the subscales results, although improvements have been observed in most of the subscales in terms of performance assessment only the evaluation score reached the strong category and most of the others were just under the strong category score.

6.2.3. <u>Inferential statistics of the HSRT results</u>

Paired t-statistics test (dependent samples t-test) was used to compare the difference in the mean score between the HSRT pre-test and post-test for the same group of students. The t-test is a parametric test that assumed the sample is normally distributed and have homogeneity of variance. Since the study is measuring the differences in the mean for the same group of students, it was therefore assumed that the sample met homogeneity of variance criteria. For this study, a Shapiro-Wilk's test (p>.05) (Shapiro and Wilk 1965; Razali and Wah, 2011) (Table 6.4) and a visual inspection of their histograms (Figure 6.2) showed that the pre- and post HSRT results for the experiment group were approximately normally distributed. The analysis showed a skewness of 0.852 (SE 0.481) and kurtosis of 0.220 (SE 0.935) for the pre-test and a skewness of 0.540 (SE 0.481) and kurtosis of 0.628 (SE 0.935) for the post-test (Cramer and Howitt, 2004; Doane and Seward, 2011).

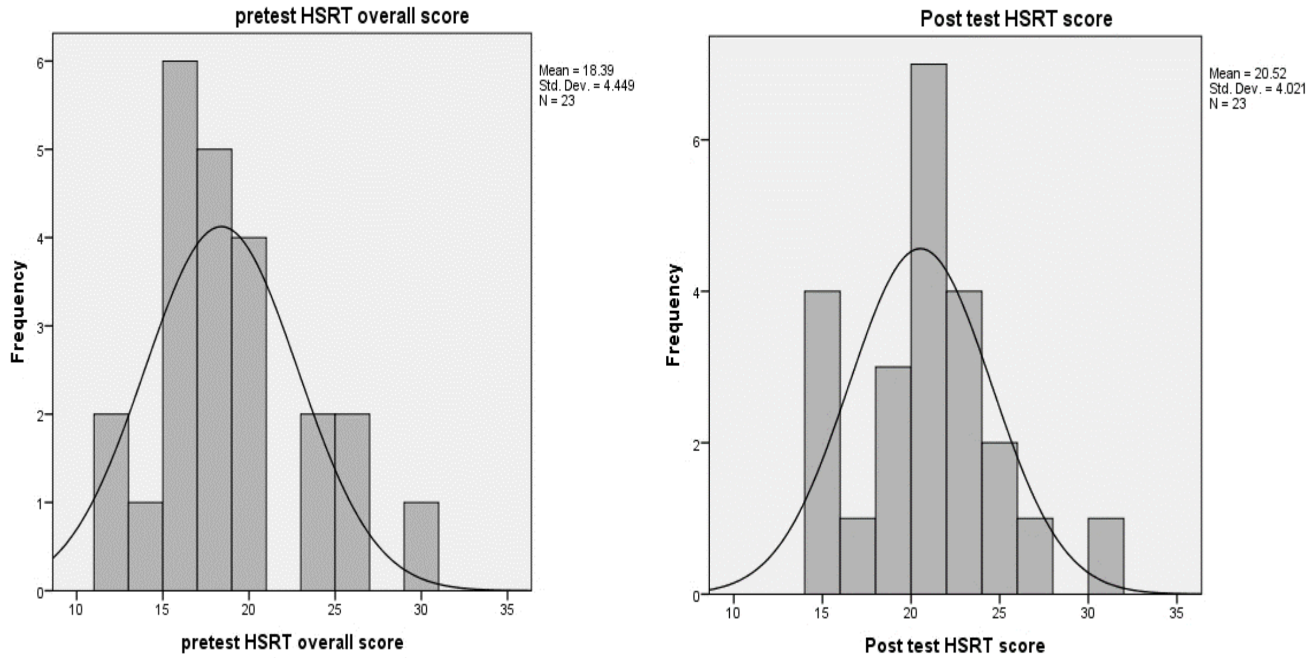

Figure 6.2: Pre- and post-test HSRT score normal distribution

Table 6.4 Tests of Normality for the pre- and post-test HSRT score

	Shapiro-Wilk		
	Statistic	df	Sig.
Pre-test HSRT overall score	.915	23	.053
Post-test HSRT score	.941	23	.190

To test the hypothesis that HSRT mean scores pre-simulation (M= 18.39, standard error (SE)=.928) and post-simulation (M=20.52, SE= .838) were equal, a dependent samples t-test performed. It will also be noted that correlation between the two conditions estimated r = .64, p = .001, suggesting that the dependent samples t-test (paired t-test) is appropriate in this case. The null hypothesis of equal HSRT mean score was rejected, t (22) = 2.82, p = .01. Thus, the post-simulation HSRT mean was statistically significantly higher than the pre-simulation HSRT mean (Table 6.5). Cohen's d was estimated at .58 which is a medium size effect based on (Cohen, 1988). The improvement in score of the sub-score for deduction and analysis was also statistically significant $p <.01$. The improvement in the other sub-scores and the marginal reduction in the inference score were not statistically significant. There was a significant increase in the HSRT over time, suggesting that participation in the simulation experience may have improved students' clinical reasoning and decision-making abilities. The findings above answer the first research question (RQ1) that there is a significant difference in the clinical reasoning measures post-simulation experience compared pre-simulation measures.

Table 6.5: Dependent sample t-test (Paired Samples t- test)

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Post-test HSRT score – pre-test HSRT overall score	2.13	3.62	.76	.56	3.7	2.82	22	.010
Pair 2	Post-test induction – pre-test induction score HSRT	.52	1.59	.33	-.17	1.21	1.57	22	.130
Pair 3	Post-test deduction – pre-test deduction score	1.43	2.31	.48	.44	2.4	2.97	22	.007
Pair 4	Post-test analysis – pre-test analysis score	1.0	1.68	.35	.27	1.72	2.86	22	.009
Pair 5	Post-test inference –	-.04	1.58	.33	-.73	.64	-.13	22	.896

	pre-test inference score								
Pair 6	Post-test evaluation - pre-test evaluation score	.39	1.47	.31	-.24	1.03	1.28	22	.215

Relationships between the students' clinical reasoning score and their demographics showed no significant correlations. Analysis of variance was conducted using one-way ANOVA to explore the impact of demographical factors on clinical reasoning and decision-making measure, as measured by HSRT. Students were divided into groups for example age groups (group 1: 20-25 years; group 2: 26-30 years; group 3: 31-35; group 4: 36-40 and group 5: >40 years). The results found that spoken language was the only factor associated with statistical significant difference in HSRT mean score for both pre-test ($F (2, 20) = 3.752$, $p = .041$) and post-test ($F (2, 20) = 4.872$, $p=0.019$). The difference in the mean score between the groups has a small size effect (eta square = .27) for pre-test and medium-size effect (eta square = .33) for the post-test. Bilingual students with English as the first language appeared to have a higher HSRT score. No other statistically significant differences were found in students' clinical decision-making scores based on their demographical factors for both pre- and post-test.

6.3. Results of the verbal protocol analysis

The results of TA protocol follow the VPA steps described in the analysis chapter section (5.4). The following sections will start by presenting the results of the concurrent TA using three VPA steps: referring script analysis results, assertional phrase analysis results and finally script analysis results. The nursing concepts, cognitive operators and type of decision making were identified during the verbal protocol analysis and PBG. The cognitive biases were also identified during the last phase of VPA

6.3.1. <u>Referring phrase analysis</u>

The referring phrase analysis and PBG analysis identified nursing concepts of care using the schedule developed and were discussed in the analysis chapter (Table 5.6). These concepts specifically related to the care of the acutely ill adult patient. The concepts were used to develop the PBG and allow the identification of students' focus at the different stages of the decision-making process. The nursing concepts were tabulated and frequencies were calculated. Initially, the frequency of the referral to nursing concepts was counted for each student and overall frequencies for the study group was produced. Table 6.6 demonstrated that students focused more on breathing and circulation concepts which were appropriate to the provided scenario.

Table 6.6: The frequency of nursing concepts during concurrent TA

Concept	Frequency	Percent
Airway	31	10.1 %
Breathing	114	37 %
Circulation	105	34.1 %
Disability	38	12.3 %
Exposure	20	6.5 %

6.3.2. <u>Assertional phrase analysis (APA): the used operators</u>

This phase of analysis focused on identifying the operators used by students at the different stages of their decision-making processes. The assertional phrase analysis used the schedule developed and discussed in the analysis chapter (Table 5.9). The operators are cognitive devices or strategies that connect each new state of knowledge the student produced during the decision-making process. The operators used by students were identified in this section.

The data on cognitive operators were collected using two methods within think aloud; concurrent (during simulation) and retrospective (after the simulation) TA and the findings are presented in two ways. First, the combined frequencies of operators for both concurrent and retrospective are presented to show the overall use of operators in the decision-making process. Second, the frequency of operators used by all students for concurrent TA sessions is presented as it represents the frequency of operators used during the actual delivery of care and reflects the content of the working memory. Finally, the frequency of operators used in the retrospective TA session is then presented as it represents the content of the long-term memory and provides more clarity and may confirm students' thought processes.

The operators identified by both concurrent and retrospective represent the same decision-making activities that occur during the simulation experience but represent different ways of collecting data on the same decision-making activities.

6.3.2a Operators frequency

Table 6.7 below presents a descriptive analysis of the frequency of the used operators by students during both the concurrent and retrospective TA sessions. It shows the overall use of operators with a combined frequency of operators used by all the students for both concurrent and retrospective.

Table 6.7 Frequency of cognitive operators

Statements coded	Operator	Frequency (SD)	Range
241	Plan	10.6% (3.8)	3-20
509	Collect	23.3% (5.4)	11-35
290	Review	12.7% (6.5)	4-24
260	Interpret	11.4% (6.5)	3-27
129	Relate	5.4% (3.2)	0-13
63	Infer	2.4% (3.7)	0-13
184	Rationale	7.8% (4.8)	2-16
23	Match	1% (1.6)	0-6
12	Predict	0.5% (0.9)	0-3
133	Diagnose	5.8% (2.9)	0-15
24	Goal	1.0% (1.7)	0-7
64	Course	2.8% (2.9)	0-9
310	Act	13.6% (4.9)	6-22
42	Evaluate	1.7% (1.9)	0-7
Total			
2284			

For the combined frequency, operators “collect, “act”, “review” and “interpret” were the most frequently used operators (Table 6.7). Operators “plan” and “rationale” were also regularly used but not as frequent. The operators “match” and “predict” had the lowest frequency.

Most of the operators’ frequencies in the concurrent TA (Table 6.8) have similar frequencies to those identified above in the combined frequency. Operator “plan” has a higher frequency in the concurrent TA compared to the combined and ranked as the second most frequently used operator after operator “collect”. In the retrospective TA, there is a shift and differences in the frequencies of operators (Table 6.8). There is an increase in the frequency of using operators “relate” and “diagnose” compared to both their combined and concurrent frequency. There is a large reduction in the frequency of operators “plan”, “review” and “act” in the retrospective TA, and operator “plan” was not coded.

Table 6.8 Operators frequencies: separated concurrent and retrospective

Operator	Concurrent			Retrospective		
	Statements coded	**Frequency (SD)**	**Range**	**Statements coded**	**Frequency (SD)**	**Range**
Plan	241	12.6% (3.8)	3-20	0	0% (0)	0-0
Review	253	13.2% (5.9)	3-23	37	5.8% (1.7)	0-6
Collect	473	25.3% (5.2)	11-34	36	7.2% (1.7)	0-5
Interpret	196	10.2% (5.1)	2-20	64	17.6% (2.5)	0-10
Relate	49	2.6% (1.8)	0-6	80	21.5% (2)	0-7
Infer	41	2.1% (2.6)	0-9	14	4.9% (1.3)	0-4
Rationale	162	8.5% (4.3)	2-15	22	5.2% (1.5)	0-4
Match	11	0.6% (0.7)	0-2	12	3.3% (1.2)	0-5
Predict	9	0.5% (0.7)	0-2	3	1.4% (0.5)	0-2
Diagnose	50	2.9% (1.9)	0-7	83	20.4% (1.6)	0-8
Goal	20	1% (1.2)	0-4	4	1.8% (0.9)	0-3
Course	57	3.5% (2.8)	0-9	7	1.9% (0.6)	0-5
Act	302	15.8% (4.9)	6-22	8	2.2% (1.1)	0-6
Evaluate	23	1.2% (1.1)	0-4	19	6.8% (1.2)	0-8
	Total: 1887			**Total: 389**		

6.3.3. <u>Script Analysis: identifying the process</u>

Each protocol was analysed by referring to the DPT as the theoretical framework and the scheduled developed in the analysis chapter (section 5.4.3a). The DPT and the schedule considered both type of decision making, type1 and type 2. The calculated percentage of operators represent students’ decision-making processes that could have been either related to the type 2 or type 1. PBG was used to show the patterns of using the different types of CDM and to identify the type of reasoning (Figure 5.2, chapter 5).

6.3.3a Type 1 CDM: non-analytical

Type 1 CDM, the key aspects of this type are the use of pattern-recognition, automated behaviour and intuition (Evans and Stanovich, 2013b; Croskerry, 2009a). Pattern-recognition and automated behaviour were frequently observed in both concurrent and retrospective TA. Intuition was not evident in the verbal data, only one occasion a student reported a behaviour in the retrospective TA that fit with features of intuition. Perhaps as a student lacks awareness when they use their intuition it makes it unavailable in their short-term memory for them to verbalise. The frequency of type 1 was based on the frequency of pattern-recognition and automated behaviours. Type 1 was less frequently used compared to type 2. It had an overall frequency of 20.2% for the concurrent TA, and a frequency of 21.1% for retrospective (Table 6.9).

Table 6.9: Descriptive statistic of the overall type of clinical decision making (CDM)

Main types of CDM	CDM approach	Concurrent frequency	**Concurrent** overall frequency	Retrospective Frequency	**Retrospective** overall frequency
Type 1	Automated	10.1%	**20.2%**	3.2%	**21.1%**
	Pattern recognition	10.1%		16.8%	
	Intuition	0%		1.1%	
Type 2	Forward reasoning	52.8%	**79.8%**	27.4%	**78.9%**
	Backward reasoning	27%		51.6%	
1887 statements coded in the concurrent TA 389 statements coded in the retrospective TA					

Pattern recognition is mainly related to type 1 CDM and was observed during TA sessions. It had the same frequency (10.1%) to that of the automated behaviours for the concurrent TA data (Table 6.9). This process had the lowest frequencies compared to backward and forward reasoning. The operators that reflect pattern-recognition include, “match” and “predict”, both operators have a relatively low level of usage compared to the other operators. Despite, the relatively low frequencies for those two operators, the frequency of this process increased during the retrospective session (4.7%) compared to the concurrent alone (1.1%) and when retrospective and concurrent are combined (1.5%).

Intuition was not identified in the concurrent TA and did not contribute to identifying type 1. For the retrospective TA, pattern recognition was the main process used for identifying type 1 CDM with a frequency of 16.8%, so that it increased compared to its concurrent frequency.

There was a drop in the frequency of the automated behaviours in the retrospective TA and only one statement referred to an intuitive decision. Perhaps students were mainly trying to relate data together, seeking diagnoses, or searching for a pattern to identifying the problem rather than using automated behaviours or procedural rules that can be observed more during participants' performance.

Another observation in the data was the distribution of processes during the verbal protocol. There is a clear picture that automated behaviours occurred mainly at the beginning of the verbal protocol compared to pattern-recognition, which was mainly distributed toward the end of the verbal protocol. The automated behaviours were observed when students tried to adhere to the routine of practice automatically despite a poor fit with the clinical situation, by gathering data in a routine manner ignoring the critical cues. This was identified from the analysis of the sequence of CDM process used to care for the presented patient and from the analysis of PBGs (Figure 5.2 in chapter 5).

6.3.3b Type 2: Hypothetico-deductive

The hypothetico-deductive approach is the main process for the analytical type of reasoning and decision making (Elstein, Schulman and Sprafka 1978; Croskerry, 2009a). It was identified through the type of cognitive operators used in this study. Forward reasoning and backward reasoning were used to reflect the hypothetico-deductive approach and identify type 2 CDM. Type 2 was the dominant type of CDM used by students during both the concurrent (frequency= 79.8%) and retrospective (frequency= 79%) think aloud. The frequency of type 2 was based on the frequency of reasoning, forward and backward, that have been identified using the cognitive operators (section 6.3.2a). The descriptive statistic shows that type 2 was the dominant type in both the concurrent TA (mean= 6.2 (SD=2.1)) and retrospective TA (mean= 3.2 (SD=0.99)). The following sections considered the different aspects of this approach.

6.3.3c Type 2: type of reasoning in hypothetico-deductive

The type of reasoning was identified through the type and order of using different operators and hypo-deductive stages.

Forward reasoning

Forward reasoning has been the dominant method of reasoning used by students during the concurrent TA session with an overall frequency for all students but its frequency was almost halved during the retrospective with a frequency of 27.4%. Moreover, it was observed that the frequency of forward reasoning at the beginning of the verbal protocol was higher and gradually dropped through the middle and end of the verbal protocol for both the concurrent and retrospective (Appendix 24).

Backward reasoning

The backward reasoning was the second most frequently used process during the concurrent TA with an overall frequency of 27% and the dominant process during the retrospective TA with a frequency of 51.6%. Moreover, the frequency of backward reasoning was generally evenly distributed throughout the concurrent TA data with slightly more concentrated in the middle of the protocol. The retrospective TA data shows that backward reasoning was concentrated in the middle and end of the protocol.

6.3.3d Stages of hypothetico-deductive reasoning

Cue Acquisition

Cue acquisition stage has the highest frequency in both the combined and concurrent results but it was not as frequently observed in the retrospective TA (Table 6.10). The operators that represent the cue acquisition stage are “plan”, “review” and “collect”. Comparing the combined frequency, concurrent and retrospective; the cue acquisition stayed the most frequently used stage in the concurrent TA data as the combined frequency but its frequency dropped during retrospective TA session. This was due to the drop in the usage of both operator “collect” and “plan” despite the observed increase in the usage of operator “review” (section 6.3.2a).

Cue interpretation

This stage has the highest frequency in the retrospective and the second highest for both the combined and then concurrent results (Table 6.10). The operators that reflect this stage includes, “interpret”, “relate”, “infer” and rationale. Those operators were frequently used by students as the second highest frequency after the cue acquisition operators. There was a clear increase in their usage during the retrospective to lead this stage to have the highest frequency (section 6.3.2a) in the retrospective compared to the other hypothetico-deductive stages. Perhaps this is due to students’ ability to access their long-term memory during retrospective TA and their attempt to relate cues together and generate hypothesis or match or form clinical patterns.

Table 6.10. The frequencies of the stages of CDM and related operators: comparison between the concurrent and retrospective

Operators	**Aspects of the CDM**	**Combined frequency: concurrent and retrospective TA**	**Frequency: Concurrent TA**	**Frequency: Retrospective TA**
Plan Review Collect	*Cue acquisition*	46.6%	51.1	13%
Interpret Relate Infer Rationale	*Cue interpretation*	27%	23.4	49.2%
Match Predict	*Pattern recognition*	1.5%	1.1%	4.7%
Diagnose Goal Course	*Hypothesis Generation*	9.6%	7.4%	24.1%
Act Evaluate	*Hypothesis evaluation*	15.3%	17	9%

Hypothesis generation

Hypothesis generation stage was not frequently used by students in the concurrent TA session and when the concurrent and retrospectives were combined. But it was the second most frequently used stage in the retrospective session. The operators that reflect this stage of the hypothetico-deductive approach include, “diagnose”, “goal” and “course”. These operators have a relatively low level of usage compared to other operators (Table 6.8) for concurrent TA. The increased frequency of this stage was mainly related to the significant increase in the frequency of the operator “diagnose” in the retrospective session compared to the concurrent session and when both concurrent and retrospective were combined.

Hypothesis evaluation

The operators that reflect this stage part of the hypothetico-deductive approach include, “evaluate” and “act. This stage came third in terms of frequency after the cue acquisition and interpretation stages during the concurrent TA (15.4%) and maintained its position after the combination (20.5%) of the frequencies of both concurrent and retrospective session. But it dropped in its frequency and was the least frequent stage in the retrospective session (9.1%). This was mainly related to the drop in the frequency of using the operator “act” despite the increase in the usage of operator “evaluate” during the retrospective session.

6.3.3f Summary

During performance or concurrent TA, the students focused on cue acquisition and interpretation as they mainly apply type 2 to solve clinical problems. The forward reasoning was more regularly used compared to backward reasoning. During the debriefing and retrospective TA, the students focused more on cue interpretation and forming a diagnosis and mainly used type 2. In contrast to concurrent TA, they applied a backward reasoning approach more than a forward reasoning during retrospective TA. During the retrospective, the students tried to sort or rank and narrow the best hypothesis that fit patient’s symptoms and clinical situation using backward reasoning. The similarities in the findings above support the validity of the study results. The students during retrospective TA were verifying their behaviours and actions they performed during concurrent TA that also enhances the validity of the findings. There were differences but these differences were expected as the different type of TA accesses different types of memories (Ericsson and Simon, 1993). The study findings confirm the need to apply both types of data collection to provide more insight into the used CDM process.

6.3.4. Categorising the type of decision making from TA data

There are patterns that can be extracted based on the frequencies discussed above. Most of the students mainly used type 2 in their CDM based on the findings of this study. During students’ performance, the group was mainly using type 2 most of the time. Nevertheless, students differ in the type of reasoning they applied in different sessions, some of them used a range of combinations between a forward and a backward reasoning. Others used an equal combination between type 1 and type 2.

The calculated frequencies of type 1 and type 2 and the frequencies of backward and forward reasoning were used to sort the students into categories (Table 6.11). People use a different combination between type 1 and type 2 during problem-solving and decision making based on the DPT (Croskerry, 2009a). So, if a student has used a specific category during this research he or she might use a totally different category or different combination of those cognitive processes with different problems or clinical situations. The developed categories could be used to explore the range of approaches the individual uses in different situations, to reflect and to produce a plan of action to enhance her/his future performance.

Table 6.11 Categories of the types of CDM based on TA sessions

Category Number	CDM category name	Category criteria	Student code
1.	***Dominant Type 1:*** *mainly using non-analytical type*	***Frequency of type 1 is more than 50% of the whole CDM process***	**-**
1a	Mainly Pattern-recognition	Frequency of pattern is more than a third of the whole CDM process	-
1b	Mainly intuitive	Frequency of intuition is more than a third of the type 1 CDM process	-
1c	Mainly automated	Frequency of automated behaviour is more than a third of the type 1 CDM process	-
1d	Combined type 1	Any combination between pattern, intuition and automated.	-
2.	***Dominant type 2:*** *Mainly using analytical type*	***Frequency of type 2 is more than 50% of the whole CDM process***	
2a	Mainly forward reasoning	Frequency of forward reasoning is more than half of the type 2 CDM process.	B1, F1, G1, H1, I1, L1, M1, N1, R1, O1, P1, T1, V1, W1, V2, P2
2b	Mainly backward reasoning	Frequency of backward reasoning is more than half of the type 2 CDM process.	Q1, E1, H2, B2, G2, K2, O2, L2, R2, Y2
2c	Equally combined type 2	Both forward and backward reasoning has equal percentage of the whole CDM process.	D1, Y1, N2, U2, I2
2d	Unequal combined type 2	Any other combination	A1, U1, X1, A2, D2, E2, F2, Q2, M2, T2, W2, X2

3.	***Combined Type 1 and type 2***	***The frequency of type 1 is equal to type 2.***	C1 and K1 C2

All the students maintained the same type of decision making in both concurrent and retrospective, except student (K) who during the retrospective TA moved from using equally combined types of CDM to be mainly in type 2. Categories in concurrent TA showed category 2a (dominant forward reasoning) as the most frequently used category (14 out of 23, 60.9%), followed by category 2d (unequal combination type 2 without dominance) with 13%. The categories changed during retrospective TA, with both categories 2b (backward reasoning dominance) and 2d had the highest occurrence of 34.8% each, followed by categories 2a and 2c with an equal frequency of 13% each.

The third step in VPA was repeated to analyse the data about the cognitive biases that could affect students' CDM. This was used instead of using content analysis as the types of biases could be linked to the type of CDM and the underlying processes.

6.3.5. <u>Script analysis: identifying cognitive biases</u>

Each protocol was analysed based on (Tversky and Kahneman, 1974 and Croskerry, 2002) and the scheduled developed and discussed in the analysis chapter (section 5.4.3b). NVivo 11 (QSR International, 2017) was used to explore the sources and to code of cognitive biases. There are a few cognitive biases that have been identified during the concurrent and retrospective TA with many of similarities (Table 6.12). In the combined frequencies, "representativeness" was the most common bias used, it was the most common bias in the retrospective TA and the second most common bias in the concurrent TA. "Order effect" was the most commonly occurring bias in the concurrent and third place in the retrospective TA. "Premature closure", "availability" and "context error" were also common biases in both the concurrent and retrospective TA.

Table 6.12 occurrences and frequency of cognitive biases

Bias	Occurrences in Concurrent TA (Frequency %)	Occurrences in Retrospective TA (Frequency %)	Combined Occurrences (Frequency %)
Representativeness	12 (10.5%)	17 (14.9%)	29 (25.4 %)
Order effect	14 (12.3%)	6 (5.3%)	20 (17.6%)
Premature closure	10 (8.8%)	5 (4.4%)	15 (13.2%)
Availability	5 (4.4%)	9 (7.9%)	14 (12.3%)
Context error	8 (7%)	5 (4.4%)	13 (11.4%)
Anchoring	6 (5.3%)	1 (0.9%)	7 (6.2%)
Confirmation	3 (2.6%)	2 (1.8%)	5 (6.1%)
Omission	5 (4.4%)	1 (0.8%)	6 (5.2%)
Commission	0 (0%)	4 (3.5%)	4 (3.5%)
Framing	0 (0%)	1(0.9%)	1 (0.9%)
	63 (55.3%)	**51 (44.7%)**	**114 (100%)**
The frequencies (%) were calculated based on the overall combined occurrences of 114 statements for both concurrent and retrospectives			

6.3.5a Cognitive biases and type of CDM in TA data

In the concurrent TA, 47 biases out of 63 were identified in parts of transcripts coded as a type 2 CDM (74.6%) and the remaining 16 biases were found in parts of transcripts that were coded as a type 1 CDM (25.4%) (Table 6.13). The ratio of bias occurrence in type 2 CDM was 47 biases in 1506 statements which equals 3% compared to 16 biases occurring in 381 statements for type 1 CDM which equals 4.2%. This suggests that bias occurrences were similar in both types of CDM in this set of data. In type 1 CDM, biases occurred equally with both the automated behaviours and pattern recognition. In type 2 CDM, biases were more frequently seen in the forward reasoning sections (50.8%) than backward reasoning.

Table 6.13 Biases occurrence during the types of CDM

CDM processes	**Cognitive biases occurrences (%)**	
	Concurrent	**Retrospective**
Type 1	**16 (25.4%)**	**13 (25.5%)**
• Automated	8 (12.7%)	2 (3.9%)
• Pattern recognition	8 (12.7%)	11 (21.6%)
• Intuition	0 (0%)	0 (0%)
Type 2	**47 (74.6%)**	**(38) 75.5%**
• Forward reasoning	32 (50.8%)	12 (23.5%)
• Backward reasoning	15 (23.8%)	26 (51%)
63 biases were coded in the concurrent TA and 51 biases were coded in the retrospective TA		

In the retrospective TA, a similar percentage of biases were found during type 2 and type 1 CDM compared to concurrent TA. However, more biases have been coded in the pattern recognition sections compared to automated behaviours sections. For type 2 CDM, more biases occurred during backward reasoning part of the transcripts (51%) than forward reasoning, this was the opposite of the results found in concurrent TA described above. "Representativeness" was the most frequently used error in both forward and backward reasoning. "Availability" was the second most frequent error during forward reasoning and "context error" was the second during backward reasoning.

The results also showed that some biases more frequently occur in a specific stage or stages in the hypothetico-deductive approach (Table 6.14)

Table 6.14 Frequency of biases in stages of CDM process

Components of the type of CDM	Cognitive biases	Frequency Concurrent	Frequency retrospective
Cue acquisition	Order effect Premature closure	9.5% 14.3%	7.8% 7.8%
Cue interpretation	Availability	6.3%	13.7%
Hypothesis generation	Representativeness Framing	12.7% 0%	21.5% 2%
Hypothesis evaluation	Context error Confirmation Omission Anchoring Commission	11.1% 4.8% 7.9% 9.5% 0%	7.8% 3.9% 2% 0% 7.8%
Automated	Order effect	12.7%	3.9%
Pattern recognition	Availability Representativeness Premature closure Context error Omission Anchoring	1.6 6.3 1.6% 1.6% 0% 0%	3.9% 11.8% 2% 2% 2% 2%
Intuition	Confirmation	0%	0%
Total number of biases		**63**	**51**

Biases related to cue acquisition

"Order effect" and "premature closure" biases have predominantly affected how the data was collected. "Order effect" referred to an error in the way the data is collected, that may cause missing vital cues which may influence the interpretation and hypothesis generation. It was commonly seen in this study during the application of ABCDE approach and the deviation from this approach. It was identified in 20 different transcripts; fourteen statements (12.3%) were given this code in the concurrent TA and six statements (5.3%) were give this code in the retrospective TA. From those 20 statements, seven (35%) were found in the automated CDM part of the transcript and thirteen (65%) were found in the forward reasoning sections associated with the operator "collect". In the retrospective TA, seven students reported the wrong order in gathering the data as a key issue for them missing the identification of the main problem (see examples below). This bias was a commonly seen in the concurrent TA during the forward reasoning and automated behaviours.

For examples of "order effect" biases during cue acquisition

Student: how are you feeling?
Manikin: short of breath
Student: ok let us do your obs, we will start with your temperature, it is 37.9, I am going to put the cuff on you to check your pressure, let us take this blanket off for you, so are you feel better? let us check the pulse. (P1).
In the quote above, the cue was shortness of breathing, despite that this participant started to do cardiac observations and forgot the breathing issue for more than 3 minutes, as other signs distracted her focus from the main cue.

"I missed many signs as I kept jumping between ABCDE" (D2)
"I was checking the wound site before checking her breathing problem, then the pulse, sometimes it gets you out of sync" (K2)

"Premature closure" also produced a similar effect as it has led students to reach conclusions prematurely and therefore ceasing cue acquisition and missing vital data. It was seen early in the TA protocols, when students were collecting data and concluded their hypotheses too early. Fifteen statements were coded in the TA transcripts with this bias, eleven statements (73.3%) were part of the forward reasoning sections and four statements (26.7%) part of backward reasoning sections. It was more commonly seen in the concurrent TA during forward reasoning. For example:

"I am rolling out an allergic reaction to blood, I have completely roll out blood reaction". B1
"there is no rash on her arm, so she is not getting a reaction" V1

"Framing" refers to being fixated on prior decisions suggested by colleagues, patients or their families and may produce a similar effect like "premature closure". It was seen only once when students got fixated on analysing a diagnosis in the patient history and got distracted from the main problem. For example:

"Initially I thought of maybe she is having chest infection, her past medical history she has been coughing recently". C2

Biases related to cue interpretation and hypothesis generation

A few cognitive biases were linked to how the cues are weighted and related, an issue that may affect students reaching appropriate hypotheses. The analysis of think-aloud data found “representativeness”, “confirmation bias” and “availability” were used during cue interpretation and hypothesis generation. These biases may have affected how students made sense of the data or the value of the clinical cues and how they related the cues together to confirm or identify hypotheses or recognise patterns.

“Representativeness” was observed mainly when students used a typical presentation of the clinical problem to confirm the likelihood of their hypotheses. The typical presentation of a problem led to reducing its ranking, its likelihood or even rolling out that problem. This was commonly seen in this study for lack of recognition of reaction to blood transfusion. Students rolled out anaphylaxis due to lack of typical symptoms such as the immediate appearance of the rash. This was considered typical sign by students but it was not available immediately to them or due to approach they used to gather data that did not reveal this cue. The key factor for rolling out an allergic reaction was the typical time of transfusion and typical symptoms.

Students received the simulated scenario 30-45 minutes after blood transfusion was initiated and the simulated patient already had signs of reaction at the time of handover, such as hyperthermia, tachycardia, tachypnoea, wheeze and oxygen desaturation. Despite that, students did not rank anaphylaxis as the key problem due to the duration of time for the blood transfusion which exceeded 15 minutes. They expected to see serious signs and symptoms within the first 15 minutes. In fact, that was true as the signs and symptoms of reaction were available and observable but it seems they expected to see worse clinical symptoms to confirm allergic reaction. This suggestion could also be considered as a knowledge deficit that a reaction only occurs in the first 15 minutes and that expectation for serious airway, breathing or circulation symptoms is key to justify the identification of reaction. For example:

Problem exclusion based on lack of atypical presentation

“How long that blood has been running for?.... so that should be fine in term if she is having anaphylaxis or any of that. As she did not have any problem in the last 45 minutes” (A1)

Delayed inclusion of the problem until typical presentation is found

> *"because of the rash and the temperature, typical signs of reaction, it is a reaction" (K1)*
> *"her low BP (blood pressure), tachycardia, tachypnoea, rash, and the temp (temperature) all are symptoms of reaction" (K2)*

Based on the concurrent and retrospective TA data, 29 statements were coded as "representativeness" bias with an overall frequency of 25.4%. From those 29 statements, eight statements were part of pattern recognition representing (27.6%) of the total occurrence of this bias, thirteen statements (44.8%) were part of backward reasoning sections and finally, eight statements were part of forward reasoning (27.6%). It was more commonly seen in retrospective TA during backward reasoning, therefore, it is more likely to affect how a problem is identified, and hypotheses are ranked and confirmed.

"Availability" is one of the classical heuristics identified by Tversky and Khnamman (1974). It was seen when students were judging the given clinical problem based on its frequency and the likelihood for it to occur in the real world. It was associated with operators like "interpret", "relate" "diagnose" and "match". Fourteen statements were coded with this bias, nine statements (57.1%) were part of backward reasoning sections, three statements (21.4%) were part of forward reasoning and two statements (14.3%) were part of pattern recognition sections. It was seen more in the retrospective TA during backward reasoning. For example:

> *"Because she came post-operative and fresh so that [hypovolaemia] is always a possibility" O2.*
> Here the students confirmed hypothesis the patient is bleeding based on the frequency (availability) of hypovolaemia to occur after surgery.

"Confirmation" bias was also seen to affect the identification and evaluation of possible hypotheses, as it led students to selectively focus on one problem and seek information related to the desired hypothesis or initial prediction. The implication of this type of error may also lead to delay in recognition and response to the key problem. Confirmation bias was not that common. It was identified in 5 transcripts, three in concurrent TA as part of the forward reasoning statements and two in retrospective TA as part of backward reasoning statements. For example *“thinking about bleeding” “ok we have a urine bag containing 200 mls… that was for the last 6 hours” “I am not too concern about that” “I am going to have a look at your leg ok” … “No obvious bleeding and the dressing is intact” “no redness and no haematoma”. “And she has drain” …. “there is nothing in the drain?” “So, I am concern about that” “because there should be something in the drain post op.” “So, there is blood stain in the tubing,” “has that been emptied at all.” C1*

Here participant continued to search for signs and symptoms of bleeding for approximately 4 minutes out of 15 minutes trying to confirm internal bleeding, despite patient’s findings suggest otherwise.

Biases related to hypothesis evaluation

Confirmation or elimination are common strategies usually used by healthcare professionals to either confirm the generated hypothesis by gathering more data to verify its likelihood or by eliminating other probabilities. Hypothesis evaluation could be affected by using cognitive errors such as representativeness. Other biases appeared to affect this stage mainly, confirmation bias, omission, commission, anchoring and context error.

“Context error” was seen in the set of data generated by TA to affect this stage with thirteen statements coded with this bias, 5 (38.5%) were part of the forward reasoning, 6 (46.2%) part of backward reasoning and 2 (15.4%) part of pattern recognition section. From those statements, four were related to hypothesis evaluation (using operator; evaluate, rationale and act), four were related to hypothesis generation and pattern recognition, three were related to cue interpretation and finally, one was related to cue acquisition using operator. This bias was found almost in the same frequency for backward and forward reasoning. It was observed that it occurred at different stages in the hypothetico-deductive approach, so it was mainly identified during the hypothesis generation and hypothesis evaluation but also it can be observed during and cue interpretation. Context error refers to misinterpretation of the clinical situation or losing situational awareness about what is happening. For example:

“Then I realised she is having blood transfusion, it seems I have forgotten that she is having blood transfusion”. C2

“So, we need something to open the airway, call for the doctors. Her temp was up and she is cold, I can’t cover her up. her temp 38.5 c, ok it is going up” D1

Biases with low frequencies that affect many stages

"Commission bias" can affect either the data gathering or the action stage as it may lead to performing unindicated intervention or deviation from protocol during data gathering. For the coding and analysis those students for example who deviated from (ABCDE) protocol in data gathering were coded as "order effect", and if they deviated from (ABCDE) protocol in terms of actions, then that was coded as "commission bias". The inaccurate gathering of data may affect the data interpretation and how cues are related and therefore reducing the likelihood of recognising or responding to key issues in a timely manner. Commission bias was infrequently used and it was identified in student retrospective TA. For example:

"I could have acted in more structure way, I felt I was jumping about" K2

"Anchoring" was not that common compared to other biases and it was mainly seen in the concurrent data. There were seven sections given this code, three out of seven were part of the backward reasoning and four were part of the forward reasoning. From the seven sections, two were related to cue interpretation using the operator "rationale", two were related to hypothesis generation using the operator "course" and "goal". Another two segments were related to hypothesis evaluation using operators "act" and one segment was related to cue acquisition using the operator "collect" and "review". Overall, it appears that this error may equally affect all the stages of the hypothetico-deductive approach. It has been seen with students who did not know what to do next, or stayed fixated on one issue and did not the recognise the main problems a point where they lost the situational awareness about what was happening to the patient. For example:

"I know she is on 50ml of Hartman's. So, we should change that to normal saline, now I know why she is on Hartman's, because she is on blood transfusion. So, maybe they are using that to support…, but again she is having blood transfusion and normal saline would help the volume" N1. N1 has been anchored on the type of fluid the patient is receiving, questioning herself and kept checking the bag forgetting the seriousness of low blood pressure she identified.

In summary, this study demonstrated that cognitive biases equally affected both types of CDM. Biases were seen more during forward reasoning. Representativeness, order effect, premature closure and availability affected different CDM processes. Therefore, it is important to consider the effect of these biases on the quality of clinical decision making.

6.4. The results of the task analysis

This section provides the results of the content analysis of the task from the concurrent TA transcripts. It focused on the number and types of cues, identification of key problems and actions taken based on the simulated task (section 4.4.2a) compared to those the students used. The aim of this analysis was to develop more insight into whether the type of CDM or process of CDM and biases affected the outcome of the CDM regardless of whether the outcome is assessment, planning, intervention or communication (Thompson et al, 2004). Students needed to respond to many issues identified in the task analysis such as recognise low oxygen level, tachycardia and then the need for key intervention such as stopping blood transfusion or seek help. The main clinical problem was considered as a reaction to blood transfusion and the need to stop the transfusion and follow ABCDE for symptoms management and escalating care.

6.4.1 <u>The effect of type and number of the cue on CDM</u>

A range of cues were used by students, related to clinical problems during their reasoning process (Appendix 25). Students who collected between 21-30 cues were more successful in solving the main problem and preventing further deterioration compared to those who used less than 21 or more than 31 cues (Table 6.15). The higher number of cues usage in this study was not always associated with identifying the main problem or executing the appropriate actions. Students used more confirmatory cues with an average of 12.04 compared to dis-confirmatory cues with an average of 5.13 (Appendix 26). The findings of this study demonstrated that the usage of seven key cues was associated with increased likelihood of solving the main problem presented in the scenario provided. The identification of the presence of rash and time of transfusion was frequently associated with identifying anaphylaxis. In contrast, the collection of other eleven cues was not associated with solving the main problem.

Table 6.15 Cue usage

Range of cue usage	Number of students	Number of problems solved	Number of unsolved problems
10-20	6	3 (50%)	3 (50%)
21-30	12	10 (83%)	2 (17%)
31-40	5	1 (20%)	4 (80%)

At the beginning of the scenario, 16 students gave the measurement of blood pressure and heart rate more clinical value and priority over respiratory rate and oxygen level. Students initially focused heavily on collecting many cues in an unstructured way that led them to miss many key cues.

6.4.2 The effect of cue interpretation on CDM

There were 11 wrong interpretations of symptoms; five about the time of blood transfusion, three about the rash, one about the causes of talking in broken sentences and one about wheeze and one about glucose level. For example, the onset of the symptoms, when students noticed more serious symptoms appearing after 15 minutes of blood transfusion, the signs are not considered relevant to blood transfusion reaction. Both the misinterpretation of rash and time of transfusion led students to prematurely infer acute allergic reaction as a cause of the patient clinical problem leading the patient to deteriorate further. Based on the retrospective TA, students justified their errors because they did not have the accurate knowledge and judged the situation on common presentation. The increased average of wrong cue interpretation was associated with reduced likelihood of solving the problem (Table 6.16).

Table 6.16 Errors in cue interpretation and problem identification

	Main problem solved	**Main problem not solved**	**Example**
Total average of wrongly interpreted cues	0.5	2.9	Wheeze caused by the oxygen therapy. If time of blood transfusion is >15 minutes then students ruled it out as cue for reaction. Rash and itching caused mainly by sepsis
Total average of wrongly related or unrelated cues	1.5	2.7	Not relating rash, shortness of breath, increase respiratory and pulse to reaction. The only explanation for high temperature, low blood pressure and rash is sepsis
Total average of wrongly inferred cues	.43	.44	Premature inferring allergic reaction based on symptoms occurring after 15 minutes. Inference the presence of hypovolaemia
Overall total of wrong interpretation, clustering and inference	2.43	6.04	

There were 21 unique occasions of wrongly clustering of the clinical cues or failure in relating clinical cues to identify the patient's problem and required action. For example, wheeze was related to the history of smoking or the low oxygen saturation. Ten occasions of inappropriate inference such as prematurely inferring the presence of allergic reaction or hypovolaemia with a fixed focus on sepsis. The average of wrong cues interpretation for the solved problem was 0.5 and for the unsolved problem was 2.9. Wrongly relating cues resulted in an increased the number of unsolved problems with an average of 2.7. Five students from those who managed to solve the main problem, verbalised the correct course of action but delayed and hesitated in performing the action or seeking senior support.

From the 23 students, 11 appropriately responded to the main problem and 12 did not. From those 12, four students accurately identified the problem but failed to stop the blood transfusion as a key action and eight did not recognise the problem and key interventions. In most of the situation, automated behaviours were not related to the provided cues rather it was related more to the procedural practice such as students immediately carrying out blood pressure measurement despite the presented cues suggest a serious respiratory problem. This automated practice was not always optimal as it was carried out without careful interpretation of the cues and led to distraction and delays in identifying and treating the clinical problem. Students who used an equal combination between type 1 and type 2 CDM or an equal combination of backward and forward reasoning when type 2 applied had 100% accuracy in identifying the main problem compared to 50-60% accuracy if any other combinations were used. Forward reasoning (mean= 3.25 minute) and backward reasoning (2.30 minute) took more time compared to pattern recognition (7 seconds) and automated action (5 seconds).

6.5. Results of the content analysis of observations

The 23 transcripts from all the study participants were analysed using the same method used with TA data, as discussed in section 6.3.2 and section 6.3.3. NVivo 11 (QSR International, 2017) was used to explore the sources, code of cognitive operators and types of CDM from the video-recording observational notes and calculate the frequencies. The frequency CDM processes and types of CDM was calculated based on the frequency of cognitive operators discussed in sections 5.4 and 6.3.3.

6.5.1. Operators' Frequencies

The frequencies of operators "collect" and "act" were the highest (Table 6.17). Followed by operators "review", "interpret" and "diagnose", but the remaining operators were not that common in comparison.

Table 6.17 Frequencies of operators from the observation

Statements coded	Operator	Frequency (SD)	Range
55	Plan	5% (1.8)	0-8
114	Review	10.3% (3)	1-12
349	Collect	31.6% (7.6)	7-39
135	Interpret	12.2% (2.5)	0-14
29	Relate	2.6% (1.1)	0-3
13	Infer	1.2% (0.8)	0-2
34	Rationale	3.1% (1.4)	0-6
16	Match	1.5% (0.6)	0-2
9	Predict	0.8% (0.6)	0-2
71	Diagnose	6.4% (1.6)	0-5
6	Goal	0.5% (0.5)	0-2
25	Course	2.3% (0.8)	0-3
226	Act	20.5% (3.3)	4-15
22	Evaluate	2% (0.8)	0-2
Total number of codes			
1104			

6.5.2 Identifying the CDM process from the observation

The calculated percentage of operators represent students' decision-making processes that could have been either related to type 2 or type 1.

6.5.2a Type 1 CDM based on the observation

In type 1 CDM, pattern-recognition and automated behaviours were frequently used and coded in the observational data. Intuition was more evident in the observation compared to verbal data. Pattern recognition was identified using operators "match" and "predict". Automated decision referred to a rapid action learned from routine or procedural rules. Intuition was identified in the form of sudden impulsive actions, that was not verbalised and out of the sequence of actions that were occurring at a specific moment of time.

Type 1 was infrequently used compared to type 2, which agrees with the findings from TA data. Pattern recognition had the highest frequency for type 1 with 16.2%, followed by automated actions and the lowest frequency was for the use of intuition (Table 6.18)

Table 6.18 Overall frequencies of the type of CDM

Main types of CDM	CDM process	Observation frequency	Overall frequency
Type 1	Automated	12.3%	**29.3%**
	Pattern recognition	14..3%	
	Intuition	2.7%	
Type 2	Forward reasoning	44%	**71%**
	Backward reasoning	27%	

Pattern recognition had a lower frequency compared to the stages of the hypothetico-deductive approach. Another observation in the data, was the distribution of processes during observational data, as automated behaviours occurred mainly at the beginning of observation and pattern recognition was mainly found in the middle and at the end of the observational data.

6.5.2b Type 2 CDM and stages of CDM based on the observations

In the observational data, type 2 was the dominant type of CDM as it had higher occurrence compared to type 2. Type 2 was identified based on the hypothetico-deductive approach during task performance. The hypothetico-deductive approach was identified using the application of cognitive operators. Forward reasoning has been the dominant method of reasoning used by students based on the observational data with 44% as an overall frequency for all students compared to backward reasoning with a frequency of 27%. Moreover, it was noted that the frequency of the forward reasoning was concentrated at the beginning of observation and backward reasoning was mainly concentrated in the middle and the end of the observational data. These findings agree with findings from the concurrent TA.

The stages of the hypothetico-deductive approach were identified and frequencies were calculated based on the occurrence frequencies of the operators as discussed in section (6.3.3b). Cue acquisition was the most frequent stage in this approach, as it accounted counted for almost half of the whole CDM process (47%). This high frequency was noted to be mainly based on the frequency of operator “collect”. The hypothesis evaluation occurrence was the second highest (22.5%) after cue acquisition stage. Which was mainly due to the frequency of operator “act”. Cue interpretation came in third place (19.1%) and the hypothesis generation (9.2%) had the lowest frequency. The operators that referred to pattern recognition were included in percentage calculation and accounted for 2.3% (Table 6.17).

6.5.3. Categorising the type of decision making from observational data

The categories identified in section (6.3.4) were used to analyse the observational data to identify each student’s dominant CDM category. It is evident from the ten transcripts that students mainly used type 2 CDM with different combinations between forward and backward reasoning. Category 2a was the most frequently used category with 11 occurrences (48%) that suggest mainly forward reasoning. Category 2c was the second in frequency with 9 occurrences (39%) and suggest an equal combination between forward and backward reasoning. Category 2d had 2 occurrences (8.7%) and finally, one student was coded as category 2a (4.3%).

6.5.4. Identifying cognitive biases from the observation

Thirty-five biases from 52 were found in parts of the transcript that were coded as type 2 CDM (67%) and 17 biases were found in parts of the transcript that were coded as in type 1 (33%). “Order effect” came as the most common biases used (32%) in both types of CDM together, followed by “representativeness” (22%). “Availability” came third (12%) followed by “omission” biases which had a frequency of 10%. Finally, “confirmation” and “context error” had an equal but the lowest frequencies (6%). The other biases were not coded during the observation.

In type 1 CDM, ten biases out of 17 occurred with the automated behaviours, six biases occurred with pattern recognition and one was associated with intuition. “Order effect” occurred only with automated behaviours and “representativeness” occurred only during pattern recognition. In type 2 CDM, 20 biases were associated with forward reasoning and 15 biases associated with backward reasoning. “Premature closure” was the most frequently used error in type 2 CDM and it was equally used in both forward and backward reasoning. “Order effect” was the second most frequent occurring error in forward reasoning and “availability” and “representativeness” were the second most frequent occurring errors in backward reasoning (table 6.19).

Biases affected the cue acquisition stage more than the other stages of the hypothetico-deductive approach. “Order effect” and “premature closure” affected the type of data that students gathered and the way the data were collected. Although these errors occurred mainly during cue acquisition they influenced all the other stages of type 2 CDM. This occurred when the wrong data was collected or wrong order for data gathering was used.

Table 6.19 Biases frequencies from observation

Components of the type of CDM	**Cognitive biases**	**Frequency**
• Cue acquisition	Order effect Premature closure	12% 15%
• Cue interpretation	Availability	10%
• Hypothesis generation	Representativeness	11%
• Hypothesis evaluation	Context error Confirmation Omission	6% 4% 10%
• Automated	Order effect	19%
• Pattern recognition	Availability Representativeness	2% 10%
• Intuition	Confirmation	2%

For the cue interpretation and hypothesis generation, “representativeness” was the main bias that affected those stages. It was found in 11 transcripts and six were associated with type 2 CDM that affected the cue interpretation and hypothesis generation. The evaluation stage of this approach was affected by three biases, the “confirmation”, “omission” and “context error”. “Context error” was also identified when students lost situation awareness that affected evaluating the effectiveness of their actions.

In summary, Cue acquisition operators were more frequently used compared to other operators. Cue acquisition, forward reasoning and type 2 were dominant processes used by students based on the observations findings. Order effect, representativeness, premature closure and availability are common biases that affected the quality of decision making based on the observation results.

6.6. Comparing the results of HSRT, VPA and observation

This section explains the similarities and differences in the findings of each method. It aims to identify whether there is agreement or disagreement between the results to support the validity of the findings and answer the research questions of this study.

6.6.1. <u>Comparison between VPA and observation results</u>

Operator usage in the observation agrees with their frequencies in the concurrent TA, high frequencies in using operators related to cue acquisition, such as operators “collect” and “review” and hypothesis evaluation, using operator “act”. Findings from the observation also slightly correlate with some of the findings from retrospective TA in hypothesis generation stage (Figure 6.3). Operators usage in retrospective TA is different with more focus given to cue interpretation operators, “interpret” and “relate and hypothesis generation operator “diagnose”.

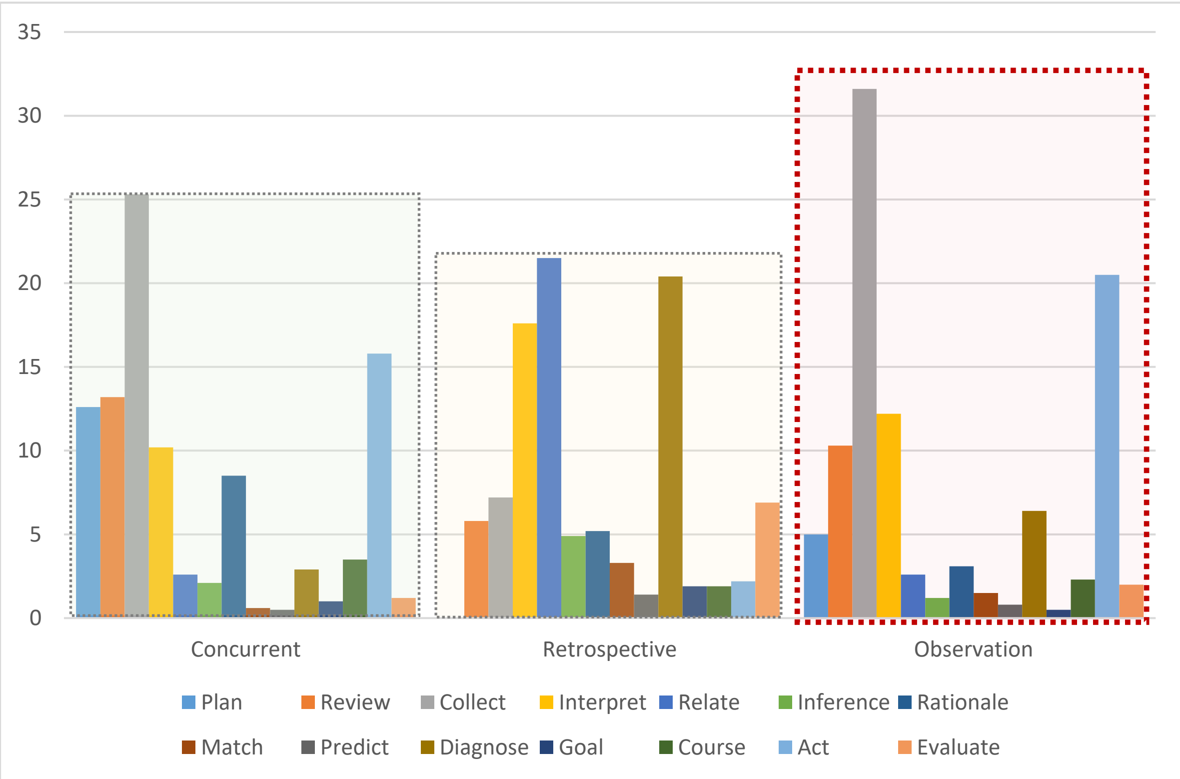

Figure 6.3 Comparison between operators’ frequencies

It was also noted that the forward reasoning although it was less frequent in the observation, its usage was similarly compared to the concurrent TA data. Overall, observational findings are very similar to the results generated by concurrent TA (Figure 6.4). In contrast, backward reasoning was more frequent in the retrospective TA.

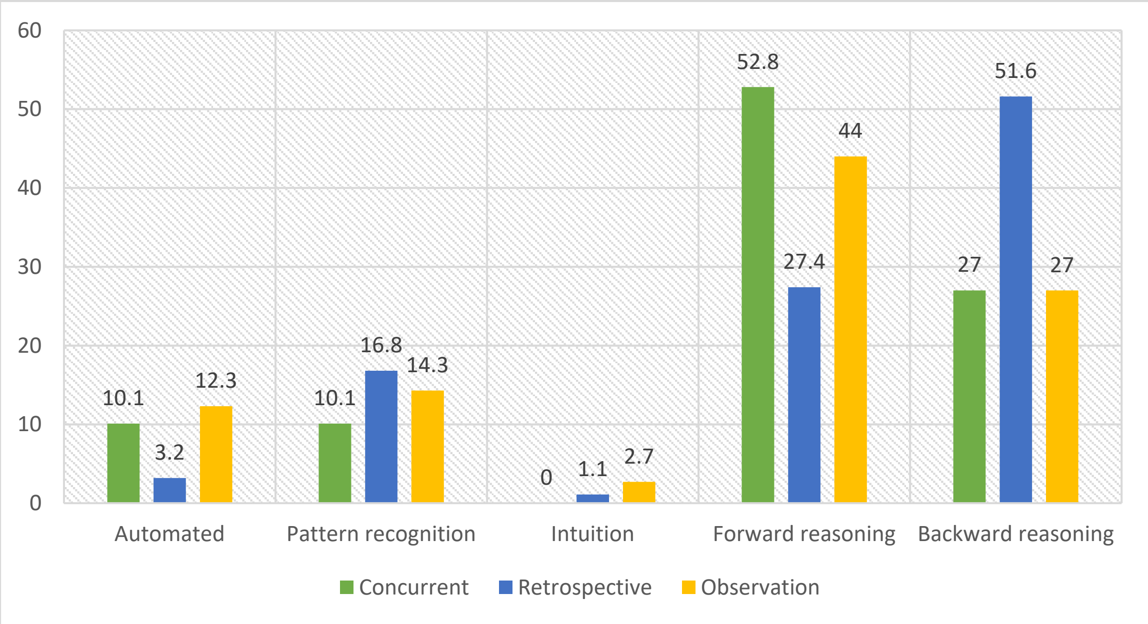

Figure 6.4 Comparison of CDM-processes between TA and observation

The findings from the concurrent and observation are largely similar about the stages of the hypothetico-deductive approach. Cue acquisition was the most frequently identified stage in both types of data concurrent TA (51.1%) and observation (47%). Cue interpretation was slightly higher in the concurrent TA (23.4%) and hypothesis evaluation was slightly higher in the observation (22.5%). The retrospective TA appears to have opposite patterns to those identified in the concurrent and observation with more emphasis on cue interpretation (49.2%) and hypothesis generation (24.1%) and less emphasis on cue acquisition and hypothesis evaluation (Figure 6.5).

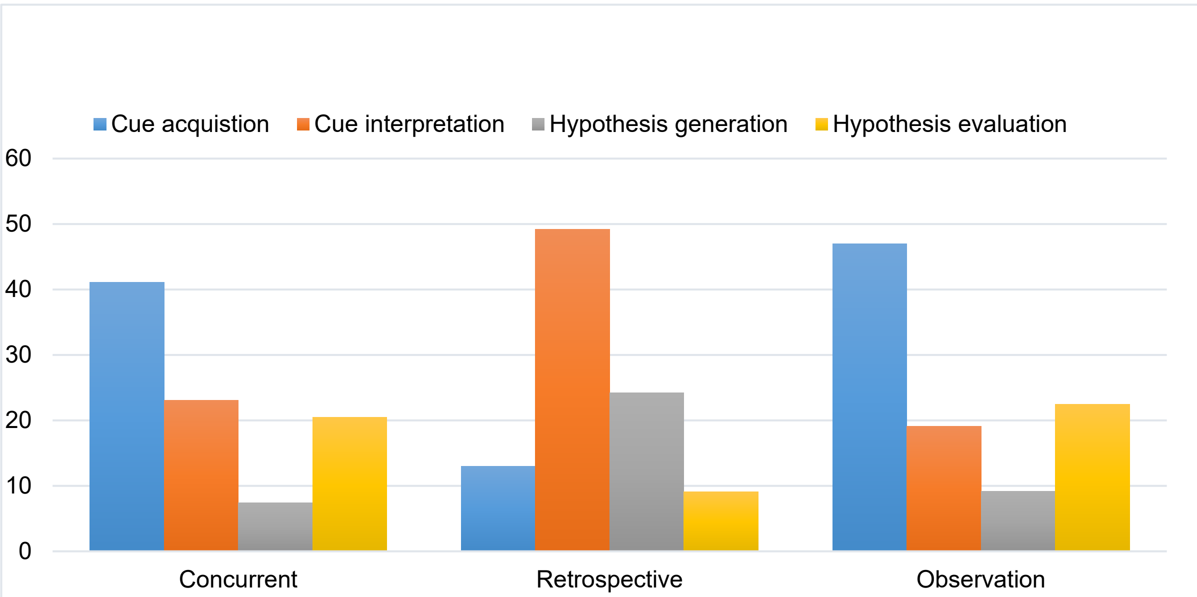

Figure 6.5 Comparison of hypothetico-deductive between TA and observation

For the type of decision making, the results from observation and TA data found type 2 was the dominant type of CDM. The TA result showed that the frequency of type 2 was almost 80% of students' decisions but it was slightly less frequent (71%) in the observational results. Type 1 was more frequently identified in the observation (29.3%) compared to TA findings. Perhaps, this was due to the increased ability in identifying the intuition and automated behaviours as part of type 1 in the observation (Figure 6.4).

The results from observational and concurrent data were similar in terms how of the data was collected and hypotheses evaluated by students. The increased identification of type 1 and backward reasoning from the observational data changed the CDM category distribution (Figure 6.6). There was an increase in category 2c compared to the other categories and compared to the categories generated from TA data. However, overall the CDM categories identified in the observation are similar to those identified in the concurrent TA.

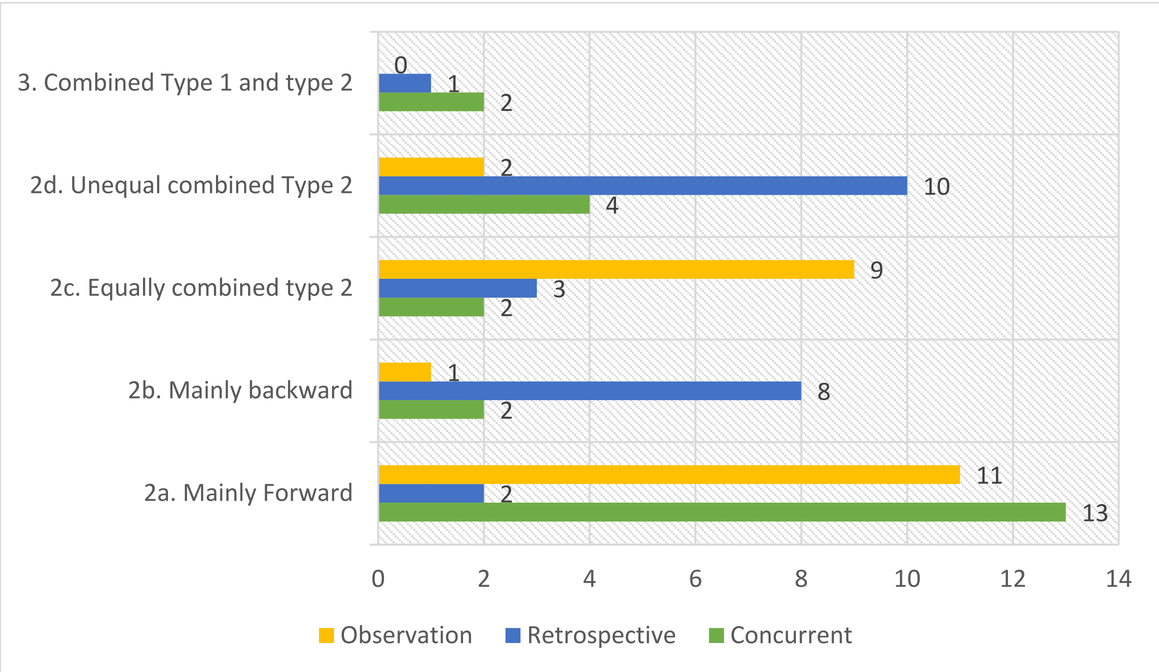

Figure 6.6 Comparison of CDM categories between TA and observation

In summary, the results from both types of TA were complementary and compensated for the limitation of each method. The results from concurrent TA and observation were confirmatory and compensated for the limitation of each method. This approach increased the depth of the analysis of students' clinical decision-making approaches during simulation experience. The comparison between the findings of the TA and observation demonstrated agreements in the most of instances as discussed above. This contributes to increase the validity of the findings of this study. This is an innovative approach which adds a methodological contribution to knowledge in the way CDM should be examined by utilising multiple methods to produce a detailed understanding of this process. This was evident in this study as both types of TA produced different findings.

6.6.2 Comparison of biases usage between TA and observation results

There are similarities in the frequency and type of biases occurring in all the stages of the hypothetico-deductive approach, during automated behaviours and pattern recognition in both the concurrent TA and observation (Table 6.7). In contrast there are differences in type and frequency of biases in the retrospective TA compared to both the concurrent and observation. Moreover, there are more biases identified in automated behaviour sections from the observational results compared to TA results. “Anchoring” was more coded in the concurrent TA. Overall the observation shows similarities to bias usage compared to those identified in the concurrent TA result (Table 6.7).

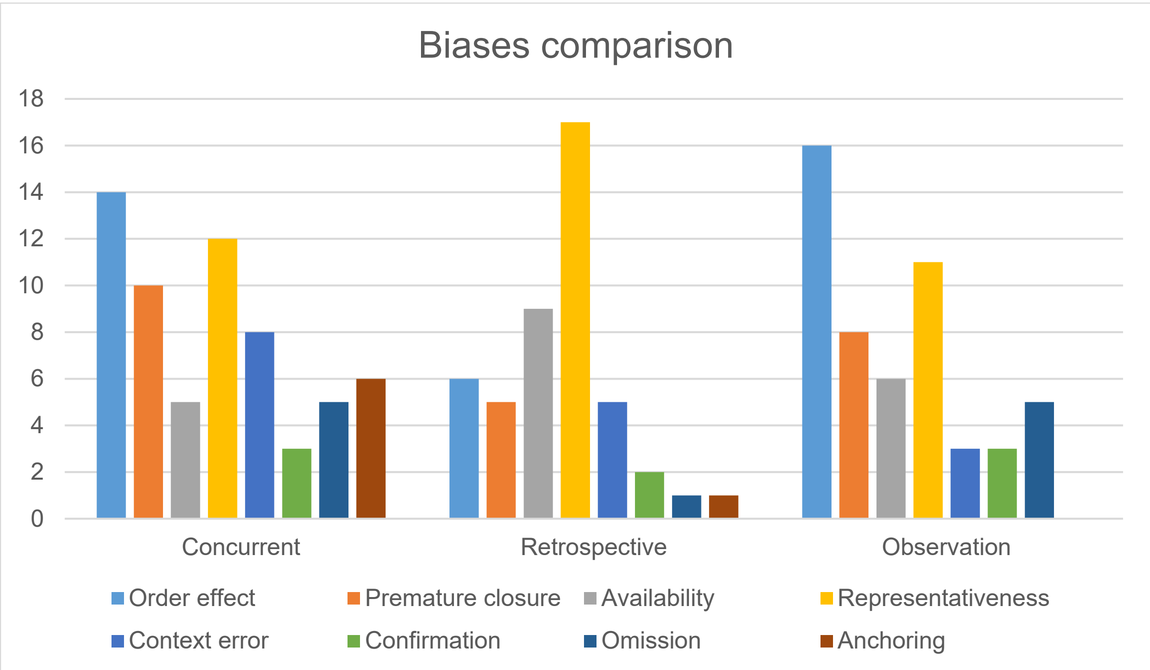

Figure 6.7 Comparing biases results between TA and observation

6.6.3 Exploring the association between types of CDM and biases

The correlation between the biases that occurred at different stages in the concurrent TA was explored using Spearman's correlation coefficient. There was a statistically significant positive correlation between the biases found in the cue interpretation (availability and representativeness) and type 2 CDM (r_s=.50, n=23, p=.02) and backward reasoning (r_s=.44, n=23, p=.04). Biases that occurred during hypothesis generation (availability and representativeness) had a statistically significant negative correlation with type 1 (r_s= - .61, n=23, p=.002). The same biases had positive correlation with pattern recognition (r_s= .45, n=23, p=.03). There was a negative correlation between the other types of biases and the other types of processes but none of those correlations reaches statistical significance. The positive correlation with type 2 could be explained due to its dominance and its frequent usage compared to type 1. Backward reasoning occurred less frequently compared to forward reasoning in the concurrent TA, so that could explain the positive correlation between the biases.

6.6.4. Comparing the types of CDM and overall HSRT score

The following sections below compare and assess for association and effect of types of CDM and biases on the HSRT overall score and HSRT sub-scale. This will provide findings that aim to answer the study research question number 3.

6.6.4a. The effect of type of CDM on HSRT score

The findings from type 1 and type 2 CDM were not normally distributed and could not be used for parametric statistics. The data was transformed using the two steps approach described by (Templeton, 2011) through SPSS. The output produced approximately normally distributed data for concurrent TA data that met parametric criteria described in section (5.2.2). From the concurrent TA data, the relationship between the types of CDM and the students' clinical decision making, measured by HSRT, was investigated using linear regression. Correlation r= 0.80 (N=23), p= .361 for type 2 and r = -.071 (n=23), p= 0.377 for type 1. From the retrospective TA data Spearman's coefficient was used, correlation r_s = -.10 (n=23), p.64 for type 1 and r_s = .12 (n= 23), p = .60 for type 2. Both results indicated small positive correlation for type 2 and small negative correlation with type 1 but was not statistically significant. The use of this test was for predictive reason rather for conclusive results.

6.6.4b. The effect of CDM categories on HSRT score

One-way between-groups analysis of variance was conducted also to explore the effect of the dominant category of CDM on the overall HSRT score. Students were divided into five different categories based on the percentage of each process to CDM as described in section (6.3.4) (category 2a, category 2b, category 2c, category 2d, and category 3).

For the data extracted from the concurrent TA, there was a statistically significant difference in the HSRT mean score for the five categories: F (4, 18) = 4.69, p = .009 (<.01). The difference in the mean score between the groups has a medium-size effect (eta square = .5). Post-hoc comparison using Tukey HSD test indicated that the mean score for category 2c (M= 28.50, SD = 3.54) was significantly different to category 2a (M= 20.23, SD=3.0) p= .019, category 2b (M=19.33, SD=4.16), p= .033 and category 2d (M=16.67, SD=2.89), p = .005 but there was no significant difference from category 3 (M=22.00, SD= 1.41), p= .267. There was no other statistical difference between the other categories (2a, 2b, 2d and 3). Students' who applied forward and backward reasoning in an equal way may have more effect on the HSRT score.

For the data from the retrospective TA, there were no statistical differences in the overall HSRT score for the five categories: F (4, 18) = .49, p =.49. Three of HSRT sub-scale were not normally distributed, therefore Kruskal-Wallis test was used to assess the effect of CDM categories on the HSRT sub-scores. The test demonstrated that the CDM categories did not have a significant effect on the HSRT sub-scale score.

6.6.4c. The effect of CDM processes on HSRT score

From the concurrent TA data, the relationship between the CDM processes and the students' clinical decision making, measured by HSRT scores, was investigated using linear regression. Preliminary analyses were conducted to ensure no violation of the assumption of normality, linearity, multicollinearity and homoscedasticity (Pallant, 2016) and the HSRT overall score met regression assumptions. Forward reasoning, pattern recognition and automated behaviours were negatively correlated to HSRT overall score but the backward reasoning was positively correlated. Forward reasoning had the strongest correlation r= -.338, p= .058 but there were no other statistically significant correlations. The type of CDM processes that included; forward reasoning, backward reasoning, intuition, automated decision and pattern recognition, from the concurrent TA data, were entered together but the results were not statistically significant to explain the variance in overall HSRT score, adjusted R= .06, F (4, 18) = 1.34, p = .29.

CDM processes where then used together to predict the HSRT deduction score. They indicated that 25% of the variance in deduction score could be related to CDM processes but the results were not significant. When the deduction score of HSRT was predicted using type 2 and type 1 processes separately, it was found that backward reasoning (β=.56, p= .012) was a significant predictor. The forward reasoning, pattern recognition and automated behaviours were not significant predictors. The overall model fit was R-adjusted = 0.25, F (4, n= 18) =2.8, p= .057) but when type 1 processes were removed, the overall model fit was R-adjusted = 0.24, F (2, n= 20) =5.58, p= .012). Forward reasoning effect was not statistically significant but backward reasoning had a significant effect (β=.60, p= .004). The statistical analysis confirms this impression with R-adjusted is .6, suggesting that more than half of the variation in the deduction score can be accounted for by this variable's relationship with backward reasoning. For type 1 CDM process, pattern recognition, automated behaviours and intuition were not significant predictors.

The backward reasoning was also a significant predictor for the analysis score (β= .46, p <.05). The overall model fit was adjusted R = 0.18, F (2, n= 20) =3.42, p= .053). Type 1 processes were not significant predictors of the analysis score. All of type 1 and 2 processors were not significant predictors of the induction, inference and evaluation score. The statistical analysis shows that pattern recognition has a statistically significant positive correlation with the induction score but as a predictor of the induction score, it did not reach statistical significance (β=.29, p= .23).

From the retrospective TA data, backward reasoning had positive correlation with deduction score (r= .37, p=.04) and analysis score (r=.46, p=.02) but did not reach statistical significance to predict both the deduction (β= .38, p = .16) and analysis (β= .32, p=.21). Forward reasoning had a significant negative correlation with the analysis score (r= -.42, p=.025) but did not reach statistical significance to predict analysis score (β= .38, p = .16). For type 1, there were no significant correlations and the results were not statistically significant to explain the variance in the scores of HSRT scale components (Appendix 27).

Some of these associations from the linear regression were statistically tentative but warrant further analysis of their involvement in contributing to predicting HSRT score. Sample size is conventionally set at 100 plus number of variables (Knofczynski and Mundfrom 2008) in order to provide a reliable prediction but in exploratory studies a sample of 2+ subjects per predictor variable (SPV) is considered to have an adequate estimation of regression coefficients with low level of bias (Austin and Steyeberg, 2015). With the current sample of students this suggests that application of up to 11 potential predictors might be of an explorative value. In this study, regression was used as an exploratory tool rather than a prediction technique and the analysis must be treated with caution.

6.6.4d Biases effect on HSRT score

The biases that occurred in the cue acquisition (premature closure and order effect) had a negative correlation with the HSRT post-test overall score, and the post-test all HSRT sub-scores but it did not reach statistical significance. When the "order effect" error occurred during the automated behaviour, it had a negative correlation with post-test deduction and analysis score but it had a positive correlation with induction, inference and evaluation score. The analysis shows a negative correlation between HSRT score and availability and representativeness errors but it was not statistically significant.

Kruskall-Wallis test was used to assess the difference in the HSRT and sub-scale post the simulation experience between the groups based on the frequencies of biases used with the type of CDM. There was a statistically significant difference in HSRT induction score associated with "premature closure" and "order effect" biases when it occurs during cue acquisition (X^2 (1, n=23) = 5.25, p=.022). The increase in the frequency of biases was associated with a reduction in the induction score. There was a statistically significant difference in the evaluation score associated with biases occurred during hypothesis evaluation (X^2 (2, n=23) = 6.67, p=.036) and no other significant difference among the other scores of HSRT components.

6.7. Summary

- The result indicates that high fidelity simulation improves nursing students' clinical reasoning and decision-making skills.
- Students' mainly used type 2 CDM and mainly followed forward reasoning in a response to a patient's acute care needs.
- Students focused on cue acquisition with little focus on cue interpretation and hypothesis generation.
- Cognitive biases are regularly used and more frequently seen during cue acquisition and cue interpretation.
- The use of both types of TA and observation provided a depth of insight to the CDM and add a methodological contribution to knowledge of CDM.
- Students' who used an equal combination between the types of CDM had a significant positive effect compared to types of CDM separately.

- Backward reasoning has a positive effect on students’ deduction score post-simulation experience and had a greater positive correlation to HSRT scores.
- The results indicated that forward reasoning and type 1 processes have a negative correlation with the HSRT score and sub-scores.
- The increased frequency of cognitive biases had a negative effect on the induction and evaluation score.

CHAPTER 7
RESULTS OF PHASE 2

7.1. Introduction

This chapter presents the results of the second phase of this study. This phase explores the potential benefits of the simulation experience on students' clinical practice. Twenty-three short interviews were conducted with the same participants recruited in phase 1. This sample size is considered adequate in similar qualitative research to answer the research question of this study (Hoffman, 2007; Ewertsson et al, 2015; Taylor-Goh, 2015). The participants are third-year nursing students in the last 6 months of their study. The students were recruited from two subsequent cohorts attending the same degree. The interviews took place between October and November 2015 for cohort 1 and in May for cohort 2. The two cohorts represented different intakes and were at the same stage of their studies. The interviews were conducted between four to six weeks after students attended the simulation experience in phase 1 (Table 7.1). During those four to six weeks between phase 1 and 2, all participants were in full time clinical placement in their management module (module eight) described in table 4.2 (Chapter 4). Interviews were audiotaped and Braun and Clarkes (2006) phases for thematic analysis was followed as described in the data analysis chapter (section 5.6). All the transcripts were organised and imported into NVivo 11© (QSR International, 2017) to manage the coding process. The themes generated in thematic analysis of the interview is presented in this chapter.

Table 7.1: Dates of data collection for phase 2

	Cohort 1		Cohort 2	
	Start	Finish	Start	Finish
Phase 2 data collection point	22nd October 2015	10th of November 2015	16th May 2016	27th May 2016

7.2. The results of thematic analysis of the interview

Twenty-five descriptive codes were initially generated (Appendix 28). Similar codes that referred to or described the same concepts were clustered together using NVivo 11 to produce a list of meaningful groups (sub-themes) and resulted in 14 different sub-themes.

The researcher used NVivo 11 to interrogate and compare the results of the sub-themes and then aggregate the identified sub-themes to produce a refined list of major themes that would answer the fourth question of this study. This software can also produce a thematic tree that link each major theme to the sub-themes, the descriptors and coded sections from the different transcripts. The content of each major theme and the related sub-themes was examined using the function 'Explore' that aggregate texts with the same code from different transcripts in one view. The identified themes were examined for coherence, prevalence and being logical by reviewing each sub-theme within NVivo 11. Ultimately, five emerging major themes were found to be the result of this analysis namely: promoting active and reflective learning, fostering the CDM skills development, recognition of the types of CDM, recognition of cognitive biases and integrating theory to practice. The content of the interview results in the delineation of the themes that described the usefulness of simulation experience in enhancing students' clinical skills and its benefits on students' clinical practice. (Table 7.2)

The usefulness of simulation in promoting active and reflective learning and fostering CDM skills development were the most important themes discussed by students followed by how the simulation affected developing students' recognition of the types of CDM, recognition of cognitive biases and integrating theory to practice. Table 7.2 presents the identified themes, number of responses per theme, the sub-themes and description of each theme.

Table 7.2 Emergent themes and sub-themes

Theme	**No. of responses**	**Sub-themes (sub-categories)**	**Description**
Theme 1: Promoting active and reflective learning	88	• Learning through active participation • Learning through reflection and self-evaluation • Learning through feedback and debrief	The usefulness of simulation as a learning method and context for active and reflective learning
Theme 2: Fostering CDM skills Development	88	• Recognising the importance to use a methodical approach	The usefulness of simulation in developing clinical decision-making skills.

		• Improving diagnostic skills • Changing the way of thinking • Increasing confidence in CDM	
Theme 3: Recognition of the types of CDM	35	• Awareness about the types of decision making	The usefulness of simulation in identifying the different types of decisions
Theme 4: Recognition of cognitive biases	64	• Awareness about cognitive biases • Awareness of the impact of biases on practice	The usefulness of simulation in identifying different types of biases that affected students' decisions.
Theme 5: Integrating theory into practice	64	• Good preparation for clinical practice • Application of theory into clinical practice	The usefulness of simulation in improving application of theory into practice. The usefulness in its fidelity and similarities to practice and the complexity of the scenarios

7.2.1. <u>Theme 1 Promoting active and reflective learning</u>

Students considered that the simulation experience was a useful method of learning but vary in the way they described the usefulness of simulation as a learning method. Some students considered that performing the task alone helped them to work on the presented clinical problems and to assess their performance. For example, one student (C4) stated that *"it was interesting to be by myself doing it rather than in a team… people can prompt you to continue to do the assessment or to focus on other aspects. So, it was useful to do it just by myself".* Another student (Y4) also commented, "*you can see yourself and it is very different from seeing or watching someone else*". Perhaps the one to one session helped students to have better focus in processing the clinical cues and making sense of the clinical situation without interruption or cognitive overload therefore they perceived it as a useful part of the simulation experience (Sweller, 1988). Interruption by others has been linked to nurses' ability to think clearly or logically that have potential to affect patient safety (Hayes et al, 2017). Similar comments were made by student *(P4) "when you're on your own you really have to think clearly for yourself and take more actions".*

Students also described how they became more actively involved in the learning process and how being more involved helped them to understand their strengths and weakness. For example, M4 noted that *"I think it's mainly about the performance bit, because you don't know how well you can do until you actually try to act it out, until you're in the situation".* Another student noted that *"Doing the simulation with limited information beforehand made it interesting to find out more about the patient" (O4).* In this way, the simulation experience appeared to lead students to immerse in the problem-solving exercise as they were seeking and relating cues to solve the clinical problem and to act on any issue they identify which made the simulation activity engaging and worthwhile for them.

Students felt the pressure and the responsibility to make decisions and to anticipate the interventions required from themselves and other professionals. *For example Q4 stated that, "we're taught the ABCDE and we go through it, but we're doing it as a class as a group, so you're not fully taking on all the responsibility…..I would have thought that I would have always done the ABC, but doing it one to one, and I had a full responsibility in that scenario, I realised that I did jump to conclusions".* They felt like that the simulation experience was like a real situation that stimulated a sense of clinical responsibility if similar situation occurs in practice. For example, *"It also put me on the spot, as if it was a real clinical situation and what I should do in practice…. really useful. I think it's really stayed with me" (D4).* Students comments of remembering the simulation experience during their practice suggests that their active involvement in the learning process may have lasting effects on knowledge and skills retention. Perhaps their active participation stimulated deep learning and motivated the students to practice high-level of critical thinking because they recognised the relevance of this experience in developing the skills needed in their clinical practice.

Most of the students described how reflecting on their experience was the most useful part of the simulation and most prevalent in all the interview transcripts. It refers to the students explaining their learning from reflecting on the simulation experience as an essential part to make sense of what they did and how to improve their skills. Students described their learning from reflection in different ways, such as watching, observing themselves, reviewing and critically analysing their performance. For example, P4 stated that *"I think looking back, and looking at myself doing things, then you can think, "Ah, I should've done that," or, "I* *could've done something different there," or, "I missed that out".* Another student (T4) noted that *"I found reviewing afterwards, so we watched the recording afterwards….you see what you've done and then you can reflect on that and look to yourself, which was really important" .* This student was commenting on how reviewing and reflecting on their performance was key to their learning and how the reflection pulled everything together to make sense of what happened during their experience in the simulation. Reviewing the video during their reflection appeared to give students a different perspective on how they really performed rather than how they thought they performed. An example from student D4 who had similar description*, "it was videoed, I reviewed part of that, it helped me appreciate just how long it took me to do the ABCDE, and to go through the individual steps. It's still engrained in my brain and seeing myself missing things, so it's something that has stayed with me".*

Students critically evaluated their performance but focused on discussing their mistakes, the causes of these mistakes and occasionally discussed how to improve their performance. For example, student A4 described what went wrong, considered the gap in their knowledge and the effect of biases on the errors made *"Then my reflection on it and going through it in my head, what I'd done, and looking at where I went wrong, which in the scenario I went wrong from the very beginning…. I think it's lack of knowledge in combination with some of these biases. So, I think, if I build my knowledge, I will be able to make better decisions".* Students regularly measured the accuracy of their performance against specific criteria commonly ABCDE approach. For example, one student stated that *"I found that I would normally approach things in an ABCDE manner but that I missed out quite a few key components and so I think I started to do my ABC and forgot about D and E and I did the blood pressure but I didn't take the pulse and I didn't take the temperature" (C4).* Similarly*, "I was all over the place. I didn't have a system, so I was moving from, maybe, A to E and then back to C" (*M4).

Students' assessment of their effectiveness resonates with Knowle's theory of learning that describes adult learners as self-directed, self-regulated with previous experience and motivation to learn to enhance their social role (Knowles, Holton and Swanson, 2012). However, students' self- evaluation of their success and failure during the task was useful to self-regulate their behaviours, they focused more on their mistakes to determine their self-efficacy and their perceived level of competency (Bandura, 1997). This could have potential negative effect on their clinical confidence in the task if students were not effectively debriefed about their performance through constructive feedback.

Many students described how feedback and debriefing was essential to their learning as it reassured them, and reduced their anxiety by focusing on their strengths and specific areas for improvement. For example, a student stated that *"I think the debriefing. Well, the simulation was good, and I felt like it put me under pressure. I thought that was interesting, but the debrief was the bit that taught me. Then we went through what I did wrong, and that taught me what I should have done instead" (G4).* Students used the feedback to verify their findings from their own reflection, validate their abilities and it also made them more aware about the types of CDM and associated biases that affected their decisions. For example*, "I would say the discussion was most useful for me because it made me know where I stand and where, I would say, my capability is at the moment and how I can improve. So, it was from the discussion between you and me after the simulation process that I felt I really needed to work on that. It made me realise the ways to go about doing things when I'm on practice" (X4).*

Going through the simulation experience appeared to lead students to be able to think more about how they might improve their skills to perform the task differently in the future, a fundamental part of the reflective process. This could suggest that they are moving from stage 2 (reflective observation) into stage 3 (abstract conceptualisation) within Kolb's experiential learning theory cycle as they concluded their learning from their experience and aimed to change the way they practice (Kolb, 1984). According to Kolb (1984) people do not learn just by reviewing by also but doing and then critically evaluating what they did through reflective observation. The outcome is to make sense of what has happened and moving to a final stage (stage 4) to put what they learned into their practice.

7.2.2. Theme 2: Clinical Decision-Making skills development

Students reported various advantages of the simulation experience that developed their clinical decision-making skills. These perceived advantages included: increasing awareness about the use of a methodical approach; developing diagnostic skills; changing the way of thinking; and increasing self-confidence. This theme had 88 reference statements from all the 23 transcripts.

Students reflected on how their approach to solving the clinical problems during the simulated experience was fragmented and lacks the structure. For example C4 described this unstructured approach in their comments *"it was quite scattered, there was no systematic way of gathering the data probably not the most thorough and systematic".*

The students also commented on how the simulation supported them to recognise the importance of using a structured approach and to pay careful attention to their actions as this student explained here:

"So just to look at the current situation, the current diagnosis and then take things from there. Also, maybe, this time around, use my ABCDE properly, not just jumping from C and D, because I know that's one of my weaknesses. It made me aware that if you do things step by step it helps a lot because if you miss anything it might affect the overall problem for that patient" (X4).

And,

"I think if you go through that methodically or systematically rather, then I think it helps you identify what possible issues there are" (D4).

Students found this experience helpful to reinforce the use of a structural approach in the form of ABCDE to reach effective decisions. This recognition of the clinical value of the ABCDE and the value of simulation experience as a cognitive and behavioural learning strategy to improve skill acquisition is demonstrated in the following examples*;*

" I think just reinforcing the ABCDE approach. I think simulating it reinforced it in my mind, to go through it methodically" (F4).

"…..it demands you to work a bit more methodically than you do in your assessments of people because then you don't miss things out."(P4)

Students therefore identified the importance of simulation to help them become more methodical in their approach to assess and respond to patient needs. Students' comments indicate that the simulation affected how they assessed and managed patients in clinical practice by aiming to enhance the content and structure of their assessment. This was evident as 12 reference statements from 12 different participants. For example,

""I'm trying to emphasize using the A, B, C, D, E approach and going step-by-step. Not rushing to D before finishing my A. I'm trying to follow that step-by-step, not rushing, just finish the airway and then go to breathing" (N4).

Another example:

"I have found it more helpful in terms of assessing patients more thoroughly..

..looking holistically, looking at it systematically as well, more now. Ask them [patients] questions and try to broaden my assessment" (H4).

The use of a methodical and structured approach is well supported in the literature to significantly improve the management of clinical deteriorating patients (NICE, 2007; Liaw et al, 2011; UK Resuscitation Council, 2015). The simulation experience helped students to recognise the importance of this approach.

Similarly, they found that simulation experience enhanced their diagnostic skills as they started to think of different alternatives before reaching conclusions about the clinical problem and discussed how the simulation increased their awareness of the effect of cognitive errors on their diagnostic skills. For example, *"They may have sepsis for example, but they're actually having a reaction to the [infused] blood." So, it could be anaphylaxis. It could be both, more than one. It could be a combined effect" (H4).*

Another example:
"you need that in clinical practice because you can't just go in one angle, there can be so many things affecting the patient, so you need to take a holistic view… If you can orientate the best way to care and treat patients, then they will come out at a better level and a better standard and receive better care" (T4). These comments from students (H4) and (T4) describe how the simulation experience influenced their diagnostic skills and thinking about the use of multiple hypotheses. This is summed up by comments from student (V4) *"still you need to do different investigations and still follow different routes just to clarify it isn't anything else…I learnt that I'd need to assess the whole thing, dismiss what's really obvious and look at it more"*

Students described how making errors had limited their considerations of different hypotheses or caused the early elimination of relevant hypothesis like getting fixated on what is common. For example:

"I think jumping to conclusions for me has been a problem, premature closures. And maybe one of those, when you find something, I don't know which one it is, when you find something, and you think, "Oh yes, that's it because that's so clear," but you stop looking for the other things as well" (A4).

"after the simulation, I had similar patient in practice when the respiration was going up and I was thinking why it is going up and whether the patient was in pain and may be that was why

or temperature and relating it to everything ….could not figure it out, I knew he had chest infection that did explain why he was consistent coughing but did not explain why he periodically get really breathless, so I went through the notes to see any previous history.. and he had COPD" (W4).

Students reported that the simulated experienced in this study helped them to change the way of thinking. Eighteen students described that after the simulation experience they started to think differently. Thinking laterally which refers to thinking more carefully about the presented situation. For example, student A4 commented *"so never stop doing a full assessment and think laterally. I've become better at that, much better than I used to be".* Another example, *"makes you think outside the box. Keeps you more aware of these things".* The experience helped them to consider alternative explanations, think thoroughly about the true value of the clinical cues and not rushing to conclusion. For example, *"I think it made me look at the bigger picture, and not assume that it's something, and get fixated on what I thought it was" (F4). Student*

Other statements that refer to the same concept and meaning such as *"it made me open my eyes and think about other things" (O4), "it made me think twice about when I was assessing the patient" (Q4)* and *"it made me think, actually, hang on. I need to think of other things that it could be" (T4).* All of these statements could be related to students developing two cognitive skills; the systematic way of thinking about alternatives for a situation which is a description of lateral thinking and the second skill concerned with judging the value of the identified cues and how it could be related, which could linked to critical thinking. Both of these cognitive processes are key components to developing effective decision-making skills (de Bono, 1970).

Here this student discussed how they became more effective and confident in the way they think and make decisions. For example, student W4 comments *"I think I am now thinking my decisions through more rather just making them". Student (A4) made similar comments "I think I've become better at keeping calm and not worrying about taking a minute to think about what's in front of me before making my decisions".*

Self-Confidence is defined best by Merriam-Webster (2019) Online Dictionary as "confidence in oneself and in one's powers and abilities". For the purposes of this study, "abilities" is focused on nursing skills and abilities to solve problems and make decisions. Students reported that simulated experience enhanced their abilities in making decisions and prepared them for future practice. For example, a student (Q4) comments *"My mentor* *has even commented that he's seen myself confidence-wise, feeling more able to take care of the patients" (Q4).* Also, here a student (D4) described the lasting effect of the experience on their performance *"It's really stayed with me about an approach that I can use in practice... I think, for me, it's given me a bit more confidence that I've got somewhere to start, it calmed me down" (D4).* A similar comment came from student (A4) *"..will never forget that…. I have become better. I think that's the key point for me".*

They reported that the simulation increased their awareness about their CDM which gave them a way to improve their performance and self-confidence. For example, *".., actually, I felt a little bit less confident initially after the simulation because I thought those processes affecting my decision making that I am not in control and maybe I am not as good in making decisions as I thought but then actually since becoming aware of that I made better decisions since [laughter] and I feel lot more confident …because I understand those flaws I became better" (Y4).*

Overall, it is evident from students' comments that the simulation experience had positive effects on them developing their clinical decision-making skills and recognising the educational and clinical value of learning through simulation. The perceived lack of using a methodical approach, narrowed thinking and considering limited options concur with findings in chapter 6 section 6.4, as these factors could have potentially contributed to the reduced students' effectiveness in solving the clinical problems. It could also be related to the effectiveness of using forward reasoning that was dominantly used during the simulation experience.

7.2.3. <u>Theme 3: Recognition of the types of CDM</u>

Students in their interview had many statements that described different approaches they used in their clinical practice and how simulation was helpful in increasing their awareness about these types. The theme was identified based on students' statements describing the features of the different approaches they used for their decisions and problem solving in their practice. Students reported the difference between conscious and unconscious decisions in their own practice. Thirty-five statements were coded for this theme, so, it is the least theme in terms of prevalence.

For example, students referred to an easy grasp of the situation that leads to quick decisions as something that they lack awareness about it, but they became more self-aware of the need to mitigate this limitation by seeking for more information before making quick

decisions. Further, they acknowledged that using “instinct” is not always effective and requires more thinking. Both of the examples below described type one CDM and demonstrate student’s awareness about the presence of different types of CDM.
Another example, *“sometimes when things are happening with your patient, you sort of kind of grasp the easy explanation, … they are post-operative patient so hypotension must be due to bleeding or something, you kind go to the simple explanation and I became more aware of it [ways of thinking] since I did the simulation…Like consciously unknowing, being aware that you don’t always know this, and you can’t decide about it without having more information” Y4. Here this student* explained how they used the initial grasp of the situation make decisions and discussed different types of thinking.

A similar example from student (G4) who described their first impression and stated that, “*I found that when I was talking through things in the simulation and with my mentor, if she asks me a question, I’ll tell her what my first thought is, and then she’ll pause, and be, like, “Well, actually, have you thought of other things?” In many occasions, that has shown me that my first impression isn’t always right, it’s like an instinct one, but I need to think more about other things.*

Other students described the same type as something they develop through routine practice of solving familiar problems and carrying repetitive actions that they become unconscious about it. But when they are faced with an unfamiliar encounter they give it more attention and so consciously think about it. For example:

“it is very easy to fall into a routine. So, if you continue the routine, I would say a lot of that is unconscious decisions, but actually, if I saw a new patient, then all of my decisions become consciously different and I’m aware of different things” (T4)
And,
“it's not that effective when you're not really paying attention because you're just going through the motions and trying to get your numbers done it was really useful to know that the kind of decisions that I make are probably not the most thorough and systematic” (C4).

Students also described themselves as using clinical pattern and gut feeling in their approach to a clinical situation which also are descriptors of type 1 CDM and they demonstrate a risk of such type as it lacks awareness and consciousness.

Then you get into that, then you do your systematic approach, and then afterwards, you can reflect. But in the time, you’ve gone into a pattern, if you like…..… so we’ve checked the *airway, checked the pulse, so on. And then we go on that way. So, often, that is partially subconscious (Y4)*

I think sometimes I do tend to go with my gut feeling on things, so I'd say that was unconscious, (F4)

They described the effectiveness of the types of CDM is depending on the tasks, and they are more effective when they pay more attention to the problem and are conscious in their decisions.

"I think it is more effective being conscious but obviously there is the environment that you need to make these decisions very quickly and being student having the luxury of a bit of time and there another nurse doing the other stuff, I can step back. May be if it comes nature to do it that way then you can do it quickly and efficiently that is some will practise. So, at the moment it is useful but a slower process and it slow me down when I making those decisions so if I am in an environment that quick decision is needed" (L4)

Overall, students described how in their clinical practice they are aware about the different types of decision-making and recognised the importance to validate their first impression of their patient by seeking further information before reaching conclusions. They discussed how they became more aware about this after the simulation and how it influenced their practice. This resonate with Dual Process Theory of people using two types of CDM that override each other if one type did not adequately solve a problem (Croskerry and Nimmo, 2011). Therefore, people could learn how to think about their thinking to calibrate their cognitive skills and modify or regulate their behaviour.

7.2.4. <u>Theme 4: Recognition of cognitive biases</u>

In the interviews, students commented and identified different types of biases they made both in simulation and in their clinical practice. Their comments showed their awareness about the impact of biases on their decision-making. Students reported how their approach to care for a patient in the simulation setting was ineffective such as making shortcuts in gathering information and how they observe that in their clinical practice. For example;

"When you talked to me about my errors, I became aware…people still going straight to the blood pressure when the patients unwell, … not following their A, B, C, D approach (N4).

Another example:
"I would be rushing around doing one thing, get distracted and go to another, and forget about what I was previously doing. But I've since then started thinking logically, finishing one task before going to another ..… I know that I go from one thing to the other. Sometimes I realise I'm doing it but sometimes I don't realise I'm doing it" (K4).

The comments above demonstrated students' awareness about order effect bias, this was the most common bias identified by students in the interviews which concurs with the findings from the concurrent think aloud (section 6.3.5). Students regularly discussed how reaching conclusions early before careful examination of the clinical situation affected their performance. For example, A4 was discussing her performance during simulation: "*jumping to conclusions for me has been a problem, premature closures. ……being more aware of it, now I'm better at it. Once you know – I don't think you need to remember all of them. You need to know which ones are relevant to you" (A4).* This student in the quote above did not only recognise there was an error but also clearly identified it as "premature closure", which is an accurate identification of this error in this situation.

Students also commented that they recognised this bias in both the simulation and clinical practice, such as the comments here: *"I think maybe I come to a conclusion early, like you think it might be one action to take, but you do not have a solid conclusion.….. I've seen people reach conclusion early (V4).* This also agrees with students' reflection on their simulated experience for example, "*I fixated on one thing and I know, I jumped to conclusions, .. only gathered the observations that would relate to the outcome that I expected…. I had no set way of gathering the data so I felt really lost and I wasted time, probably. I've seen others fixating,…I'm only aware from doing the simulation, I never thought that I'd do it before, but, .., I think I was jumping to conclusions" (C4).*

Other students reported recognising being fixated on one issue. This is captured in student (C4) comments earlier but also emerged from other students' reflection in both their simulation and clinical experience. Another example from this student commenting on the simulation experience*: "I remember I homed in one possibility, and forgot all other possible scenarios" (D4).* Another example from clinical experience: "*recently, I had a patient who everyone thought was going into acute kidney injury. I think it was really interesting the way that people fixated on the fact that he might be going into AKI but he already had quite a chronic heart condition that was not considered" (C4).*

Sometimes the clinical context led them or their colleagues to be fixated on one aspect such as the comments from these students from their clinical practice: *"We tend to just think and be focused on just one particular thing, and not thinking broadly, I presume. I think on my simulation that's what happened. I was just jumping to a conclusion" (E4).*

"..because it [patient condition] *was in a respiratory context everybody was overlooking the cardiac condition that was causing the chest pain. So, they were like fixated or reaching conclusions early... I have seen it in practice I became more aware of it since we went through the scenario" (Y4).*

These comments demonstrated students' awareness about different types of biases that could affect hypothesis generation or their actions such as premature closure and anchoring. Other students recognised other errors that affected patient diagnosis such as students reporting the bias "availability" in their comments from practice "..*they're a post-operative patient, so their hypotension must be to do with bleeding".*

The effect of clinical context such as the clinical speciality, patients' history or handover from colleagues on people interpretation of the clinical situation was also reported by students. This is described in framing the way people think or seek simple interpretation rooted in the clinical context. For example: *"I think in the simulation in the history it said something about an MI, and they're a smoker, so straightaway I was thinking, "Chest pain." I wanted to look at the heart rate, ….So, I immediately went down that route based on the background information" (G4).* A similar explanation is offered by student (P4) in comments about their practice "*when you're in practice, and if you're in a similar sort of ward like cardiothoracic, people generally come and have the same sort of things that will happen If someone comes and does have something different, like anaphylactic or something like that, then it's hard for you to think, of"*

Student (L4) stated that, *" they were handing it over but assuming he opened his bowel and other issues appeared more obvious. So, going through the simulation made me aware of these sorts of assumptions and using methodical approach was handy" .* This example illustrates how the simulation experienced enhanced their awareness about their errors and assumptions. Similar example*, "when you go to see the patient obviously it's already in the back of your brain that 'this is what's wrong with the patient'. But actually, it's important to make your own assessment as well, not just rely on the staff before their assessment. It's important to take in everything with a fresh set of eyes" (B4).*

From the discussion above it is clear that students became more aware about these biases after the simulation, this was a result of reflective learning and during the debriefing session, as discussed under theme one. This awareness led them to improve their approach in thinking logically and more systematically to mitigate and regulate these biases which is linked to the findings in Theme two, where they described this experience to improve their decision- making skills.

The biases described by students in the interviews such as order effect, premature closure, availability, anchoring and representativeness were the most frequently identified biases in the think aloud data (section 6.3.5). Students identification of these biases in their simulation and practice reflect the findings from the think aloud but more importantly support the effect of learning through simulation.

7.2.5. Theme 5: Integrating theory into practice

This theme was developed based on two sub-themes including" "good preparation to practice" and "application to clinical practice". Both sub-themes fitted together as the comments from good preparation to practice appears to lead to applying theory to practice. Students' commented on how the simulation experience was "good preparation to practice" based on four aspects; the similarity of simulation to the real world of practice, complexity of the scenario, how simulation bridges between theory and practice and how simulation prepares students to the future role.

Students commented about the similarity of the simulated scenario and its complexity to what they see in clinical practice. For example: *"I found the most useful was like with simulation, we were looking at multiple things happening with the same patient. Which is more applicable to practice ... Obviously, in module 7 we are focusing on one thing at a time so we can understand it properly but in the real-world, patients come with multiple co-morbidities and for that, I found the simulation really helpful" (Y4)*

Another example:

"Very useful in terms of experience….so when your patient is truly ill, then it [simulation experience] is really a good to experience to have before you go into practice and during training, and have more exposure to it because then you know when it actually happens, how to react to it" (T4). This also agrees with student (G4) comments about the similarity of clinical pressure produced in the simulated scenario to the one they feel in clinical practice, *"I*

think I kept skipping steps because I was just trying to get through it. Pressure-wise, I'd say they're quite like real patients"

Here those students (Y4, T4 and G4) described that the complexity of the patient situation provided more realistic conditions for them to practice within and they found that helpful to prepare them for future encounters in the real-world. This supports the authenticity of the scenario and its relevance to students practice. Perhaps the gradual increase in complexity of the task stimulated students to think deeper and harder about their actions and engage both types of decisions therefore students felt the pressure.

Students reported earlier how they actively learn through simulation, which helped them to develop their CDM skills and awareness. This was clear in their perception that the experience was useful in preparing them for the real-world of practice and to bridge theory to practice. For example, students (P4 and D4) described how useful for students to practice their actions in simulation to improve clinical application. For example, *"It was good practice for running through the ABCD approach and made you think about what you'd do if it was a real-life situation. I was kind of relating it back to practice" (P4).* Student (D4) stated, *"it made me appreciate the difference between having the theory and then putting it into practice. Having said that the simulation scenario was a good opportunity to improve the way I practise and take action".*

Finally, students comment on how they found their learning was transferable to practice and how the experience led to change and improve the way they practice. For example, *"when I was reflecting on it, I had a similar situation with a patient in practice, but the instant thought I had, is to stop whatever is running if there is something going wrong….They wanted to start the [Tacozin] simultaneously with the blood, which we said we couldn't do. Because that was like the simulation scenario the antibiotic and transfusion" (A4).*

For example:

"It helped you to identify what you could see in yourself, and in others and you could then try to change. It's really stayed with me about an approach that I can be using in practice. Even with a patient that's not acutely ill, I can think and still apply it" (D4). Similar example, "*since the simulation I know I make less assumptions and I am aware of the bigger picture and try made decision" (L4)*.

Overall, simulation helped them to improve the content and structure of ABCDE and their application to clinical practice. It is illustrated in the quotes above in students (T4, D4 and L4) of applying what they learn in simulation to similar clinical situations.

7.3. Summary

To summarise Phase 2 finding, the interviews identified:

- Students perceived usefulness of the simulation experience as a way to support deep learning that influenced them developing CDM skills, develop self-awareness to regulate their thinking, improve their applications and clinical practice.

- This study used a single one-one simulation session and, based on the findings of this Phase 2, considering regular individualised sessions throughout the nursing curricula could have potential positive effects on students learning and preparation for practice.

CHAPTER 8
DISCUSSION

8.1 Introduction

In chapters 6 and 7, the findings of the study were presented from different perspectives. This chapter considers the meaning of the results of the study in relation to the literature, and considers the potential impact on nursing education, practice and future research. From the findings of this study, this research proposes a framework of clinical decision-making and clinical reasoning for nursing students to support the development of clinical reasoning and decision making.

The goal of this study was to investigate nursing students' clinical reasoning and decision making using manikin-based high fidelity simulation (HFS) of "deteriorating patients". Students were required to think aloud while collecting clinical cues, identifying clinical problems and taking appropriate actions in response to the presented problems. The Health Science Reasoning Score (HSRT) aimed to assess the impact of HFS design on students' clinical reasoning and decision-making score. The qualitative methods aimed to explore the applied types of clinical decision-making, and associated processes and biases during the simulated experience. Both types of data were compared to assess any association or effect of the applied type of decision-making and biases on the clinical reasoning and decision-making score. Finally, an exploration of the perceived benefits of simulation to students' clinical practice was conducted. The discussion below is organised based on the study research questions and then discusses the proposed framework in section 8.6 and the methodological contribution of this study in section 8.7.

8.2. RQ1: "Is there a difference in clinical reasoning (CR) and clinical decision making (CDM) measures for students after having HFS experience?"

In the literature, there is ambiguity and a lack of consistency regarding the concept of simulation and whether different types of classroom or clinical skills activities are considered clinical simulation (chapter 3, section 3.1.2). Moreover, there is a lack of clarity about the simulation design reported in the literature and which part of the simulation experience has the impact on knowledge attainment, skills development and clinical confidence (section 3.3.3). Most of the literary sources classified the fidelity of clinical simulation as low, moderate or high fidelity with lack of description about the used equipment, the created environment or whether a briefing and debriefing session were included in the simulation experience. Other literary sources focused on the impact of debriefing on students' performance with a limited discussion about the simulated activities before debriefing (section 3.3.2g). This study describes the use of a model of clinical simulation (section 4.4.2) that integrates the preparation for the simulation stage, performance during the simulated activities and the debriefing post-simulation stage. It considered these stages as essential parts for students learning experience to maximize the benefits of clinical simulation. The model also added a new stage as part of the debriefing to focus on debiasing, all the four stages are part of a model that has the potential to enhance students' decision-making skills. The result of this study will be used to propose a framework for CR and CDM and for further development and future research.

There has been significant interest in examining the effect of clinical simulation on knowledge acquisition, self-perceived confidence and clinical performance (Shepherd et al, 2010; Levett-Jones et al, 2011a; White et al, 2013; Merriman, Stayt and Ricketts, 2014; Young and Jung, 2015; Cobbett and Snelgrove-Clarke, 2016). One of the aims in nursing education and professional bodies is to ensure that the learning activities in the nursing curricula is not only focused on theoretical attainment of knowledge, attitude and skills but also learning that can be translated and effectively integrate to the real world of clinical practice. Moreover, it is vital to ensure that the learning activities adequately prepare students to be a competent and safe practitioner in recognising and responding effectively to deteriorating patients. This goal requires students to develop their critical thinking, clinical reasoning and decision-making skills. Although those skills have been extensively studied mainly in natural settings (Hoffman, 2007; Bjork and Hamilton, 2011, Pirret, 2013; Smith, 2013), there are only a few studies that investigated the impact of high fidelity simulation in developing clinical reasoning and decision making skills and how to use clinical simulation to assess and support the development of these skills (Dreifuerst, 2010; Shephred et al 2010; Walsh, 2010; Pierce, 2011; Levett-Jones et al 2011b; Cobbett and Snelgrove, 2016; Woda et al, 2017). These types of manikins could have a different effect on CR and CDM compared to previous studies in CR and CDM that focused on these measures but used paper-based problem or low fidelity simulation (Jones, 1989; Lamond, Crow and Chase, 1996; Twycross and Powls, 2006; Fossum et al 2011).

It was important to assess the feasibility of applying the designed simulation model and whether the results indicate positive effects on CR and CDM. In this study, the effect was assessed using the Health Science Reasoning Test (HSRT) overall score and the test components scores which include induction, deduction, analysis, and inference and evaluation scores. The findings from the HSRT overall score demonstrated statistically significant improvement in the post-simulation mean score of the sample compared to the pre-test. This indicates that the simulated experience may have led to an incremental improvement in the HSRT over time and with the repetitions and larger group the effect may become more apparent.

The results of this study reflect the findings of previous research in nursing education. It reflects Dreifuerst (2010) results who found that students in the intervention group had a significant improvement in their HSRT mean score post-simulation compared to the pre-simulation score. Young and Jung (2015) and Shepherd et al (2010) also reported positive results using a locally developed decision making tool with students who had had high fidelity simulation experience compared to the control group. The current study results also concur with findings reported by Yan, Willian and Man (2014) and Fawaz and Hamdan-Mansour (2016) who found a significant improvement in the clinical judgement score among the intervention groups using Lasater Clinical Judgement Rubric. Similar findings reported by Cobbett and Snelgrove-Clarke (2016) and Woda et al (2017) who used the Clinical Decision Making Scale in Nursing (CDMNS). Walsh (2010) and Pierce (2011) also found students perceived that HFS sessions improved their clinical reasoning and judgement. Most of the discussed studies used valid and reliable tools but mainly relied on self-report.

Both Driefurest (2010) and Walsh (2010) found deleterious effects on clinical reasoning score for simulation if debriefing was not included or if traditional debriefing was used. This suggests that effective debriefing tailored to students' performance is an important aspect of the simulation experience and should be effectively planned and executed. This supports the current study's perceived benefits of simulation reported in chapter 7 (section 7.2.1) and the study's proposal that all stages of simulation, which include pre-briefing, simulation experience, debriefing and debiasing are important to increase the effectiveness of simulation and its impact on students' developing CR and CDM skills.

The results of this study also demonstrate that there was a significant improvement in the deduction and analysis post-test score compared to pre-test but the improvement was not significant in the induction, inference and evaluation scores. This to some extend agrees with Dreifuerst (2010) results that found significant improvement in the overall HSRT score and all the HSRT sub-scores when the study debriefing design is used in comparison with to usual debriefing. The Dreifuerst (2010) study has a relatively large sample size compared to this study and perhaps increasing the sample size of the current study could produce significant improvement in induction, inference and evaluation. Possibly there is a need for more repetition of the simulation experience to produce a significant effect on the higher levels of cognitive processes such as inference and evaluation.

Most the studies that examined critical thinking did not demonstrate statistically significant difference between the intervention and the control groups (Ravert, 2008; Brown and Chronsiter, 2009; Walsh, 2010; Wood and Toronto, 2012; Knoesel, 2017) but they all showed a trend of improvement in critical thinking score in the intervention groups. This trend is similar to the findings of the current study, which reports positive effect on clinical reasoning score. The improvement in the clinical reasoning score in the current study could also be related to the improvement in clinical performance after simulation experience identified in the simulation literature (Radhakrishnan, Roche and Cunninghum, 2007; Ackermann, 2009; Merriman, Stayt and Ricketts, 2014; Lee et al, 2016).

The evidence on the effect of simulation on knowledge acquisition, critical thinking and self-confidence is inconclusive and inconsistent (chapter 3 section 3.3.3). Most of the studies that assessed the effectiveness of HFS used multiple choice questions (MCQ) that not necessarily assess decision-making skills as a high-order cognitive processes (Anderson, Krathwohl and Airasian, 2001). The question is whether the use of knowledge acquisition and retention is appropriate as an outcome measure that reflects clinical reasoning and decision-making skills (Tarrant et al, 2006).

8.3. RQ2: What are the CR and CDM types used and cognitive errors made by the third-year nursing students in managing acutely deteriorating patients using HFS experience?

The following sections explain and integrate the findings of this study about the types of CDM, reasoning processes, stages of hypothetico-deductive approach and cognitive biases compared to the literature to demonstrate how this study answered the research question.

8.3.1. <u>The type of clinical decision making</u>

In contrast to many nursing studies that either focused on the analytical or non-analytical approaches to CR and CDM, this the study applied the dual process theory (DPT) of clinical decision making to identify the different types of CDM and associated processes used by nursing students (Croskerry and Nimmo, 2011; Evans and Stanovich 2013b). The application of different types of decision making to solve a problem is dependent on multiple factors such as the complexity of the task, nurses' knowledge and experience and the conditions under which the task is performed (Hoffman, Donoghue and Duffield, 2004; Croskerry, 2009a). The types of CDM as defined by DPT (Croskerry, 2009a) are type 1 that refers to non-analytical and type 2 that refer to the analytical approach to decision making. The analytical approach refers mainly to the use of the hypothetico-deductive method and non-analytical approach refers to the use of intuition or pattern recognition or automated behaviours as conceptualised by (Evans and Stanovich 2013b).

The think-aloud data and PBG showed that nursing students in this study used a combination of both types of CDM but generally used type 2 as the main the method. There were many occasions when both types of CDM were used together in the same task which suggests that the CDM is not a linear process. This agrees with DPT suggestion that clinical decision making is achieved through a combination of two types of thinking, each with distinctive features, and that they can override each other (Croskerry and Nimmo, 2011).

The study results partly agree with Hoffman's (2007) findings that novice nurses mainly used the hypothetico-deductive approach compared to the non-analytical approaches but disagree with the method of reasoning used by the novice. The current study identified that nursing students used hypothesis-driven reasoning (type 2 CDM) in 79.8 % of the CDM followed by pattern recognition (10.1%) and automated behaviours (10.1%). Hoffman (2007) found that novices mainly used hypothesis generation in 26.2% of the CDM process followed pattern matchings (15.8%). Therefore, Hoffman's (2007) results agree with this study findings that nurses used two types of CDM and novice nurses tend to use type 2 more than type 1.

The study results agreed with more recent findings reported by Smith (2009), Andersson, Pelaccia and Klang (2012) and Kydonaki et al (2016) that nursing staff used both types of CDM regardless to the level of experience. Andersson, Pelaccia and Klang (2012) found that pattern recognition is used by both novice and expert. Kydonaki et al (2016) found that both inexperienced and experienced critical care nurses used intuition in their CDM approach to wean patients from mechanical ventilation. Smith (2009) also found that inexperienced nurses used intuition in clinical situations. Tanner (2006) clinical judgement framework and O'Neill and Dluhy (1997) model concur with the results of this study. Both authors conducted extensive literature reviews and found that nursing staff apply analytical and non-analytical approaches to CDM. The current study did not find students using intuition and this concur with Ellis (2002) findings who found that both experienced and novice nurses could not recall the use of intuition and they reported that being mostly engaged in reasoning. Perhaps the participants in Ellis's study were mainly using an analytical approach to decision making but they could also be not conscious about the use of intuition and the other form of reasoning.

In contrast, the results of this study partly disagree with nursing literature that refer to the use of non-analytical approach as solely an expert nurse approach to CDM (Benner, 1984; Benner, 2001; Coderre et al., 2003). For example, Cioffi (2000) reported that expert nurses were referring to "gut feeling" in identifying deteriorating patients before it happened. These studies do not always clearly differentiate between the different forms of non-analytical reasoning such as pattern recognition, automated behaviours and intuition and focus mainly on intuition. For example, one participant in Cioffi (2000, p. 111) said "You can just tell by looking at someone when you know them from day to day for you can pick up on the little things", where the participant could be referring to the use of subtle cues and possible pattern recognition due to familiarity of the patient to recognise patient clinical deterioration but this was categorised as "gut feeling" and use of intuition. The current study found nursing students using both types of clinical reasoning and regularly using non-analytical approaches (20.2%) to reach clinical decisions in the form of pattern recognition (10.1%) and automated behaviours (10.1%).

This study agrees with other evidence in nursing that nurses used a mixture of CDM strategies (Lauri and Salantera, 2001; Thompson et al, 2009; Pirret, 2013). Indeed, Offredy et al (1998) found nurses use different thinking strategies in different clinical situations. The use of DPT as a theoretical framework was useful as a pluralistic approach that considers the different types of CDM. This adoption led to a mixed method research design and an in-depth analysis of the types CDM in this study. It will useful to utilise this theory in future nursing research.

8.3.2. <u>Hypothetico-deductive approach</u>

This model embraces two approaches to clinical reasoning: forward and backward reasoning (Elstein, Schulman, and Sprafka 1978). This study found that in clinical simulation, nursing students applied a range of reasoning processes during their clinical performance. They used hypothetico-deductive approach, pattern recognition and automated behaviour.

Hoffman, Aitken and Duffield (2009) found novice participants used more backward reasoning and expert nurse used mainly forward reasoning. In contrast to some nursing literature (Lamond, Crow and Chase, 1996; Hoffman, 2007), this study found that nursing students used more forward reasoning in the concurrent TA data and less backward reasoning. This finding is consistent with the results found among medical students (Arocha, Patel and Patel, 1993; Pottier et al, 2010). Both Pottier et al (2010) and Arocha, Patel and Patel (1993) reported that medical students used more forward reasoning compared to specialists in internal medicine. Similar results were found among experienced physiotherapists who mainly used backward reasoning using HFS (Thackray and Roberts, 2017). Twycross and Powls (2006) used think aloud (TA) and also found contradicting results to the majority of nursing research. They found that all the participants used backward reasoning regardless of their experience including experts. Johnsen, Slettebo and Fossum (2016) found that community nurses used inductive and deductive reasoning equally but were reactive in their CDM. This suggests that the use of clinical reasoning process does not only depend on the level of experience and that other factors may affect the type of CDM and associated processes applied to different clinical problems.

Many studies that found forward reasoning used by experts and backward reasoning used by novice acknowledged that their findings are not an exclusive pattern and most of their participants used a mixed approach of both processes in their reasoning (Lamond, Crow and Chase, 1996; Hoffman, Aitken and Duffield, 2009). This could be related to the origin of the hypothetico-deductive model and how it evolved over time. As a deterministic reasoning model, it was historically viewed as the model of expert reasoning used in solving medical problems (Joseph and Patel 1990; Elstein et al, 1993). However, after few years of research, this view was shifted and the model was considered as a model predominantly used by novice healthcare practitioners for diagnostic and clinical reasoning (Elstein, 2009; Pirret 2013). Nursing research identified the use of this model among both expert and novices' nurses. Recently, the Dual Process Theory considered this model as part of the human reasoning system that includes also other processes and that a mixture of processes may be used to solve a clinical problem.

8.3.2a Cue acquisition

This stage was defined as the recognition and collection of clinical cues such as patient's signs and symptoms (Elstein and Bordage, 1991). Based on the combined frequencies from both concurrent and retrospective TA, the results of this study demonstrated that students used cue acquisition as the most frequent stage of the hypothetico-deductive approach in their reasoning and clinical decision-making process. Most of the nursing studies compared novices to experts in terms of cue acquisition in both natural and simulated environments. However, the results are not always consistent (Hoffman, Aitken and Duffield, 2009), the expert is frequently seen to collect and cluster fewer but more relevant cues that are more accurately related to the presented task. Novice nurses collected a larger number of cues that focused on the presenting symptoms but with reduced diagnostic accuracy (Kydonaki et al, 2016). The findings of this study corroborate the findings of similar studies that examined nursing clinical decision making and problem-solving.

Hoffman (2007) found that novice critical care nurses used cue acquisition as the most frequent stage in their analysis of nurses' CDM during routine care delivery of surgical patients. Similar results are observed from the following studies that used paper-based simulated scenarios and think aloud protocol. Jones (1989) examined the CDM of nursing staff in providing care for patients with pulmonary disease and found that regardless of their level of experience nurses used operator collect and review in more than 60% of the reasoning process to make cue acquisition the main stage of nurses clinical reasoning. Greenwood and King (1995) also found that cue acquisition was the dominant part in the clinical reasoning process of both novice and expert orthopaedic nurses. Similarly, Lamond, Crow and Chase (1996) found descriptive judgment accounted for 65% of all the judgements made by qualified nurses working with scenarios of an acutely ill patient. This is also supported by Higuchi and Donald (2002) who explored nurses reasoning process by using retrospective think aloud of nurses' documentation in natural settings. Kydonaki et al (2016) also found that novice critical care nurses needed more encounters of cues to attain concept with more certainty in natural settings. However, the current study differs from some of the studies above as it is not in natural settings and uses high fidelity simulation that is physiological responsive and more interactive with participants compared to paper-based scenarios. The similarities in the finding of this study compared to those studies indicate that the simulation experience to some extent could replicate parts of the natural settings to produce similar effects. Therefore, it will be useful to conduct more nursing research in the field of CDM using high fidelity simulation to support students learning and development.

The respective TA results of this study contradict with Hoffman's (2007) retrospective TA findings. In Hoffman's study cue acquisition continued to be the dominant stage in terms of frequency but in this study, cue acquisition was less frequently observed and moved to the third place. This could be explained through the method of conducting the retrospective TA, in the Hoffman (2007) study, the retrospective TA was carried few weeks post the concurrent TA and this study carried out retrospective TA immediately after the concurrent and simulation experience as recommended by Ericsson and Simon (1993). Also, the retrospective TA sessions in this study were supported by using the recorded videos. In this study during the retrospective TA, students were focusing on relating cues, justifying their conclusions and actions and reduced their collection and description of cues.

8.3.2b. Cue interpretation

At this stage, the students identify the meaning of different cues and infer the relationship among the collected cues. Cue interpretation was the second most common stage of the hypothetico-deductive approach used by the students in this study with a frequency of 27.9%. The results of this study about cue interpretation concur with the findings of similar studies in nursing and other healthcare professionals (Jones 1989; Greenwood and King, 1995; Hoffman, 2007; Taylor-Goh, 2015). These authors also found cue interpretation as the second most common stage with a frequency of 20% in Jones (1989) study, 25% in Greenwood and King (1995) study, 31% in Lamond, Crow and Chase (1996) 14.1% in Hoffman (2007) research and 25% in Taylor-Goh (2015). Higuchi and Donald (2002) found inference the third most frequent process used by nurses during the care delivery for patients with both medical and surgical conditions. Perhaps the slight differences from this study could be explained due to the data collection method applied by (Higuchi and Donald 2002). They analysed patients' records and nurses' documentation rather asking nurses to think aloud about their decisions.

8.3.2c. Hypothesis generation and evaluation

In the combined TA results, both hypothesis generation (9.7%) and hypothesis evaluation (15.4%) were less frequently used compare to cue acquisition and interpretation with the hypothesis generation having the least frequency. This agrees with Jones (1989) results for operators that reflect hypothesis generation and hypothesis evaluation. This study concurs with Lamond, Crow and Chase (1996) and Hoffman (2007) findings of the low frequency in reaching a diagnosis. Hoffman (2007) reported that the novice nurses referred to hypothesis generation in 7.9% and 28.2% referred to hypothesis evaluation. This study also reflects the findings of Higuchi and Donald (2002) study. They identified that nurses were using "synthesis" which is equivalent to hypothesis generation as the second lowest stage and "verification" which is equivalent to evaluation was the lowest stage in the decision-making process. However, this study's observational results showed students using the hypothesis evaluation slightly more than cue interpretation which is similar findings to Hoffman (2007) findings.

8.3.2d. Pattern recognition as part of type 1 CDM

In this study, type 1 processes were less frequently used compared to type 2. The use of operators "predict" and "match" help in identifying the process of pattern recognition and it were apparent in most of the students' TA scripts. Much of nursing research equates pattern recognition to intuition (Benner and Tanner, 1987) others considered it as part of the analytical reasoning (Offredy, 1998) and Klein (2008) considered that pattern recognition requires a blend between intuition and analysis. This is also confirmed in Patterson et al (2009) simulation modelling of Klein (2008) Recognition-Primed Decision (RPD) who found that it takes 8 seconds to make decisions based on RPD model, which is considered as fast.

In the concurrent TA results of this study, pattern recognition had a frequency of 1.1% and 4.7% for retrospective TA. In contrast to many studies that considered pattern recognition a feature of expert practitioners and not part of the novice reasoning process (Benner, 1984; Norman, Young and Brooks, 2007), this study found that students used pattern recognition as part of their reasoning process that was accurately used to identify an allergic reaction. The findings of the present study agree with recent nursing research that explored pattern recognition in both simulated and natural settings (Hoffman, 2007; Walsh, 2010). The findings of this study concord with Hoffman (2007) findings, who reported that novice nurses used pattern recognition in 2% of their CDM during the concurrent TA and 5.8% their CDM during the retrospective interviews. Burman et al (2002) identified that primary care nurses used pattern recognition as the primary approach to their diagnostic process and described the approach of pattern recognition as it contains searching for red flags and the use of cognitive schemas.

The result of this study was also in agreement with Coderre et al (2003) who found that novices used three types of reasoning strategies; hypothetico-deductive reasoning (43%), scheme-inductive (43%) and pattern recognition (13%) but the first two were the dominant reasoning strategies compared to experts who mainly used pattern recognition (48%). Manias, Aitken and Dunning (2004) found that pattern recognition was more prevalent among new graduate nursing staff with 10 decisions (27%) and intuition was identified only twice (5.4%). Their results agree with the current study and illustrate the difficulty in observing intuition and type 2 appears to be the dominant method. Walsh (2010) found that students who trained in using pattern recognition during simulation had improved critical thinking and reasoning scores compared to the control group and simulation group without the use of patterns. This suggests the use of simulation to develop patterns and apply pattern recognition could have a positive effect of CR and CDM skills.

In this study, students did not verbalise the different parts of the recognised patterns rather when few key cues were found to immediately relate to the initially found cues or patient's history, students made diagnoses or carried out actions immediately after finding a key cue such as when they saw the rash they immediately stopped blood transfusion. The way how pattern recognition was used appeared very fast and impulsive compared to other types of decisions. The rapid nature of pattern recognition and the action that followed it confirm that this strategy is part of type 1 decision making. This finding agrees with recent consensuses (Evans and Stanovich, 2013b). In contrast to concurrent TA data, some students verbalised how they linked the cues together to match a recognisable clinical pattern during retrospective TA. Perhaps their ability to access the long-term memory allowed them to verbalise in order to rationalise their conclusions and actions. It could also be explained based on the Loading Theory, that a person could maintain their focus on specific parts of a given situation during performance due to the limited working memory capacity (Sweller, 1988) but that is dependent on the complexity of the situation or tasks, the person's knowledge and experience and the environment.

8.3.2f. Automated behaviour as part of type 1 CDM

According to dual-process theory, the automaticity is recognised by missing steps in the reasoning process, the move straight to action and solution from the perception of information or automatically appear to know what they are doing (Croskerry and Nimmo, 2011; Evans and Stanovich, 2013b). It usually occurs so fast that the decision-maker may not be aware of it (Ericsson and Simon, 1993). In the current study, the automated behaviours were rarely verbalised by students when they carried out actions or intended to carry out actions immediately after they noticed clinical cues. In the retrospective TA of the present study, some of the students justified this approach as this "our routine of practice". It appears as a way of reasoning that became automated due to repeated practice and internalised routine. This automaticity in the behaviour was described by Effken (2001) who suggested that these behaviours could be observed and measured and could be linked to intuition. Automated behaviours were observed by Hoffman (2007) in 5.4% of the novice nurses' CDM process which is similar to the findings of the present study that found automated behaviours in 10.1% CDM process. While automaticity has the advantage of needing low levels of attention to adequately perform a task, it has significant hazardous effects on situational awareness and the overall performance (Endsley, 2000).

8.3.3. <u>Task performance during simulation</u>

Students' ability to recognise and collect relevant cues, relate cues together to support the recognition of a patient's clinical problem and provide appropriate interventions, has a central role in the students' ability to develop their clinical reasoning and clinical decision-making skills. Missing subtle but relevant cues, assigning a wrong clinical value to cues, wrongly clustering and relating a patient's signs and symptoms will produce ineffective judgement and decisions that can lead to mistakes and cause adverse effects on patient outcome (Levett-Jone et al 2011a; Alfaro-LeFevre, 2013).

The findings of the study demonstrated that nursing students used confirmatory, dis-confirmatory and contextual signs and symptoms during their decision-making process to identify the clinical problem and the appropriate actions but focused more on the confirmatory symptoms. This corroborates with Levett-Jones et al (2011a) who found that the average number of cues collected by students was 8.89 and that specific cues were associated with increasing the likelihood of identifying the problem such as the use of diuretic in Levett-Jones, et al (2011a) study and, in this study, the presence of rash and time of transfusion. These findings also corroborate with Walsh (2010) who found that students relied on five essential cues to identify the main diagnosis of myocardial infarction (MI). Levett-Jones, et al (2011a) also found that nursing students used more confirmatory cues more than dis-confirmatory cues, with average total cues collected of 8.89 and 3.32, retrospectively which agree with the results of this study.

The results of the current study concur with Greenwood and King, (1995), Lamond and Farrell (1998) and Kydonaki et al (2016). Greenwood and King (1995) found that novice nurses collected slightly more cues compared to experts with an average of 17 concepts collected by novices compared to 16 for the expert. Lamond and Farrell (1998) found novice nurse over-select cues with less focus on specific or relevant cues compared to experienced nurses. Kydonaki et al (2016) found that despite the novice collect many clinical cues, this was not associated with increasing diagnostic accuracy. Previous evidence also highlights that novice nurses tend to focus on specific cues to trigger hypotheses and ignore cues which were perceived not to fit (Carenvali et al, 1984; Arbon, 2004). Certain information acted like a "trigger" to activate specific knowledge from memory that allowing the

recognition of a potential problem. It has been recognised that experts have the ability to activate the relevant knowledge quickly and can process larger numbers of cues due to the refined cognitive presentation and nodes linkage in the long-term memory (Ericsson and Simon, 1993).
Levett-Jones et al, (2011a) discussed the importance of collecting the “right cue” as an essential aspect for a clinical reasoning and decision making. Endacott, et al (2007) found that nurses and doctors with different levels of experience focused on different types of cues and relied on routine practice and vital sign for initial identification. This could also be linked to the earlier research of deteriorating patients in the ward where missing key clinical cues can lead to failure to rescue (McQuillan, et al, 1998). The larger number of cue usage in this study was not always associated with identifying the main problem or executing the appropriate actions to stop further deterioration in the patient’s condition. In fact, the increasing number of cues, above 30 in 15 minutes was associated with a negative effect on solving the problem.

This study found that the increased average number of wrongly interpreted cue and wrong clustering was also associated with reducing the students’ ability to solve the main problem (section 6.4). These results agree to some extent with Greenwood and King (1995) and Hoffman (2007) who found that novices significantly reduce their emphasis on cue interpretation and relating information compared to experts. Levett-Jones et al (2011a) also found that increased number of cues interpretation, clustering and inference was associated with increased accuracy of problem-solving among nursing students. They found that the average problem solved was 9.7 when many cues were interpreted and clustered together compared to an average of 3.57 when the problems were not solved and a limited number of cues were interpreted and clustered. The current study found that students focused on cue acquisition but the accurate interpretation and clustering appeared to have a significant effect on solving the problem compared to the increased of cues. Walsh (2010) found similar results about missed interpretation affecting nursing students’ diagnosis and identification of the problem.

Tanner (2006) describes similar findings, that the first grasp of patient condition dependent on the individual’s knowledge, is an important factor for cue interpretation. Schank and Abelson (1977) describe how information is stored in and retrieved by the human mind to influence individuals’ interpretation of events around them. They suggest that specialised knowledge structures are stored and used, linking together in clusters like script or patterns. For students to make sense of and produce meaning for the presenting symptoms during a performance, they need to access and compare the cues to store a cognitive representation of the relevant clinical knowledge. This an important stage in the reasoning process as it can confirm or disconfirm the relevance and significance of clinical cues contribution to hypothesis generation, therefore, an ineffective cue interpretation can lead misinterpretation and ineffective diagnostic and decision-making accuracy. Elstein and Schwarz (2002) found that cue gathering, along with accurate cue interpretation is closely associated with diagnostic accuracy. This influences how people allocate clinical values to cues which have an impact on the accuracy of judgement of the situation.

The students responded to patient deterioration by carrying out a further assessment, monitoring, considering or taking actions or communicating with team members (Thompson et al, 2004). The used cues were not always appropriate to the provided stimuli, the clinical context or the ABCDE, as a recommended approach for assessment and management of an acutely ill patient. In this study, less than 50% of students accurately identified the main problem and appropriately responded to the findings in a timely manner (section 6.4). This automated practice was not always optimal as it was carried out without careful interpretation of the cues and led to distraction and delays in identifying and treating the clinical problem.

Noticing and collecting the right cue is a key stage in decision-making that can increase students' ability to identify patients' clinical deterioration and appropriately response to their clinical needs. The lack of gathering the right cue, the ineffective interpretation and clustering of cues could be linked to "failure to rescue" (Tanner, 2006; Levett-Jones et al, 2011a). High fidelity simulation could be used to help students develop how to effectively collect, interpret and cluster cues to enhance their problem solving and decision making skills.

8.3.4. <u>Cognitive Biases</u>

This study demonstrated that cognitive biases are present during the CR and CDM process and commonly affected cue acquisition and interpretation during student nurses' performance. Biases frequently associated with type 1 decision making and the forward reasoning as part of type 2 of CDM. Representativeness, order effects, premature closure, availability and context effect frequently used biases by students in the study. Representativeness was the most commonly occurring bias in this study. There is limited nursing research in the field on cognitive biases that affect clinical reasoning and decision making and abundant research in the medical field, cognitive psychology and behavioural science. Cognitive biases affect human thinking and decision making and could affect how nursing staff recognise and respond to the acutely deteriorating patient. Nursing research in the field of heuristics and bias focused on the classical heuristics identified by Tversky and Kahneman (1974) and did not consider other different biases that have been identified in cognitive psychology and medicine (Croskerry, 2002). This study considered the classical cognitive biases and key other biases frequently observed among medical staff (Stiegler et al, 2012).

This study findings support the findings of the other nursing research in the field of heuristic and biases (O'Neill, 1994; O'Neill, 1995; Cioffi and Markham, 1997; Ferrario; 2003; Brannon and Carson, 2003; Mullenback, 2007; Riva et al, 2011). O'Neill (1994) studied the heuristic and biases that affect clinical decision making of community nurses, particularly the use of representativeness. They found that novices and experts frequently used representativeness to make judgements. Similar findings in Cioffi and Markham (1997) who found that midwives used three classical heuristics during their decision-making process. Representativeness was the most frequently used heuristic in both scenarios; followed by anchoring and then availability. The frequent use of representativeness has also been reported among emergency nursing using simulated scenarios (Ferrario, 2003; Brannon and Carson, 2003). This bias was more frequently utilised by the experienced nurses in Ferrario (2003). Mullbenback (2007) used an explorative designed study but only explored whether the classical heuristics could be explored with high fidelity simulation. Mullbenback (2007) suggested that nurses referred to heuristics to save time for searching for cues and reach a timely decision. Availability, representativeness and take the best were the most frequent heuristics used.

Finally, Riva et al (2011) investigated the effect of anchoring as cognitive bias on clinicians' clinical judgement about pain. This was a large study in Italy that included nurses, physicians, nursing and medical students. Riva et al (2011) found that participants had a tendency to anchor their pain judgement on their first impression ($Z= -7.85$, $P= 0.001$). Walsh (2010) also found nursing students reached diagnosis prematurely but this error frequently occurred with the group that was assigned simulation with pattern-recognition . Walsh (2010) results corroborate with this study results and Levett-Jones et al (2011b) that described students calling medical staff prematurely before collecting all the relevant cues.

The current study found that the average frequency of bias was slightly higher with students who did not solve the main problem compared to those that managed to solve it. This finding is similar to the findings of Brannon and Carson (2003) and Riva et al (2011) but contradicts with Cioffi and Markham (1997) results. Brannon and Carson (2003) found participants selected less serious diagnoses in favour of ones that are available using representativeness. In contrast, Cioffi and Markham (1997) found that midwives were 100% accurate in their diagnosis. However, their results in terms of the prevalence of biases in more complex and uncertain situations were consistent with previous research, they did not relate the 100% accuracy to any research but discussed previous research findings of the adverse effect of biases on the judgement. The authors concluded that midwives need to be aware of the adverse effects of biases on their judgement and how that depends on the accuracy of their knowledge from experience. The effect of biases on causing misdiagnosis or leading to inaccurate judgement and is well established in medicine and cognitive psychology (Elstein, 1999; Croskerry; 2002).

The current study used a more in-depth analysis of the different types of biases against the types of clinical decision-making processes used by the students and found that the “order effect” and “premature closure” biases were frequently seen during cue acquisition and concurrent TA. “Availability” and “representativeness” biases were seen more during cue interpretation and retrospective TA. The increased frequency of biases had a negative association to the induction and evaluation sub-scores of HSRT.

In summary, the discussion above demonstrates a few issues in students’ clinical reasoning and decision-making skills that includes over-selecting cues and not always distinguishing relevant from irrelevant cues. Students predominantly used type 2 CDM and focused on cue acquisition during performance and cue clustering during retrospective TA and reflection. This suggests that both stages are important for developing decision making and reasoning skills and should be considered during the debriefing. Errors in cue interpretation and clustering result in lack of recognition of the main problem and delayed action and finally the effect of heuristics and bias on all stages of reasoning whether type 1 or 2 CDM both can be affected.

8.4. RQ3: Do students who use mainly the non-analytical type (type 1) of clinical decision making in HFS experience perform differently on measures of CR and CDM to those who mainly use the analytical type (type 2)?

Students in this study who equally applied the two types of CDM during the performance were associated with more positive effects on post-experiment HSRT score compared to applying one type of CDM more than the other. The results of this study demonstrate a small positive correlation between type 2 and HSRT and a small negative correlation between type 1 and overall HSRT score (section 6.6.4). Students who equally combined backward and forward reasoning in type 2 produce a significant difference in the overall HSRT. The backward reasoning was positively correlated to HSRT and was a predictor of the deduction and analysis sub-scores of HRST. Forward reasoning, automated behaviour and pattern recognition were negatively correlated with HSRT; however, pattern recognition was positively corrected to the evaluation sub-scores of HRST. This is consistent with DPT Croskerry and Nimmo (2011) the results of Ark, Brooks and Eva (2006) and Presseau et al (2014).

Thirteen students out of 23 correctly solved the main clinical problem and type 2 was the dominant type of CDM. However, students who used an equal combination between type 1 and type 2 or an equal combination of backward and forward reasoning when type 2 applied had increased accuracy in solving the main problem (section 6.4.2) which has a similar effect in improving in the HSRT. This suggests that supporting students to develop both types of clinical reasoning and decision making could have a better outcome of their decision compared to focusing on type one in isolation. Ark, Brooks and Eva (2006) compared the application of the two types of CDM among psychology students and found that there was no significant difference in students' performance when one type of CDM was applied alone and significant improvement in diagnostic accuracy when both types were applied together. In summary, there is limited nursing research that explores the accuracy of action against the type of decision making. The findings in this study support a predominance of type 2 CDM among nursing students but more significantly suggests a contribution of both types of CDM is the main model, rather than one type in particular. The findings of this study demonstrates a new contribution in this perspective.

8.5. RQ4: How do students perceive the usefulness of HFS experience on their clinical practice?

The findings of this study showed that students positively perceived and reacted to the simulation experienced. They described that the simulation experience enhanced their active learning and engagement in the learning process. Students also felt that they learned and developed their critical thinking and decision-making skills during performance and their reflection on this experience. In the follow-up interview, they described that while in clinical practice they felt that the simulation had increased their self-awareness about their CDM skills, improved the way how they apply theory to practice and a few described changes in their behaviour.

8.5.1. <u>Promoting active and reflective learning</u>

This theme in the current study corroborates with Botma (2014), Loke et al (2014) and Reilly and Spratt (2007) findings. Active participation and reflection on practice were perceived to be the most useful attributes of the simulation experience by students. Students in the current study reported how they found the session useful as a way for self-evaluation. Botma (2014) explored the perceived benefits of 3 high fidelity simulation (HFS) sessions among eight nursing students and found that students perceived HFS to enhance active learning and developing deliberate practice. Loke et al (2014) used a cross-sectional survey among 232 nursing students in Singapore and Reilly and Spratt (2007) who used medium fidelity simulation among nursing students. Both found that an HFS session promoted active learning and active participation.

The students in the current study reported that reflecting on their experience and evaluating their performance was very useful to improve their future performance. This resonates with self-efficacy theory (Bandura, 1997) and also adult learning theory which describes the adult learner as self-regulated (Knowles, Holton and Swanson, 2012). It also corroborates with findings of Driefurest (2010) and Walsh (2010) who reported that a structured debriefing and reflection after the simulation experience was a critical factor to enhance students learning, knowledge acquisition, improve their cognitive skills such as critical thinking and clinical reasoning. Based on this study and the discussed literature findings, HFS support experiential learning to actively seek problem identification and support students in reflecting on their performance and clinical decisions. Reflective learning is important as it allows the students to apply what has been learned in one clinical situation to another and reduce the gap between theory and practice (Tanner, 2006).

8.5.2. <u>Development of clinical decision-making skills</u>

In the current study, nursing students perceived that HFS improved cognitive skills such as their diagnostic skills, critical thinking and the use of a methodical approach to decision making. Students reported that it helped them to think laterally and recognised the importance of using a methodological approach to problem solving. It agrees with the quantitative findings of this results that demonstrated improvement in the clinical reasoning score and other quantitative studies (Driefurest, 2010; Fawaz and Hamdan-Mansour, 2016). Yuan, Williams and Man, (2014) and Pierce (2011) reported that nursing students perceived simulation to improve their clinical judgment and decision make skills. This is consistent with qualitative studies (Walsh, 2010; Kaddoura, 2016). Walsh (2010) collected qualitative feedback from students after simulation and reported that students perceived the HFS experience to improve their clinical reasoning and decision-making skills. Similar finding with Kaddoura (2016) used repeated HFS sessions among 107 first year nursing students using a qualitative survey and found that students perceived HSF to improve their critical thinking, competence and confidence.

The current study provided both qualitative and quantitative findings by using a mixed methods approach to provide more depth analysis of students' clinical reasoning and decision-making skills using HFS. The findings of this study support the positive effect of HFS on students' CR and CDM skills. However, a few quantitative studies that examined CDM did not demonstrate significant improvement after the simulation experience (Shepherd eta l, 2010; Cobbett and Snelgrove-Clarke, 2016; Woda et al, 2017). These inconsistent findings suggest that the methods of these studies are different, and more research is needed to explore and assess the impact of HFS on high order thinking. The self- reporting and students' perception of improvement in their cognitive skills are not always seen as a strong evidence for actual improvement.

8.5.3. <u>Recognition of the types of CDM</u>

The students in this study reported that HFS increased their awareness about the different types of clinical decision making, such as the conscious and unconscious decision. They described how they used quick decisions based on routine practice, thoughtful process, first thought or using familiar patterns. This support the findings from the think aloud data of this study that identified students used both types of CDM. It also reflects the results of other studies that found nursing staff reporting the use of a combination of different strategies and types of approaches for decision making (Offredy et al, 1998; Thompson et al, 2009; Bjork and Hamilton, 2011; Pirret 2013; Price, 2017). This theme was linked to or as a result of the previous themes about reflective learning and developing CDM skills.

The increased self-awareness and the recognition of the types of CDM indicate that students linked theory learned to simulation in their clinical practice, by recognising their strengths and weaknesses. This is consistent with Sedgwick, Grigg and Dersch (2014) who found simulation and reflective debriefing enhanced the quality of novice and experts' clinical decision-making skills and reported that nursing staff being reflective and using self-correction that improve self-awareness. Similar findings by (Walsh, 2010) for students who attended both the HFS and pattern recognition intervention reported that HFS enhanced their learning and self-awareness. Buykx et al (2011) used five steps simulation-based education and found that the model increased students' self-awareness about their knowledge, confidence and competency.

8.5.4. <u>Recognition of cognitive biases</u>

This current study found that HFS increased students' awareness of cognitive biases and how it affected their reasoning and decision making. People's tendency to deny their own bias, even while recognising bias in others, may indicate reduced self-awareness (Pronin, 2006). Students in this study reported being aware in their clinical practice post-simulation experience of resisting reaching conclusions too early and they reported observing others using biases to make a quick decision. This finding indicates students learning from the simulation session and applying what they learned into their practice. However, many nursing studies described the use of bias and heuristic by nursing staff during their decision-making process (O'Neill, 1994; Cioffi and Markham, 1997; Brannon and Carson, 2003; Ferrario; 2003; Mullenbach, 2007; Riva et al, 2011). They used methods that relied on either testing or think aloud data analysis with limited research on exploring nursing staff recognising their biases and attempting to change their behaviour.

The concept of students' ability to think about their thinking, self-evaluation and recognising their limitations is referred as metacognition (Flavell, 1979) that is linked to the mental decoupling feature of type 2 CDM (Croskerry and Nimmo, 2011). Metacognition could be developed through regular simulation sessions and effective debriefing and reflection on performance. In the current study, students' recognition of their weaknesses indicates self-evaluation of their performance and changes in their perceptions of their skills; essential steps for them to change their (Prochaska and DiClemente, 1970). Increasing people awareness about their biases is considered the first step to avoid future biases (Croskerry, Singhal and Mamede, 2012). The findings for the current study may stimulate future research in this field.

8.5.5. <u>Integrating theory into practice</u>

Failure to rescue could be influenced by students' inability to transfer what they learned in the classroom or skill laboratory to the clinical settings. Transferring the learning into practice is a complex process that is affected by multiple factors such as students' abilities and motivation, educational designs and the working environment (Ewertsson et al, 2015). It also requires students to internalise the newly developed knowledge with existing knowledge.

Understanding the benefits of simulation experience on transferring the learning to practice can guide nurse educators to improve the educational and simulation design to enhance students learning.

Students in the current study perceived the simulation session as useful experience to prepare for the real world of practice and promoted change in their behaviours about how to make decisions. This is consistent with few studies where students perceived the benefits of simulation in preparing them to practice (McCaughey and Traynor, 2010) and integrating their learning from simulation into practice (Traynor et al., 2010; Hope, Garside and Prescott, 2011; Botma, 2014; Kaddoura, 2016). McCaughey and Traynor (2010) found that 95.7% of respondents agreed that they could use the clinical skills learning in HFS in clinical practice. In Traynor's et al (2010) study, students reported improvement in their understanding of the relationship between theory and practice and clinical confidence. This reflects similar findings from (Hope, Garside and Prescott, 2011). In their study, students felt that HFS facilitated the application of theory to practice in a safe environment and improved their confidence. Improving competence, and theory-practice integration were also identified by Botma (2014) and Kaddoura et al (2016).

In summary, the qualitative results in nursing research provides a depth of analysis of the participants' experience and this is very useful for students to actively engage in the learning process and to develop their self-awareness. However, the self- reporting and students' perception of improvement in their skills is not always seen as a strong evidence for actual improvement and quantitative findings do not alone provide a depth of support for the experience. The application of mixed method in this study provides a more convincing argument for the benefits of HFS in students learning and development of CDM. The findings of the perceived benefits of the simulation experience discussed above in section 8.5 (see also chapter 7) appear to progress in three steps as illustrated below (Figure 8.1), illustrating the usefulness of the experience in the form of learning through and from the simulation, developing self-awareness and changing the ways of practice.

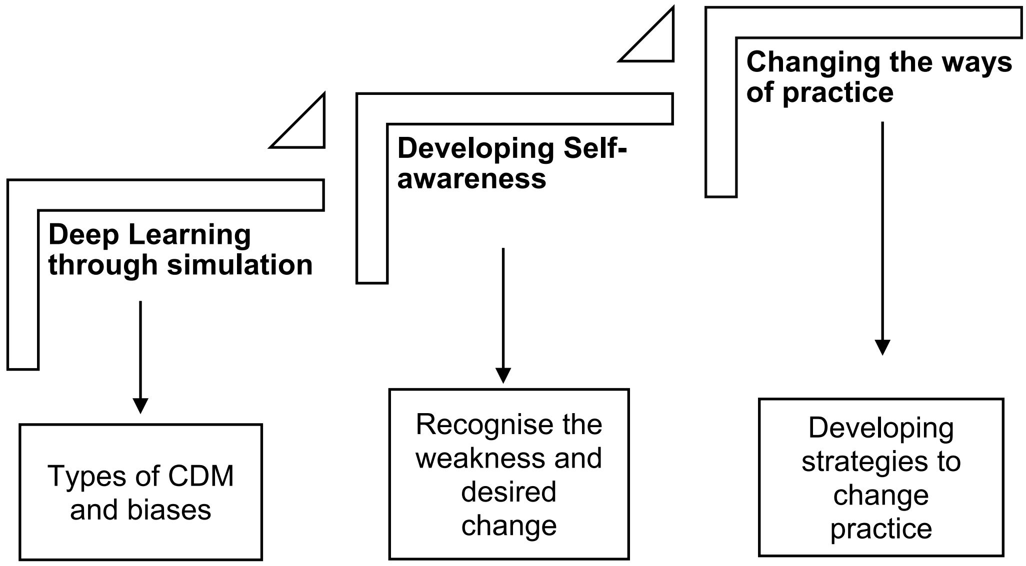

Figure 8.1 Perceived benefits of the HFS experience

A more detailed framework about the CDM and reasoning is provided in the next section 8.6.

8.6. Proposed framework and contribution to knowledge

8.6.1. A Conceptual framework for clinical decision making

I have constructed a conceptual framework to bring together the types of CDM observed in my study and based on the Dual Process Theory (DPT) and based on the nursing literature. It integrates the types of CDM identified by (Croskerry 2009a), cognitive processes for clinical reasoning (Elstein et al, 1978), cognitive biases and factors that affected the students' reasoning and decision making. The focus of the framework is on how to improve nursing students' clinical reasoning and decision-making skills by using three main stages during clinical simulation and the use of reflection and debrief after the simulation to increase awareness about the effects of biases. The framework has also been related to other models of clinical judgement and reasoning in nursing literature (O'Neill, Dluhy and Chin, 2005; Tanner, 2006; Levett-Jones, et al, 2009) throughout the explanation of this framework.

Based on the DPT, the proposed framework (Figures 8.2, 8.3) starts from the left and moves to the right but then it moves up and down between the types of CDM. The reasoning process moves in a cyclic way and dynamic manner. The framework also considers the importance of the contextual factors, the complexity of the task and the nurses' attributes that could affect their approach to decision making (Croskerry, 2009a; Smith, 2009). The proposed framework considers the clinical reasoning and decision-making processes as non-linear and dynamic processes. Croskerry (2009a) described the override between type 1 and type 2 and the current study also found students frequently moving from one type to another to solve the problem and make decisions they also had a dynamic movement between the forward and backward reasoning within type 2 as observed in this study. Tanner (2006) carried an extensive literature review and confirmed that clinical judgements are more influenced by the individual and what they bring to the situation more than any other factors; she recognised few approaches for situational interpretation and the importance of reflection.

The proposed framework in this study has three main stages:

8.6.1a Stage one

In this stage, the selection of the type of CDM based on the complexity of the task, the contextual factors and individual attributes. These factors have been identified in both medical and nursing literature to affect people's clinical reasoning, judgement and decision making (Tanner, 2006; Klein, 2008; Croskerry, 2009a; Smith, 2009). Increasing students' awareness about the impact of these factors on their performance through reflection could help students to become more mindful in their practice and support them in developing strategies to maintain patient's safety such as to promptly seeking help if the situation becomes more complex or fast-paced.

8.6.1b Stage two

In this stage it considers the application of the relevant reasoning and decision-making cycles (Figure 8.2 and 8.3), this is the performance stage that educators can use to support students in enhancing their clinical reasoning and decision-making skills. This could be achieved by applying different teaching and learning strategies to stimulate the development of cognitive skills such as cue acquisition, selecting the right cues, interpretation and pattern matching. In a clinical simulation, this is the part when students work with different types of manikin and clinical scenarios to collect cues and learn how to solve clinical problems.

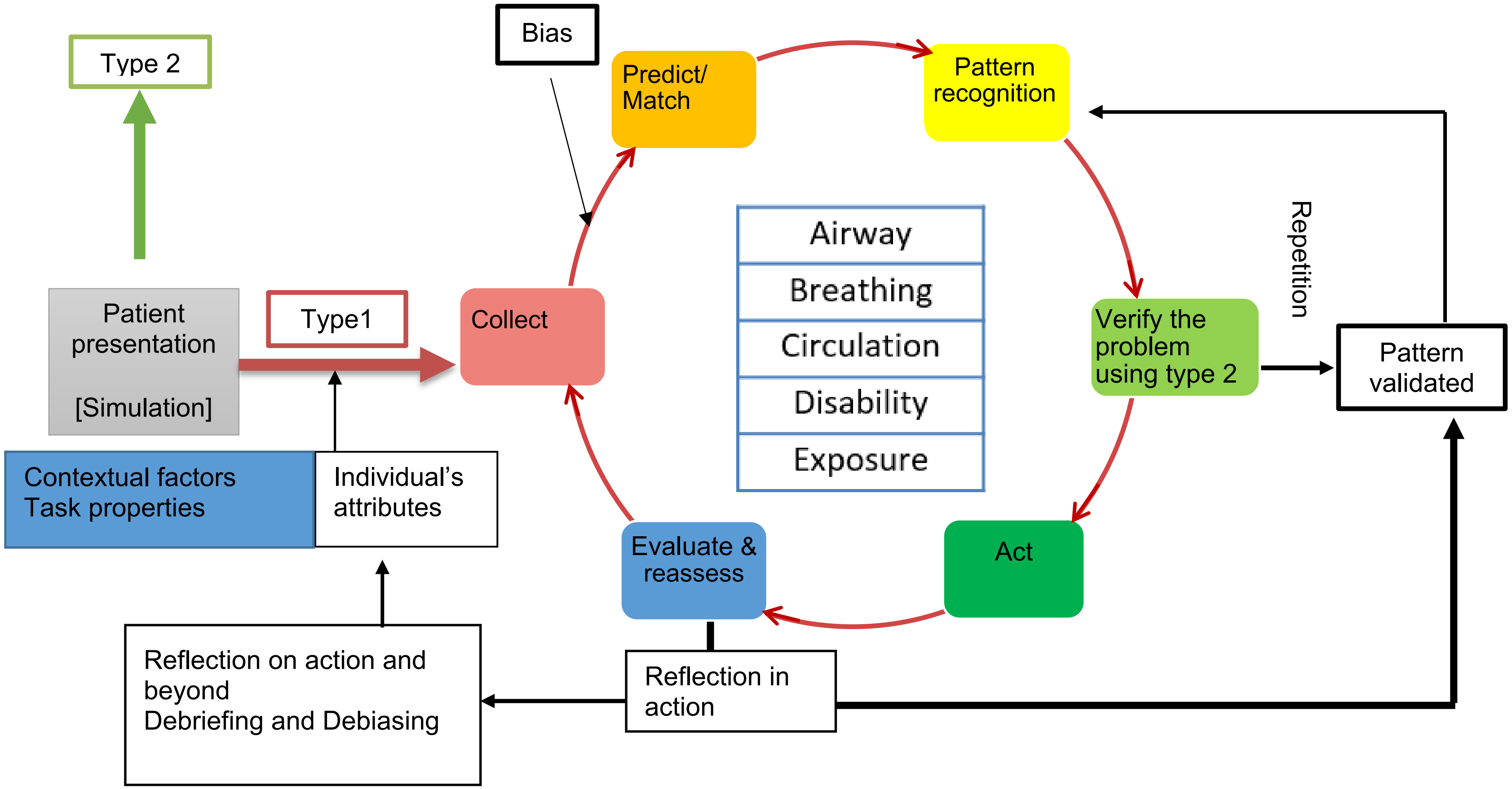

Figure 8.2: Conceptual framework for clinical decision making with type 1 clinical reasoning cycle

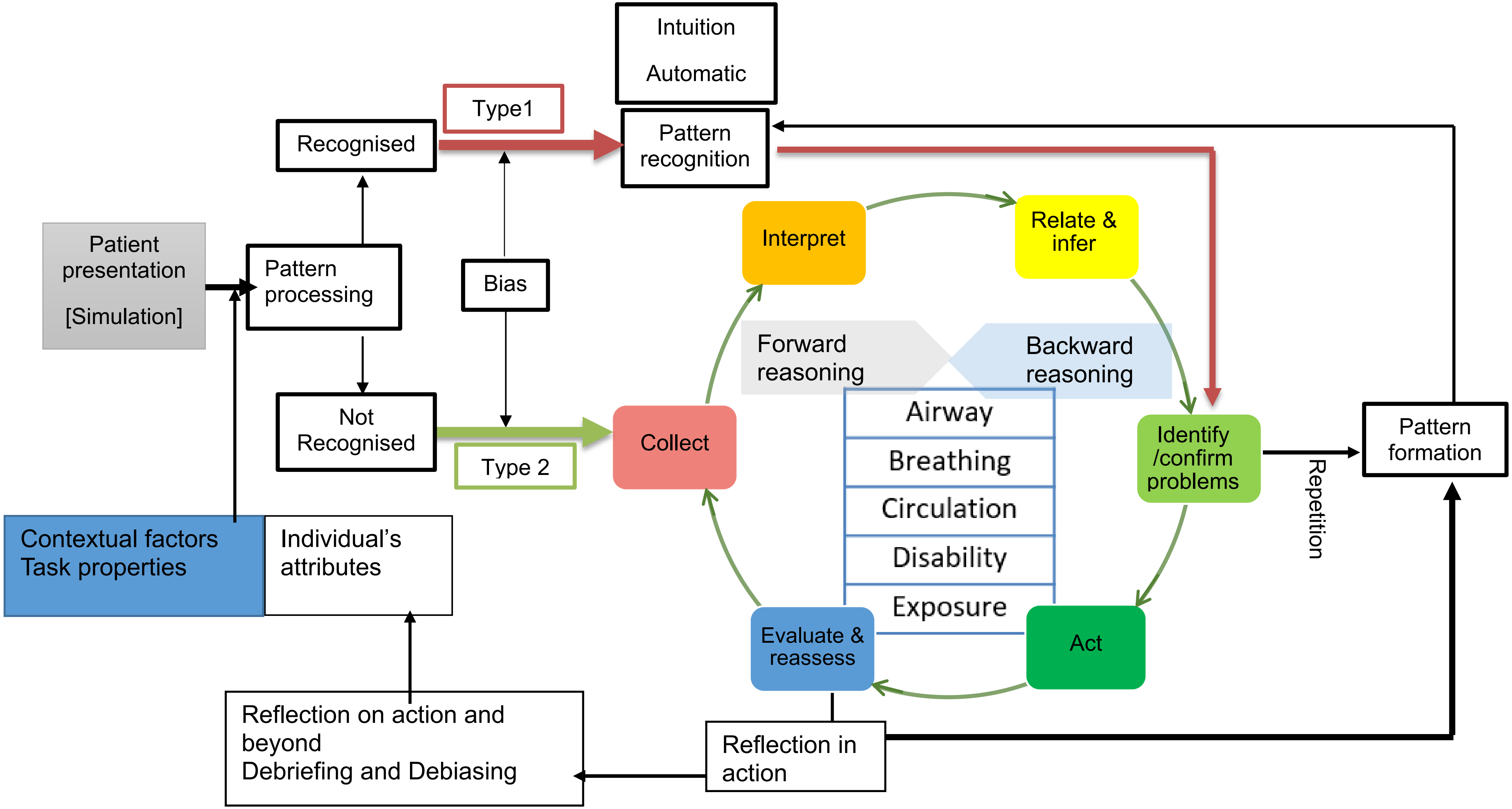

Figure 8.3: Conceptual Framework for clinical reasoning and decision making based on a deteriorated patient scenario with type 2 clinical reasoning cycle

Stage 2 of the framework contains two reasoning cycles, one for type one CDM and the second one for type two. Based on the DPT people can move from one type of CDM to the other if not satisfied with the outcomes or the situation becomes complicated to be processed through type 2. The reasoning stage of the framework is a process in a form of a cycle that tend to move in a step-wise approach using the following steps

1. *Collect*

   This is the first step of CR for type 1 and 2 CDM. It refers to nursing students reviewing data, describing situations, gathering data, searching for patterns or key cues. So, the first step asks students to collect data and cues about the patient, by reviewing the patient's history, documents and collecting subjective and objective data. Nursing students tend to over-select clinical cues, so this step should also focus on teaching students to recognise the importance of the types of cues they collect and how the selected cues could impact on the final decision. This step matches the 'cue acquisition', the first stage of the hypothetico-deductive approach (Elstein, Schulman and Sprafka, 1978), the 'noticing' and the 'initial grasp' of the situation step of (Tanner, 2006) model and first and second steps of Levett-Jones et al (2009) model.

   The collect step is shared by both types of CDM but in type 1, it refers more to searching for familiar clinical patterns or key critical cue to start the reasoning process. Tanner's (2006) model recognised the different approaches to CDM such as analytical and intuitive approaches; the 'initial grasp' step in her model suggests the focus on pattern matching and pattern recognition, which is more related to type 1 of CDM than type 2 as described by Klein (2008), an intuitive pattern-recognition based decision-making model that use initial typical presentation of the situation to stimulate pattern recognition decision making.

2. *Interpret*

   This is the second step in type 2 CR cycle that considers the importance of accurate interpretation that affected students' overall problem identification and performance. This step matches 'cue interpretation' in (Elstein, Schulman and Sprafka, 1978) approach, 'reasoning the patterns using interpretation' in the (Tanner, 2006) model and the 'information processing steps' that include 6 cognitive operators in (Levett-Jones et al, 2009) model. Students need to learn how to make sense of the clinical signs and symptoms, recognise the clinical value of cues, create the clinical links cues between the identified cues, and distinguish the relevant from the irrelevant cue or patterns without overloading the working memory.

3. *Relate and infer*

This is the third step in type 2 CR cycle. This step matches cue ‘hypothesis generation’ in (Elstein, Schulman and Sprafka, 1978) approach, ‘reasoning the patterns using interpretation’ in (Tanner, 2006) model and the ‘information processing steps’ that include 6 cognitive operators in (Levett-Jones et al, 2009) model. Step two and three appeared immaturely developed among nursing students and novice nursing staff. One explanation is as students collected many cues, this overloads the working memory to articulate the relevant cues or accurately cluster cues together and subsequently affects problem recognition based Cognitive Loading Theory (Sweller, 1988).

Pattern matching

This is the second step in type 1 CR and it is equivalent to both steps two and three above in type 2 CR. ‘Predict and match’ is a different approach that is usually applied for problem recognition using pattern matching, a process that is usually much faster than the application of interpretation, relating and inference processes. Pattern matching step is dependent on the person’s previous experience of similar or familiar situations and a feature of expert practitioners. Novice nurses also applied this process but it also depends on the type of tasks and environment (Offredy, 1998; Botti and Reeve, 2003). As discussed above this step matches the ‘interpreting’ or pattern reasoning step in Tanner’s (2006) model and part of the information processing step in Levett-Jone et al (2009), it reflects the second stage in the (Klein, 2008) model that uses matching the current situation with typical presentation, ‘is the situation familiar or typical?’

Step two and three in type 2 CR and the step of pattern matching in type 1 could improve by first ensuring that students develop the required clinical knowledge as a pre-requisite to developing these skills. Second, to actively and regularly participate in solving case scenarios in simulated or clinical settings, so they develop the ability to acquire and interpret cues effectively. Finally, the use of self-evaluation, reflection and immediate debrief post-simulation could be used to enhance students’ interpretive and inference skills (Dreifuerst, 2010; Walsh, 2010). This could enhance and refined the formed clinical patterns, which could subsequently be utilised by type

CDM 1 to enhance problem recognition using pattern matching. Accurately interpreting, relating and inferring cues are key cognitive processes for recognition of acutely-ill patients.

4. *Identify and confirm problems*

This is the fourth step in type 2 CR and it matches the 'hypothesis generation and verification' in (Elstein, Schulman and Sprafka, 1978) model. There is no equivalence to this step in Tanner (2006) model but the author implicitly considered it under the 'interpretation' step of their model. Levett-Jones et al (2009) have a similar step called "identify the problem" based on the operator "synthesis" to reach a definitive conclusion. Problem identification is dependent on the previous steps and any error in the previous steps could reduce the likelihood of problem recognition and delayed actions. The identification of the problem step should also consider the severity of the clinical problem and priorities of the care needs based on a valid clinical framework of clinical practice such as an early warning score and the ABCDE as recommended by national and international consensus as an effective approach to assess the acutely deteriorating patient (NICE, 2007; NICE 2016; UK Resuscitation Council, 2015).

Pattern recognition

This is the third step in type 1 reasoning cycle, which is the same step of 'identify and confirm problems' in type 2 but occurs earlier. The difference is that the 'pattern recognition' step could be reached much faster due to the faster processing of pattern matching by the working memory compared to type 2 processing. There is no clear step for pattern recognition in both (Tanner, 2006; Levett-Jones et al, 2009) models, but it is clearly described in Klein (2008) and DPT of decision-making models as a step for non-analytical or intuitive based CDM. An additional step has been added after pattern recognition to optimise the reasoning and decision making produced by type 1 by 'verifying the identified pattern' to reduce the effects of cognitive biases by applying type 2 processes from step one, two and three.

At the end of the steps above nurses will reach conclusions and make decisions to act upon. Although there is no clear step in any of the compared models about verifying recognised patterns, Klein (2008) discussed that if an anomaly or violation of the expected pattern occurs, the practitioner should seek diagnosis clarification and return to story building.

5. *Act*

   This step is shared between type 1 and type 2 reasoning cycles. It refers to the point when a nurse decides to take actions to resolve the recognise problem or meet clinical targets, going back in the process to collect more information about the potential problems, seeking help or escalating the care. Actions in this process are behaviours following on from clinical decisions (Thompson and Dowding, 2009). These actions should be relevant to the identified problem and the priorities of care based on a valid clinical framework of practice such as the track and trigger system and ABCDE as recommended by National and International consensus as an effective approach to responding to the acutely deteriorating patients. This stage partly matches the 'hypothesis evaluation' part of (Elstein, Schulman and Sprafka, 1978) approach, 'implement a course of action' in Klein (2008) model and 'reflecting on the action' stage in (Tanner, 2006) model and 'establishing goal and take-action' in (Levett-Jone et al, 2009) model.

   Levett-Jones, et al (2009) discussed taking "the right action" as one of the five rights (R's) to clinical reasoning. A number of nursing studied found that clinical decisions could be categorised to a few categories which include; deciding the need for further assessment, or delivering management interventions, diagnosing and classifying signs and symptoms for management, planning for reassess or further assessment, evaluating the effectiveness of interventions or re-relating cues together and finally seeking help (Thompson et al, 2004; Aitken et al, 2011). These categories are considered relevant for the "act" step and "evaluate" step in this cycle

6. *Evaluate*

   This is the final step for both type 1 and 2 CR. It focuses on evaluating and reassessing the effectiveness of the taken actions. This is an important step as it does not only give nurses feedback about the effectiveness of their actions but also the accuracy of the reached conclusions or formed patterns, the need for further data gathering or eliminating contributing factors to reach a more definitive diagnosis. This step reflects the 'hypothesis evaluation' in (Elstein, Schulman and Sprafka, 1978) approach; the 'outcome' step in (Tanner, 2006) though that was not explicitly discussed in her model and finally it matches 'evaluate outcome' step in (Levett-Jones et al, 2009) model. However, Levett-Jones et al (2009) appeared to focus on evaluating the effectiveness of actions on clinical outcomes with little emphasis on the other parts of the reasoning process.

Overall, in Tanner (2006) model the ‘interpretation’ step followed by ‘responding’ with little emphasis on effectively collecting cues, accurately relating and inferring cues before taking actions. Levett-Jones et al (2009) mainly focused on the analytical approach of reasoning and produced a detailed cycle for reasoning. They added pattern recognition operators as part of the information processing and had limited focus on how the reasoning cycle would improve type 1 CDM and the impact of heuristic and biases on both types of CDM. Mapping a detailed reasoning cycle with associated cognitive operators may affect the practicality of using such a cycle in teaching nursing students. The proposed framework in this study can help students to use a dynamic approach for clinical reasoning that may have the potential to enhance pattern formation. Subsequently, this with repetition and practice could improve the capacity of working memory, enhance the accuracy of the formed patterns and facilitated its integration within the long-term memory (LTM).

Table 8.1 Steps of reasoning cycle for type 1 and 2

Step	Type 1 reasoning cycle	Type 2 reasoning cycle
1	Collect and search for pattern	Collect
2	Predict and match	Interpret
3	Pattern recognition	Relate and Infer
4	Verify problem (identified pattern)	Identify the problem
5	Act	Act
6	Evaluate	Evaluate

8.6.1c Stage three

This stage considers the reflection and debriefing that also includes debiasing. Reflection and debriefing are critical parts of the students’ development that enhance the application of theory to practice, increase the effectiveness of the learning process and stimulate behavioural change. This stage focuses on students analysing their performance and tutors providing structured constructive feedback.

Reflection and debriefing

The effect of reflection in this stage was evident based on the retrospective think aloud data and the follow-up interviews of this study; as students were relating cues and using pattern matching to solve or confirm the problem, evaluate the actions and their performance. This stage includes three aspects of reflection; reflection (in action, on action and beyond action), debriefing and debiasing. This stage also matches the ‘reflecting’ stage in (Tanner, 2006) model and ‘reflect on the process’ and new learning” in the Levett-Jones et al, (2009) but both focused on reflection on action.

Reflection is an important learning strategy for adult learners in both clinical and simulation settings and can significantly affect nurses’ clinical reasoning skills and performance. This aspect is important to refine, improve and consolidate the learning from the simulation experience. It will give students an opportunity to self-evaluate, to deconstruct their experience and reconstruct a new learning with the support of facilitators. It can support knowledge acquisition, increase students’ awareness and stimulate behavioural change. This stage may have a long-lasting effect on students as described in the follow-up interviews. The facilitator could enhance the effectiveness of the debriefing, provide feedback and maintain the focus on the learned skills.

Debiasing

The CR steps above were affected by cognitive biases and the effects are more apparent during the data collection and interpretation steps in type 2 and pattern recognition for type 1 based on the results of this study. The effects of biases on reasoning and decision making are not considered explicitly in any of the previous models (Tanner, 2006; O’Neill, Dluhy and Chin, 2005; Levett-Jone et al 2009). In Croskerry’s DPT, biases were considered part of the factors related to the individual’s attributes. However, they discussed different cognitive bias effects on the quality of clinical decision in a different publication (Croskerry, 2002). For Tanner (2006) and Levett-Jone et al (2009), this is not clearly considered. Increasing nursing students’ knowledge and awareness about the cognitive biases through the reflection stages could have the potential to enhance the effectiveness of the reasoning and decision-making process.

Debiasing increased students’ awareness about the different type of biases and strategies that could be used to reduce these biases and stimulate a change in the way that students practise. To help students with the debiasing, a list of common biases was shared in the study which could be used before and after the simulation to educate students about the different biases (Croskerry, 2002; Croskerry, 2003; Graber et al, 2014) (Appendix 6 and 7). A cognitive bias observational sheet was designed based on this study’s results and literature (Croskerry, 2003; Fletcher et al, 2004; Stieglier et al, 2012; Blumenthal-Barby and Krieger et al, 2014). Table (8.2) provides a brief design of the biases observational sheet and Appendix (29) provides a more detailed sheet with description. This sheet could be used by students to self-evaluate their usage of biases and for staff to give feedback during the debriefing. A list of strategies was developed to increase students' awareness of cognitive biases and to support them to reduce the effect of these biases (Croskerry, 2003b). The use of the observational tool and recommended strategies could be used during the debriefing session to increase students' awareness and support students reflect. Its effects need validation in future research.

Table 8.2 Cognitive biases observation sheet for CDM process

Instructions: Complete this self-assessment before debriefing. Reflect on your performance and score yourself on a scale of 5, with 1 is poor and 5 is excellent performance. Under each behaviour a list of cognitive errors. Please circle Yes or No whether any of the following error occurred in your performance during simulation experience.

Circle	Behaviour	Poor Excellent
	1. Correctly following evidence based protocols/pathway in a timely manner (such as early warning score or ABCDE)	1 2 3 4 5 Comments:
Yes No	Lack of knowledge	
Yes No	Omission bias	
Yes No	Commission bias	
	2. Demonstrate good data gathering skills and accurately identifying and weighting right cues	1 2 3 4 5 Comments:
Yes No	Order effects	
Yes No	Premature closure	
Yes No	Framing	
	3. Accurately interpreting and relating relevant cues, matching pattern and demonstrating good diagnostic skills.	1 2 3 4 5 Comments:
Yes No	Representativeness bias	
Yes No	Confirmation bias	
Yes No	Availability bias	
	4. Demonstrate awareness about contextual factors and maintain situational awareness.	1 2 3 4 5 Comments:
Yes No	Context error	
Yes No	Anchoring bias	
	5. *Accurately prioritizing the most critical care needs first.*	1 2 3 4 5 Comments:
	6. Response and initiate appropriate treatment/ intervention or action in a timely manner (such as clinical interventions or escalating care)	1 2 3 4 5 Comments:
Yes No	Overconfidence bias	
Yes No	Omission bias	
	7. Demonstrate good evaluation and decision-making skills if therapies failed	1 2 3 4 5 Comments:
Yes No	Hindsight	
Yes No	Sunk cost	

8.7. Methodological contribution

This study was innovative in the way it investigated the process of decision making and the outcome of this process when high fidelity simulation was applied. It used mixed methods to explore the decision-making process during the simulation and after the simulation to produce a depth of analysis of this process. Many of the nursing studies either explored the process of clinical decision making or the outcome with limited research that examined both at the same time. Previous studies that used think aloud to examine nurses' clinical reasoning and decision making either used concurrent or retrospective think aloud (Jones, 1989; Lamond, Crow and Chase, 1996; Fowler, 1997; Higuchi and Donald, 2002; Han et al 2007). Other studies that included both techniques together, did not use the retrospective think aloud immediately after the performance (Aitken, 2003; Greenwood et al, 2000; Hoffman, 2007; Johnsen, Slettebo and Fossum, 2016) instead it was used much later which could have affected the accuracy of recalling the events by the participants (Ericsson and Simon, 1993). These studies reported the findings of both types of TA combined and did not always differentiate between the concurrent and retrospective TA findings. The current study is adding clarity to the CDM process by separately presenting the findings of each method as well as the combined results of both methods together. It also adding more depth of understanding of this process by showing the differences in CDM process identified by each method.

The concurrent think aloud was applied to explore this process during the simulation which only reflect the content of the working memory and illustrate the strength and weakness of the information processing used during task performance. As discussed previously, students used a combination of forward and backward reasoning but mainly used forward reasoning and focused on cue acquisition during the performance. In contrast, the retrospective think aloud was used to examine the CDM immediately after performance where students mainly used backward reasoning. Retrospective TA reflected the effect of accessing the long-term memory to make sense of how the cues were utilised, valued and related together to reach decisions. The used of both method of TA shed the light on the how students processed the information and illustrated the differences in the cognitive operators and the reasoning approaches used after the simulation compared to those used during the performance. This also highlighted the importance of both, the learning through simulation and debriefing after the simulation, as both stages stimulate the development of different types of reasoning.

The findings from the observation concurred with the concurrent TA and increased the validity of the findings but also showed that non-verbalised behaviours could be captured more through observations which added more depth to analysis of CDM during performance. Aitken et al (2011) recommended the use of observation and think aloud methods together to optimise the completeness of data gathering about CDM. This study compared the data collected about the process of CDM using three methods, concurrent TA, retrospective TA and observation to provide an in-depth examination of CDM process and enhance the validity of the findings. It provided a detailed application of the verbal protocol analysis (VPA) as an effective way to analyse the TA data and trace the process of CDM. VPA as a method of data analysis has limited application in nursing research and this study demonstrated the usefulness of this technique.

Investigating clinical decision-making using manikin-based high-fidelity simulation has limited research compared to the research that applied paper-based simulated scenarios. The current study also examined the impact of this type of simulation on the clinical reasoning score, problem solving and the perceived benefits of simulation to practice. Transforming the findings from the TA and observation to frequencies and correlating that with the findings from HSRT sub-scores was a useful methodological approach to explore and predict the relationship between the applied CDM processes and HSRT sub-score. The findings of the follow up interview was also an important approach to assess the perceived educational and clinical value of the simulated experience to students due to the limited research that examined the transferability of learning from this educational intervention to clinical practice. It also provided more depth of understanding about impact of simulation experience on students learning CDM. The depth of analysis provided in the application of mixed methods in this study allowed the development of the details steps presented Figure 8.2 and 8.3. to learning and teach CDM.

8.8 Summary

- The study discussed the usefulness of mixed method designs to investigate the complexity of clinical decision making process. It also identified the types of CDM used by nursing students, their strengths and weaknesses. The study proposes a decision-making framework that aims to improve students' clinical reasoning and decision-making skills needed to prepare them for the real-world of practice.

- The proposed framework is based on the following key points:

- It is based on a theory of decision making that acknowledges the use of both the analytical and non-analytical approaches to decision making.
- It focuses on how to develop the decision maker skills but also considers the importance of the contextual factors and task complexity.
- It recognises the effects of heuristic and cognitive biases on the quality of decision making.
- It recommends the use of simulated case scenarios as a problem-based learning, a teaching strategy that promotes active participation and the development of high order thinking.
- It emphasises the importance of learning through reflection and effective debrief.

CHAPTER 9
CONCLUSION

9.1 Introduction

This chapter revisits the questions and design. It is written in a reflective style and I discuss the strength and limitation of this study, the implications for nursing education, recommendations for further research, how this study contributes to knowledge and finally I discuss the learning from this study and reflexive thoughts about my thesis.

9.2 Why this study was undertaken?

Many reports found that clinical deterioration in patients' condition has been unrecognised by healthcare professionals and inadequately managed in a timely manner (McQuillan et al 1998; DH, 2000; NCEPOD, 2005; NPSA, 2007; Rattray et al 2011). NPSA (2007) reported that a major factor for 'failure to rescue' patients with acute clinical deterioration was a failure to recognise relevant clinical information and hence failure to make and implement appropriate clinical decisions. NCEPOD (2012) reported that deficiencies in the decision making and recognition of the severity of patient illness by junior doctors and nurses led to failure to rescue before cardiac arrest.

Seventy percent of graduate nurses in a USA study scored "unsafe" levels of clinical reasoning which suggest poor decision-making abilities (Del Beuno, 2005) and similar results were published about graduate nurses' clinical reasoning level in Australia (New South Wales Health, 2006). Many studies in nursing found that novice nurses are less able to reason accurately, process information effectively to form decisions and reach appropriate judgements compared to experienced nurses (Benner, 1984; Del Bueno, 2005, Hoffman, Aitken and Duffield, 2009). Nurses' decisions and contributions to clinical decision making can affect patients' outcome related to both quality and safety (National Patient Safety Agency (NPSA), 2007; Rattray et al 2011; NCEPOD, 2012; Aiken et al, 2016). The healthcare team depends on the nurse's ability to recognise critical cues, interpret the importance of those cues, and reach accurate conclusions about patients' needs (Etheridge, 2007). Effective decision making is an integral part of safe nursing practice and clinical competency (Nursing and Midwifery Council, 2014).

This study began with assessing the effectiveness of high fidelity simulation on students' clinical reasoning skills but developed to also explore the process of clinical reasoning (CR) and decision making (CDM) using high fidelity simulation (HFS). As an educator and former clinician in critical care nursing, I found that scenarios-based education and HFS a useful approach to support students developing their CR and CDM skills. However I found multiple models for CR and CDM and complex factors that have effects on the clinical decision-making process with a tendency in the literature to explore how experts reason (Tanner, 2006; Hoffman, 2007; Rew and Barrow, 2007; Cappelletti, Engle and Prentice, 2014). The complexity of the theoretical perspectives of CDM makes it difficult to articulate which approach would best support students' development and how to help students in developing their CDM using HFS. The results identified in the literature informed the study design but showed there is a limited knowledge about the type of reasoning and cognitive biases used by nursing students and how HFS affects nursing students learning about their decision making and biases. Therefore, a better understanding of such processes is essential for the education of nurses before registration and working with real patients. This will support patient's safety and enhance the quality of patient care. There is inconclusive evidence of the impact of HFS on clinical reasoning and limited evidence about the use of HFS to explore clinical decision making among nursing students (section 3.3.3).

9.3. Study design and research questions

This thesis followed a pragmatic approach and a multiphase mixed method design, to gain a greater understanding of nursing students' CR and CDM skills and to examine the impact of HFS on clinical reasoning score (Creswell and Plano Clark, 2011). The objective was to develop a theory-based simulation design, tools and model to support students in developing their clinical reasoning and decision-making skills using HFS. To achieve this objective, the current study examined the following questions:

1. Is there a difference in CR and CDM measures for students after having HFS experience?
2. What are the CR and CDM types used and cognitive errors made by the third- year nursing students in managing acutely deteriorating patients using HFS experience?
3. Do students who use mainly the non-analytical type (type 1) of clinical decision making in HFS experience perform differently on measures of CR and CDM to those who mainly use the analytical type (type 2)?
4. How do students perceive the usefulness of HFS experience on their clinical practice?

The study included 23 pre-registration nursing students in their third year who worked with a deteriorating patient scenario using high fidelity simulation. The Dual Process Theory (DPT) and multiple methods were chosen for this study after an examination of a range of approaches for studying decision-making. The methods used to answer the research questions included think aloud (TA) and observation to explore the type of CDM and clinical reasoning and the associated cognitive biases, a measure to assess students' clinical reasoning score and a follow up semi-structured interview to gain understanding from students about the benefits of HFS experience on their clinical practice. Other methods explored such as those from phenomenology and grounded theory give good descriptions of decision-making but do not necessary outline how it proceeds and gives less guidance to educators to improve decision-making. Decision making analysis prescribes ideal decision making, not CDM as it occurs. Natural decision making (NDM), on the other hand, is useful for identifying contextual variables on CDM but does not trace the actual decision-making process.

The utilised methods in this study were appropriate and generated rich of data about the clinical decision making process and benefits of simulation that answered the study research questions. The study identified students applying forward and backward reasoning in a dynamic way to decision making. It also indicated that the used of backward reasoning or equally applying both types of CDM together was associated with more positive improvement in HSRT. The interview also provided confirmatory comments from students about the finding from TA. This study also provided an insight into the type of cognitive biases used by nursing students. Collectively, the study has demonstrated the usefulness of the experience of students utilising simulation in developing their reflective learning, self-awareness and application of theory to practice.

9.4. Strengths and limitations

9.4.1 <u>Strengths</u>

When used alone, qualitative and quantitative methods inherently had strengths and limitations. This is the first study to use a multiphase mixed method design to investigate nursing students' clinical reasoning and decision making using high fidelity simulation. The collected data from the concurrent and retrospective think aloud, observation and HSRT was comprehensively analysed using qualitative and quantitative techniques to provide a depth of synthesis about this process. These approaches were used to compensate for their respective limitations and integrate their strengths to allow the examination of the different types of clinical decision making based on the dual process theory.

This is in contrast with studies that relied on one method only and the potential biases associated with a single method such as self-report (Pirret, 2013), observations or use of quasi-experimental design without randomisation (Pierce, 2011). The study has a relatively medium sample size as a qualitative study that applied think aloud compared to other studies that used the same method (Hoffman, 2007). Comparing and corroborating the finding of TA and observation produced a detailed description of students' clinical decision, which increased the validity and credibility of the study results. The ability to review students' performance from the recorded video add strength to the study data analysis as I repeatedly viewed the videos to ensure I did not miss anything. The use of video review and retrospective think aloud to ask students about their decisions was done immediately after the performance and enhanced students' recall of events. The use of individual semi-structured interviews added strength to the study as it considered how students perceived the benefits of simulation experience in their real world of practice and provided me with students' reflection on their learning.

The use of verbal protocol analysis and transforming the TA data to frequencies was useful technique to correlate and compare the findings from TA methods and HSRT. This study highlighted the importance of cognitive biases and demonstrated how to identify these biases from TA and observational data. It proposes conceptual frameworks and a new observational tool that could be used to educate student nurses how to enhance their clinical reasoning and decision making through clinical simulation. It also demonstrates the potential role of clinical simulation in teaching and exploring clinical reasoning and decision making.

9.4.2 Limitations

Being reflective, it is important to acknowledge the limitations of the research presented in this thesis. The study participants were a small convenience sample from a single institution which limits generalisability and the study used one post-operative clinical scenario in a simulated environment. Therefore, the findings can only make a theoretical generalisation (Yin, 2009). For quantitative data analysis, the study was limited by the small sample size. While there was sufficient power to detect significant mean differences on HSRT overall score, plus the deduction and analysis sub-scores, the sample size was insufficient to provide sufficient power to detect a significant improvement in HSRT evaluation, induction and inference sub-scores.

A second limitation was selection bias due to voluntary participation, self-selection and lack of randomisation. Quantitative results are also limited due to lack of a control group that could be used for comparative purposes which affects the inference that the post-test differences in HSRT were as a result of the intervention. Finally, while HRST is scenario based and intended for assessing clinical reasoning of healthcare professionals, it does not necessarily measure a change in nursing students' clinical reasoning in their natural settings, as many environmental and contextual factors influence clinical reasoning and decision making (Croskerry, 2009a; Smith, 2009; Smith, 2013).

The other limitation that could be considered arose from exclusion of students who are under direct supervision of the researcher from the study who may have a different experience to those included in this study. This was necessary to ensure adherence to ethical principles and approval and to eliminate power imbalance between students and educator during the recruitment stage of this study. In actuality, there was no exclusion since no students who came forward to participate were considered under the direct supervision of the researcher from the used cohorts in this study. The lack of overlap between the role of researcher and educator could also be seen as a strength to this study as it removes the potential for a number of related biases: social desirability, selection bias and bias in reporting. Since a large aspect of this study is interpretive research, it is important to consider the researcher's bias during the research process. The researcher collected, code and analyse the data which increases the subjectivity but at the same time this improve the consistency of the data collection and analysis. The use of multi-methods that considered participants perspectives in the retrospective TA and interviews, comparing the findings of different methods, memos and a reflective diary helped researcher bias and confirming the results throughout the research process.

9.5. Implications for nursing education

NMC (2014) requires nursing students to develop competency in clinical decision making, be able to recognise and respond appropriately to the needs of acutely ill patients as part of the pre-registration curricula. There are similar requirements for post-registration nursing students (DH, 2009; National Outreach Forum and Critical Care Network, 2018). The results of this study suggest that the use of HFS and an appropriate debriefing strategy can effectively support students in developing their CR and CDM skills and transfer their learning to a similar clinical context. The current study and the developed framework in section 8.6.1 address the requirements above and aimed to improve students' clinical competency in making decisions and enhances their self-awareness. The simulation model (section 4.4.2) is based on problem solving and experiential learning strategies that encourage students to be actively engaged in the learning process.

The results of the current study provide nurse educators and curricula development teams with a framework (section 8.6) that could be used to support students to gradually develop their clinical reasoning and CDM skills throughout the nursing course. The proposed framework and observational tools have potentials to improve students' CR skills, forming more accurate clinical patterns and support the development of self-awareness. It could provide students with a structure to guide their reflection and self-evaluation and provide tutors with a structure to guide their feedback. The developed framework and proposed stages provide a theory-based simulation design that can be more effective in supporting the development of CR and CDM skill if the simulation activities were carefully designed.

Educators who use simulation should be aware of cognitive biases and it could be used by students due to the potential of it being inadvertently taught during the simulation. To produce effective CDM skills attainment during simulation, it is important to consider the different stages of simulation from scenarios' design, contextual factors within scenarios, environment, and orientation to the environment, performance and most importantly effective debriefing. Therefore, it is recommended that educators receive training on to how to design, use simulation effectively to support students' learning and provide effective debriefing sessions. Perhaps the development of a simulation strategy focused on CR and CDM that consider how simulation is mapped against the curricula outcomes and national competency would add clarity, stimulate more training and a more effective approach to integrate simulation in nursing education. This is endorsed by the Department of Health strategy in their Framework for Technology Enhanced Learning (DH, 2011); which recommends the training is patient centred to improve patients' safety, delivers a high-quality educational outcome, is evidence-based and is educationally coherent. The study findings are built on these recommendations and support a CDM theory-based simulation to improve nursing students' skills and patient safety.

9.6. Direction for future research and dissemination

The goal of this study was to investigate clinical reasoning and decision making using high fidelity simulation to support nursing education and future research. Several recommendations for future work can be driven from this work. The study used a single site for participation and recruitment and a single simulation experience. A multi-site, repeated measure design with multiple exposures to simulation would add more breadth and depth to the information. Further research is required to validate the proposed observational tool and the effect of cognitive biases using a larger sample size. This would fuel further research on the proposed framework to assess the effect on students' clinical reasoning and clinical decision-making skills with a larger sample and more experienced nurses. The exploration of whether the clinical decision made is followed by appropriate actions also needs further exploration and assessment. Additionally, further research on the application of different scenarios in combination with the proposed framework would shed light on the usefulness and practicality of using the proposed framework. In that respect, developing a rubric system to assess the development of reasoning steps during the nursing course would be useful to develop in future research.

Different aspects of the study have been disseminated throughout the research process, such as the literature review findings, methodological debate and initial findings. The dissemination was through the University Research Students Conference, national and international conferences. The findings have been presented at the Royal College of Nursing Education Conference and the Association for Simulated Practice in Healthcare (ASPiH). This provided me with incremental and constructive feedbacks, peer reviews and supported my development throughout my study.

9.7. Conclusion

The major contribution of my study to the nursing knowledge is that it has helped in identifying strengths and weakness in the clinical reasoning and decision-making processes among nursing students. The findings have helped create a new dynamic conceptual framework that could support the development of clinical reasoning and decision-making skills. The study also identified areas to improve and optimise students' decision making and clinical reasoning, such as the use of the right cues and effective interpretation and cue clustering. The second major contribution is identifying that a range of cognitive biases can affect the different steps of the clinical reasoning process. This is the first study to apply the Dual Process Theory (DPT) as a framework for analyzing the decision-making processes, tracing the cognitive operators and analyzing the effect of cognitive biases in a simulated environment. This is filling a gap in the nursing literature about the use of a CDM theory-based simulation design that has the potential to enhance the effectiveness of simulation as a teaching and learning strategy for clinical reasoning and decision making. The proposed framework with three stages could be used to design different simulation experiences that are tailored to students' level of knowledge and clinical experience to enhance their decision-making process

The study additionally provides a methodological contribution to knowledge by applying an innovative mixed-methods design and combination of think aloud and observation to produce an in-depth analysis of the decision making and reasoning processes and relating the findings to quantitative measures. The follow-up interview conducted with participants added insight and confirmation of students learning from the simulation experience and its usefulness to their clinical practice. The application of a range of methods to study the same phenomena increases credibility, confirmability and transferability of the study findings. The study extends the literature about the usefulness of think aloud and observation to explore clinical reasoning and decision making.

9.8. Reflection on my study

This study came about through my interest in clinical decision making and how to improve students and nursing staff ability to recognise and effectively management acutely and critically ill patients. At the beginning of my study, the idea came to me from my 10 years as experienced critical care nurse and clinical educator and my 3- years of experience in teaching acute care and critical care. In the early stage of my academic career, I did not see simulation as an authentic approach to teaching real patient situations, but this belief gradually changed through my teaching practice as I found it to have potentials to replicate reality to some extent, to support repetitive and deliberate practice through the application of multiple scenarios. Moreover, I found most of my students benefited from the simulation and debriefing despite their level of clinical experience and education. My interest in decision making to improve patients' safety and the growing interest I had for simulation led me through this investigative journey to examine how simulation affects clinical decision making and how nurses make clinical decisions in a simulated environment. Now that I have had eight years in an academic role I see how important is it for nursing staff from students to experts to continuously develop their CDM and reflect on their biases to optimise their decisions and maintain patient's safety and how theory-based CDM simulation could be a useful technique to support their development.

I had formal pedagogical training at the start of my academic career and I had a clinical Master degree in critical care nursing before starting this study. Both contributed to my understanding of the literature and analysis of the findings. My knowledge about theories of clinical decision making and clinical reasoning greatly developed throughout this study as I saw potential ways simulation could be used to improve people skills and how theory-based simulation could be integrated into the nursing curricula. The findings of this study and my previous experience led me to develop the proposed framework to support students' development and increase the effectiveness of HFS. My knowledge of the research process and the use of mixed methods greatly improved. I acknowledge the limitations of my study, but I would recommend the use of think aloud and observations as methods to gain an in-depth understanding of the CDM and CR processes.

I found the use of concurrent and retrospective think aloud helpful to support data analysis and provide confirmatory results about the clinical decision-making process. Video recording was useful in that it allowed me to watch the participants repeatedly and improve the consistency of data analysis. Throughout my research journey, I kept a diary and wrote details about my thought process, refining my analysis and the interpretation of my data, questioning myself and the way I made my research questions. This led me to analyse the data using multiple methods to confirm findings, satisfy they were correct and greatly support the development of my research skills. As a nurse educator, I strive to enhance the quality of staff education and training for the ultimate benefit of improving patient care and safety. This study and the research skills I developed has given me a new momentum and fresh passion for a new exciting journey to enhance the quality of patient care through further research.

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Appendix 1: Literature review question and keywords

Review question: Does high fidelity simulation improve pre-registration nursing students clinical reasoning and decision-making skills?			
Population	**Intervention**	**Comparison (or control)**	**Outcome**
Pre-registration nursing students	High fidelity simulation		Clinical decision making
Pre-registration nursing education Undergraduate nursing education Nursing student	Human patient simulation HPS Simulat*		Clinical reasoning Clinical judgement Decision making

Appendix 2: Literature search strategy

A. Results of CINHAL/ EBSCO

Limitations: January 2005-December 2018

Steps	Keywords	Hits
S1	Pre-registration nursing student	261
S2	Pre-registration nursing education	108
S3	Pre-registration nurse education	115
S4	Undergraduate nursing education	600
S5	Undergraduate nursing students	2281
S6	S1 OR S2 OR S3 OR S4 OR S5	3306
S7	High fidelity simulation	975
S8	Human patient simulation	219
S9	Simulat*	55278
S10	S7 OR S8 OR S9	55278
S11	Clinical decision making	31958
S12	Clinical reasoning	2379
S13	Clinical judgement	2943
S14	Decision making	119408
S15	S11 OR S12 OR S13 OR S14	122996
S16	**S6 AND S9 AND 14**	**67**

B. Results of CINAHL/ EBSCO using Subject headings

Limitations: January 2005-December 2018

Keywords	Steps	Subject heading used	Hits
Pre-registration nursing student	S1	(MM "Students, Nursing, Baccalaureate+)	2091
Undergraduate nursing education Undergraduate nursing students	S2	MM "Students, College	7242
Pre-registration nursing education Pre-registration nurse education	S3	(MM "Education, Nursing, Baccalaureate+)	4124
	S4	S1 OR S2 OR S3	12731
High fidelity simulation Human patient simulation	S5	(MM "Patient Simulation"	1914
Simulat*	S6	MM "Simulations"	11795
	S7	S5 OR S6	7568
Clinical decision making Clinical reasoning Clinical judgement Decision making	S8	MM "Decision Making, Clinical"	11148
	S9	**S4 AND S7 AND S8**	**17**

C. Results of Medline /Pubmed

Limitations: January 2005-December 2018

Steps	Keywords	Hits
S1	Pre-registration nursing student	647
S2	Pre-registration nursing education	727
S3	Pre-registration nurse education	632
S4	Undergraduate nursing education	10080
S5	Undergraduate nursing students	3825
S6	S1 OR S2 OR S3 OR S4 OR S5	11072
S7	High fidelity simulation	2234
S8	Human patient simulation	17782
S9	Simulat*	447232
S10	S7 OR S8 OR S9	447232
S11	Clinical decision making	48730
S12	Clinical reasoning	4937
S13	Clinical judgement	8498
S14	Decision making	185890
S15	S11 OR S12 OR S13 OR S14	196547
S16	**S6 AND S9 AND 14 (English)**	**163**

D. Results of Medline /Pubmed using Medical subject heading (MeSH)

Limitations: January 2005-December 2018

Keywords	Steps	Used MeSH	Hit
Pre-registration nursing student Pre-registration nursing education Pre-registration nurse education Undergraduate nursing education Undergraduate nursing students	S1	Education, Nursing	27308
High fidelity simulation Human patient simulation Simulat*	S2	Simulation training	6308
Clinical decision making Clinical reasoning Clinical judgement Decision making	S3	Clinical Decision making	5053
	S4	**S1 AND S2 AND S3**	**7**

E. Results of BNI/Proguest

Limitations: January 2005-December 2018 and English language

Steps	Keywords	Hits
S1	Pre-registration nursing student	3207
S2	Pre-registration nursing education	3482
S3	Pre-registration nurse education	3356
S4	Undergraduate nursing education	51449
S5	Undergraduate nursing students	52521
S6	S1 OR S2 OR S3 OR S4 OR S5	42733
S7	High fidelity simulation	50400
S8	Human patient simulation	146379
S9	Simulat*	3751132
S10	S7 OR S8 OR S9	3696879
S11	Clinical decision making	355785
S12	Clinical reasoning	97202
S13	Clinical judgement	151315
S14	Decision making	1919821
S15	S11 OR S12 OR S13 OR S14	1861990
S16	S6 AND S9 AND 14	6252
S17	Limitations: full text, peer review, scholarly journal **Subject:** Simulation, clinical competence Education, nursing, baccalaureate, students, nursing Decision making Patient simulation Manikins Cognition and reasoning Problem solving **Document type:** Article, thesis	**771**

Appendix 3: Finding from the quality assessment

a. JBI Quality assessment of RCTs

Author and year / Questions	Jeffries & Rizzolo (2006)	Howard (2007)	Radhakrishn Roche & Cunninghum (2007)	Ravert (2008)	Walsh (2010)	Akhu-Zaheya et al (2013)	Cobbett & Snelgrove-Clarke (2016)	Merriman, Stayt & Rickett (2014)
Was true randomization used for assignment of participants to treatment groups?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was allocation to treatment groups concealed?	No	No	No	No	No	No	No	Yes
Were treatment groups similar at the baseline?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were participants blind to treatment assignment?	No	No	No	No	No	No	No	No
Were those delivering treatment blind to treatment assignment?	No	No	No	No	No	No	No	No
Were outcomes assessors blind to treatment assignment?	No	No	No	No	No	No	No	Yes
Were treatment groups treated identically other than the intervention of interest?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were participants analyzed in the groups to which they were randomized?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were outcomes measured in the same way for treatment groups?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were outcomes measured in a reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was appropriate statistical analysis used?	No	Yes	No	Yes	Yes	Yes	Yes	Yes

Was the trial design appropriate, and any deviations from the standard RCT design accounted for in the conduct and analysis of the trial?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Score	8/13	9/13	8/13	9/13	9/13	9/13	9/13	11/13

b. JBI Quality assessment of the non-randomised quasi-experimental design studies

Author and year	Is it clear in the study what is the cause and what is the effect?	Were the participants included in any comparisons similar?	Were the participants included in any comparisons receiving similar treatment other than the exposure or intervention of interest?	Was there a control group?	Were there multiple measurements of the outcome both pre- and post the intervention/exposure?	Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?	Were the outcomes of participants included in any comparisons measured in the same way?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	score
Hoffmann, O'Donnell and Kim (2007)	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	7/9
Brannan, White, and Bezanson (2008)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9/9
Ackermann (2009)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8/9
Brown and Chronister (2009)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9/9
Kardong-Edgren et al (2009)	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	7/9
Dreifuerst (2010)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9/9
Shepherd (2010)	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	6/9
Levett-Jones et al (2011b)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9/9
Pierce (2011)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	8/9
Wood and Toronto (2012)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	8/9
White et al (2013)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	8/9
Kelly et al (2014)	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	6/9

Yuan, Williams and Man (2014)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	8/9
Young and Jung (2015)	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	6/9
Fawaz and Hamdan-Mansour (2016)	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	7/9
Lee et al (2016)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8/9
Knoesel (2017)	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	7/9
Woda et al (2017)	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	7/9

c. JBI quality assessment of qualitative studies

Author and year	Endacott et al (2010)	Ashley and Stamp (2014)
Is there congruity between the stated philosophical perspective and the research methodology?	Unclear	Unclear
Is there congruity between the research methodology and the research question or objectives?	Yes	Yes
Is there congruity between the research methodology and the methods used to collect data?	Yes	Yes
Is there congruity between the research methodology and the representation and analysis of data?	Yes	Yes
Is there congruity between the research methodology and the interpretation of results?	Yes	Yes
Is there a statement locating the researcher culturally or theoretically?	No	No
Is the influence of the researcher on the research, and vice- versa, addressed?	Yes, partly two research did the analysis	Yes, partly two research did the analysis
Are participants, and their voices, adequately represented?	Yes	Yes
Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	Yes	Yes
Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	Yes	Yes
	8/10	8/10

Appendix 4: Data extraction and summary of literature about the impact of High Fidelity Simulation effects on clinical reasoning and decision making

Author and year	Research design	Intervention	Outcome and Results	Overall evaluation
Jeffries and Rizzolo (2006) USA	Randomised experimental. N= 403, first year nursing student 4-year programme Multiple sites	Group 1: Paper/pencil case study simulation Group 2: static manikin Group 3: HFS	SDS and EPSS: Knowledge gain, Self-perceived judgement, Student satisfaction. Significant difference in the knowledge gain (p <0.001), signification higher level of satisfaction with HFS. No difference in self-perceived judgement score	Large study, 8 different sites, control and comparison groups Inadequate statistical analysis is provided for a large study
Hoffmann, O'Donnell and Kim (2007) USA	Pre-test and post-test design. Senior BSc nursing students (N=29) Setting: Pittsburgh School of Nursing	7 weeks of traditional experience and 7 weeks of simulation using SimMan	Basic Knowledge Assessment Tool (BKAT) 3-month post simulation. Pre-test and post-test repeated measure design Significant improvement in knowledge attainment p <0.005	Quasi-experimental Knowledge attainment not specific measurement of CDM. Small sample size. No control or randomisation to ensure cause-effect relationship
Howard 2007 USA PhD	Multi-site quasi-experimental pre-test and post-test design Undergraduate. N=49. Robert Morris University and Sharon Regional Hospital School of Nursing. Degree and diploma students	Group 1 (N=25) HFS Group 2(n=24) Interactive Cases study	HESI: Knowledge gain and Critical thinking. Satisfaction Significant improvement in knowledge gain, critical thinking and satisfaction	Random allocation Validity of the used tools
Radhakrishn, Roche and Cunninghum (2007) USA	Quasi-experimental, pre-test and post-test design. 13 Second year nursing student. Randomised allocation.	Group 1 (n=6) simulation practice with SimMan with 2 complex assignment and clinical requirements Group 2 (n=6): no simulation but clinical requirements.	Faculty developed Clinical Simulation Evaluation Tool (CSET). Safety, Basic assessment, Focused assessment, Delegation, Intervention, Communication	Strength in the randomisation One student withdrew before the experiment 10 Female and one male

	Settings: University of Massachusetts School of Nursing	Then both group participated in HFS	Significant improvement in the safety and basic assessment scoring p <.001	Small sample. The validity of the measurement tool is not described
Ravert (2008) USA PHD	Randomised experimental pre-test and post-test design N=40 undergraduate nursing students.	Group1 = (N= 13). Regular education process and five enrichment session without simulation. Group 2: (N=12) HFS plus regular education and five enrichment session Group 3 (n=15) regular education session without enrichment	Critical thinking disposition Critical thinking skills (CCTD, CCTS) Gain in the critical thinking score and learning style but not statistical significant	Control Small sample with limited statistical power
Brannan, White, and Bezanson (2008) USA	Quasi-experimental pre-test and post-test comparison group N= 107 junior level of BSc nursing students Settings: WellStar College of Health	Group 1: (N=53) traditional lecture Group 2 (N=54) HFS method	AMIQ and confidence level (CL) Statistical difference in the mean score of post-test for HFS group (P< .05) but no difference in the CL.	Has control group. No randomisation or blinding. Comparisons of demographics and educational statistics of Groups 1 and 2 were statistically non-significant
Ackermann (2009) USA	Quasi-experimental, pre/post-test design. N=65 Junior BSc students Setting: small college of nursing	Initial training on low resuscitation manikin for all participants then randomly allocation. Group 1 (n=32) review algorithm and DVD Group 2 (n=33) 20-30 of CPR using high fidelity simulator and 10 minutes debrief.	Knowledge acquisition MCQ using 14-items MCQ extracted from AHA BLS exam. AHA skill evaluation form. Pre-test no statistical difference in knowledge but significant for skills. For the post-test 1 and 2 significant difference in both knowledge and skills	49 students only did the post-test 2 so 16 dropped out for the second post-test
Brown and Chronister (2009) USA	Comparative, correlational and experimental design N=140: senior level undergraduate nursing student University of Akon	Group 1 (n=70) 350 minutes of didactic instruction and 150 minutes of simulation (SimMan) > 5 weeks. Group 2 (N=70) 400 minute of didactic instruction >4 weeks	Critical thinking using (Elsevier's ECG Sim-test, Self confidence No statistical significant differences between the critical thinking and self-confidence score between the groups.	

Kardong-Edgren et al (2009) USA	Experimental design. Repeated measure factorial design. Pre-test Post-test 1 at 2 weeks post intervention. Post-test 2 at 6 months post intervention. N= 103, nursing student. Setting: a large Nursing school	Group 1 Lecture 50 minutes Group 2 (n =40) SimMan 15 minutes and Lecture 50 minutes Group 3 Vital Sim and Lecture	Knowledge acquisition and retention. 15-items MCQ using AHA bank. Satisfaction level Significant difference between pre-test and post-test 1 No statistical difference in the mean score of Knowledge acquisition between post-test 1 and 2	46% drop out in the participant in the post-test 2 (at 6 months) only 65 (54%) participate from 103. It was the first time for the participant to use SimMan, the author also acknowledges the limitation of using MCQ
Dreifuerst (2010) USA PhD	Exploratory, quasi-experimental pre-/post-test design. N=238 nursing student in multiple cohorts Setting: University	Intervention: simulation with debriefing Meaningful Learning Control: simulation with usual debrief	Measuring clinical reasoning skills. Using HSRT. Measuring student's perception of the quality of the debriefing DASH-SV. Statistical significant different in HSRT for the intervention group $F(1, 237) = 28.55$, $p = <.05$. Significant difference in the student's perception of the quality of the debrief for the intervention group $p = < .001$.	Selection bias: Not all the cohorts were invited to participate in the study. Voluntary participation. HSRT limitation as suitable to healthcare but specific for the nursing domain
Endacott et al (2010) Australia	Thematic analysis Interpretative approach N=51, final year nursing students Settings: University	1.5 hour of simulation 2 scenarios video-recorded reviewed using reflective interview. manikin-based simulation	Knowledge acquisition- 11-items MCQ. Team performance OSCE Situational awareness. Initial response, differential recognition of cues, accumulation of signs and diversionary activity	Fidelity of the simulation is not clearly described
Shepherd et al, (2010) UK	A longitudinal, comparative quasi-experimental design. Final year adult nursing students. N= 28 in two sites, site A, (n=18) and site B, (n=10).	Phase 1 Site A: volunteer patient role plays simulations Site B: High-fidelity manikin Phase 2: follow up after six months	Cognitive (knowledge and decision making), motor and affective. self-assessments of confidence and anxiety levels. There was no significant difference between sites ($F(1, 24) = 0.03$, $P=0.863$) in students confidence and anxiety. Cognitive scores were similar but motor and	External examiner review of the recording? Small sample size under powered Pilot study was carried before the main study

			affective improvement was better with the SP group.	
Walsh (2010) USA PhD	Quasi-experimental three group pre-/post-test design and qualitative data to triangulate. Random allocation N= 54, Junior nursing student. Settings: a large metropolitan university	Students were instructed to work in pairs in simulation Group 1 (n= 9 pairs) No simulation (90 minutes) think aloud. Group 2 (n= 9 pairs). Typical Simulation (3-4 hours) three simulation sessions (SimMan) using think aloud. Group 3 (n= 9 pairs). Simulation-pattern recognition (3-4 hours) three simulation sessions TA	MI Welk Pattern recognition tool Critical thinking in MI test (HESI) Jenkin's CDM scale SBAR Reporting system Interview. Significant difference in the WPRT between pre/post and between groups Post Hoc ANOVA analysis shows the difference between the simulation groups and the control suggesting simulation enhance pattern recognition. No statistical significant in CDM, HESI scores between groups.	Convenience sample
Levett-Jones et al (2011) Australia	Quasi-experimental pre-test and post-test Third year nursing students N= 84 Setting: School of Nursing	Group 1 (n= 42) Simulation session with high fidelity session with HFS (SimMan3G) Group 2 (N=42) simulation session with medium = fidelity (MegaCode Kelly with VitalSim)	Knowledge acquisition and retention using multiple choice test from TestGen of deteriorating patient. t-test and ANCOVA to measure difference overtime. not statistical difference in the mean score or covariance difference over time	No significant difference in knowledge acquisition between the different types of simulation. Pair-matching based on HSRT and random allocation No blinding
Pierce (2011) PhD USA	Quasi-experimental time series design. N= 50, senior nursing student. Settings: University of North Alabama	Three HFS sessions with different scenarios	Lasater Clinical Judgment Rubric (LCJR). Satisfaction and Self-Confidence in Learning. Statistically significant increase (p = .041) in students' perceptions of clinical judgment occurred between Time 1 and Time 3. Students' perceptions of self-efficacy also increased significantly from Time 1 and Time 3 (p = .003) and from Time 2 and Time 3(p = .001). Regression analysis revealed a	Strength Repeated measure Weakness One group Self-report Convenience sample

			slight positive correlation (sig. = .003) between students' perceptions of self-efficacy and clinical judgment	
Wood and Toronto (2012) USA	Quasi-experimental design. Pre/post-test design A self-selected convenience sample Second year N=85	Intervention: 2 hour- session of HFS-manikin based and traditional practice (n =42) in small groups of 4-5. They individually carried the assessment with other peer observing same skill. Followed by debriefing Control: traditional practice only alone without simulator same skill like the intervention group (n=43)	California Critical Thinking Disposition Inventory (CCTDI) measuring critical thinking. Higher CCTDI in the experiment group compared to the control but the overall the difference is not statistically different between the overall score. Statistically significant improvement in CCTDI score between pre and post-test for the intervention.	Generic CT test not specific to healthcare or nursing. Small sample size Effect of observing other is not controlled in the intervention group
Akhu-Zaheya et al (2013) Jordan	Quasi-experimental, pre-test and post-test design Second year nursing student in 4 years BSc programme Nursing school N=110	Group 1 (n=52) three-hour traditional session and HFS. Group 2 (N=58) three hour traditional	Knowledge acquisition and retention using MCQ 12-items from AHA BLS exam. Self-efficacy (Arnold's study 2009). No significant difference in the mean in MCQ but statistical significant difference in the mean score of in self-efficacy post-test	Control group, random allocation
White et al (2013) USA	Experimental design Two groups N=54, senior nursing student Kennesaw University	Group 1(n=16) HFS Group 2 (n=38) classroom instruction	Cognitive skills (DSQ)- MCQ test. Confidence level (CL) Significant difference in cognitive skills for the traditional classroom method. No difference in CL	Difference in the sample size. Weakness MCQ-test reliability to test high order thinking
Ashley and Stamp (2014) USA	Interventional and explorative study N=104 First year n=48 Second year =56	Two simulated scenarios each 15-20 minute simulation followed by one-one video-assisted debriefing. The debriefing interview was audiotaped and analysed	Identified themes are: thinking like a nurse, assessment, looking for answers, communication and reflective thinking. Junior nursing were more systematic and actively thinking about the problem more than the second year students. Under the	Scenario content was review by expert faculty All students participated in simulation no comparison No control Different scenarios used in both junior and senior students

			assessment Second year did not consider initial cues as important compare to the junior and they were observing the environment to explain the problem and focused mainly on vital signs. Junior were more actively listening to patient complain and symptoms and considered vital signs. Junior were quicker in solving the problem. both felt sense of urgency to solve the problem. In their discussion Junior used more analytical approach than senior students. Junior were faster than senior in noticing important cue both failed in carrying key assessment and senior student had delay cue recognition.	Convenience sample.
Kelly et al (2014) USA	Descriptive pre/post-test. Convenience sample. N=57 final year nursing students, third year students and second year accelerate programme students 29 third year students. 15 second year Enrolled Nursing programme and 11 second year Graduate nursing programme. Settings: large urban university	First exposure to simulation. Either active or observer role. Simulation 10-12 minutes Debriefing 20 minutes	Examine student's ability to recognise a deteriorating patient; self-rate their ability (six questions) on Likert scale (1-4). And rating of their confidence in in communicating and seeking assistance. T-test and ANOVA to assess the difference between the groups. Significant difference in pre-simulation score favouring the Enrolled Nursing programme (f=6.90; p<0.01) but no difference in the post-simulation. Significant improvement in the mean score	Convenient sample Small and equal groups Not clear what are the components within the survey, the validity and reliability of the survey Reliance on self-report

			post-simulation for all the groups, $p < 0.01$	
Merriman et al (2014) UK	RCT-single blinding Nursing student 34 students: 19 as a control group and 15 as an intervention group Setting: University	Control: classroom teaching 1- hour lecture. Experiment: 2-hour initial observation of the facilitator followed by multiple individual practice with feedback. High fidelity	OSCE, Self-reported competence, self-efficacy (GPSEC), satisfaction. Significant improve in OSCE for both group post-intervention with ($p < 0.05$). Not significant differences in GPSEC. Student in the simulation group were more satisfied	Pilot study Duration of teaching is different between the two interventions
Young and Jung (2015) South Korea	Quasi-experimental crossover design consisted of intervention Junior students (n=94)	Group A (n=48) 12 weeks didactic and simulation Group B (n=46) 12 weeks didactic course After 6 weeks the groups swapped for the intervention SimMan 2-hour session in small group 3-4	Knowledge MCQ test, clinical reasoning test using a rubric based on nursing process, and self-confidence. Significant improvement in the knowledge and clinical reasoning of the intervention compared the control. No difference in the self-confidence score between the groups ($t=-0.81$, $p = .418$).	Content validity of the MCQ test was reviewed by 2 experts. The content of the clinical reasoning rubric was based on literature and reviewed. No baseline assessment of knowledge and clinical reasoning. Only one member assessed the clinical reasoning scores may have resulted in a lack of reliability for this measure. The immediate cross over increasing familiarity of the test.
Yuan, Williams and Man (2014) China	Quasi-experimental study. A single group repeated-measures design N= 115, 49 2nd year and 64 in 3rd year	5 HFS simulation sessions with different scenarios. 2 tutors assessed student clinical judgment	Clinical Judgment Rubric Inter-rater reliability Clinical judgment score over time. Comparing students' scores in the different years of study. Third year had higher clinical judgment score	No control, comparison on year of study

Cobbett and Snelgrove-Clarke (2016) Canada	Randomised control trail (pre/post-test design). N= 56, third year nursing students. A public research university.	Group 1(n=27): Virtual clinical simulation (VCS) Group 2 (n=28): face to face (F2F) Manikin-based simulation. Repeated Group 1: F2F, Group 2: VCS	Nursing Anxiety and Self-Confidence with CDM Scale (NASC-CDM), knowledge test, Simulation Questionnaire. High score for knowledge, confidence and CDM in the F2F but difference not statistically significant differences in knowledge and self-confidence between F2F and VCS. Anxiety scores were higher for students in VCS. Students preferred F2F	No blinding Small study Validity of the knowledge test was not discussed Student had limited experience with VCS compared to F2F
Fawaz and Hamdan-Mansour (2016) Lebanon	A post-test, quasi-experimental design. Two private universities A convenience sample of 56 nursing students. First year with no previous experience N= 26 from university A N= 30 from University B	Control: traditional lecture about heart failure and tradition course work with clinical placement with patient suffering heart failure Intervention: High fidelity simulation and clinical placement with patient suffering heart failure	Lasater Clinical Judgment Rubric and the Motivated Strategies for Learning questionnaires. The intervention group had a higher mean score of clinical judgment (29.5, SD=5.4) than the control group (22.1, SD= 5.7). Significant difference post HFS between the intervention group and the control group in clinical judgment intervention (t = 5.23, p= 0.001).	High order thinking assessed at very early year of study? No baseline to assess true effect. Outcome measure for academic achievement only? Study scenario was based on a previous study in USA that used senior nursing students that has been applied in junior nursing students. Heterogeneity in the demographics gender and age
Lee et al (2016) South Korea	A quasi-experimental pre/post-test design N= 49 Convenience sampling Senior students	Simulation in clinical a reasoning course N=23 2 hour per week for 16 weeks (32 hours) Control n=23	The experimental group significantly scored higher on nursing core competencies (256.47 ± 32.33; F = 7.747, P = 0.008). There was no significant difference between the two groups for problem solving.	Heterogeneity between the experimental and control groups. Self-report measures Clinical reasoning is elective, Therefore risk of selection bias. Limited discussion about the content validity of the scenarios.
Woda et al (2017) USA	A quasi-experimental crossover design. A convenience	Group 1: Simulation followed by hospital placement (S-H)	Clinical Decision Making in Nursing Scale (CDMNS) and the Nurse Anxiety	Only self-reported instrument

	sample of nursing students (n= 117) Third year. 68 BSc undergraduate 49 MSc	Group 2: hospital followed by simulation (H-S) part of 14 weeks course. Cross over after week 7. In pairs student attended 4 hours simulation experience within 7 weeks.	and Self-Confidence with Clinical Decision Making (NASC-CDM) Significant improvement in self-confidence with group that had S-H but after 14 week no difference in CDMNS and NASC-CDM between the groups.	used. Repeated use of the same measure could affect the results The use of cross over deigns without control does not allow accurate inferring cause effect relationship. Heterogeneity between the group at the baseline assessment.
Knoesel (2017) Phd USA	Quasi-experimental Pre/post-test design Nursing students (n= 218 (n=115 traditional students and n= 103 accelerated course)) Private Urban University	Simulation, n= 112 No simulation, n=106 35 hours of combination of standardised patient and Manikin simulator	HESI exit exam The average critical thinking skill score for simulation exposure was higher than the no simulation exposure, but this was not statistically significant ($t(202.8) = 1.68$, $p=0.09$). No significance different the accelerated and traditional course.	The description of the sample and population is complex and not clear. Incomplete data of the traditional group for the baseline.
Educational Practices in Simulation Scale (EPSS) and the Simulation Design Scale (SDS)				

Appendix 5: Modified SHARP debriefing tool

<u>Set learning objectives</u>

- What would you like to get out of this scenario? (clarified the objectives of this study)

<u>How did it go?</u>

- What went well? Why?

<u>Address concerns</u>

- What did not go so well? Why?
- What could you do better?

<u>Review learning points</u>

- What was the main problem for this patient? What led you to this conclusion?
- What other possible problems could it be? Why?
- What did you learn about your actions/interventions you took and patient’s outcome?
- What did you learn about your clinical/technical skills?

<u>Plan ahead</u>

- What actions can you take to improve your future practice?
- What will you do differently next time?

Source: Ahmed et al (2013)

Appendix 6: Cognitive errors and biases

	Type of bias or error in DM	**Description**	Strategy number
Data gathering	**Premature closure**	Reach conclusion before all the information are obtained and accept diagnosis prematurely, without reasonable differential possibilities	Essential: 1-5 Recommended: 6-9
	Order effects	*Vital information sometime gets lost in handover between staff (between physicians, between nurses, patient and healthcare)* The order of data gathering Capturing information transfer at the beginning and end of handover. Tendency to miss information transferred in the **middle**.	Essential: 1-5 Recommended: 6-9
	Search satisfacing	A tendency to stop searching for possible alternative once abnormality is identified	Essential: 1-5 Recommended: 6-9
	Confirmation bias	Seeking only data that confirms the desired or suspected problem. Or modifying interpretation of data to fit with initial prediction or selected diagnosis. *e.g., repeatedly cycling a blood pressure cuff, changing cuff sizes and locations, because you "do not believe" the low reading*	Essential: 1-5 Recommended: 6-9
	Framing	[fixated on prior decision or labels placed on patient by previous clinicians/ lay person or patient/family] the tendency for a diagnosis to become established without adequate evidence e.g., colleague handover that patient is very anxious preoperative, so you link his restlessness to that and ignoring low blood glucose or low oxygen level.	Essential: 1-5 Recommended: 6-9
	Omission	Hesitation to perform intervention warning about the consequences	
Analysis stage	**Anchoring**	Fixated on one issue at the expense of understanding the whole situation. e.g., While troubleshooting a catheter problem, you are unaware of a sudden bleeding and hypotension	Essential: 1-5 Recommended: 6-9
	Over-confidence	[we usually think that we know more than we actually know without gathering enough information/ greatly believe in our opinion/ common cause of error. Ignore our tendency to fail or failed the need for help when required as you believe you can eventually manage the situation.	Essential: 1-5 Recommended: 6-9
	Representativeness	Tendency to use typical presentation of clinical problem to reach diagnosis without considering possible alternative. Cues indicate a particular condition that the participant has previously encountered. Issues could be missed if atypically presented.	Essential: 1-5, 8 Recommended: 6,7,9

	Confirmation bias	Seeking only data that confirms the desired or suspected diagnosis/ issue/ action. e.*g., keep repeating blood pressure or changing the cuff size or location, because you don't believe the low readings*	Essential: 1-5 Recommended: 6-9
	Availability/non-Availability	Tendency for things to be judged more frequent if they come readily in mind and insufficient attention to that is not immediately present. Similar conditions come to mind **non- Availability: "**out of sight out of mind" insufficient attention to that is not immediately present	Essential: 1-5 Recommended: 6-9
Diagnose and evaluate stages	**Hindsight**	[clinician opinion will be influence by the outcome of a case despite the initial information] Provide coherent, deterministic logic such that no other outcome could possibly have occurred. *Knew it all along Wisdom after the fact*	Essential: 1-5 Recommended: 6-9
	Context error	Critical cues are distorted by the background against which it is perceived	
	Outcome bias	[overestimation of the probability of good outcome against the underestimation of the probability of poor outcome]	Essential: 1-5 Recommended: 6-9
	Commission Bias	Tendency toward action rather than inaction. Performing unindicated deviating from protocol. May be due to overconfidence, desperation, or pressure from others.	Essential: 1-5 Recommended: 6-9
	Sunk cost:	Failing to give up a failing therapy, intervention or plan and continue pursing particular lead, diagnosis or plan.	Essential: 1-5 Recommended: 6-9

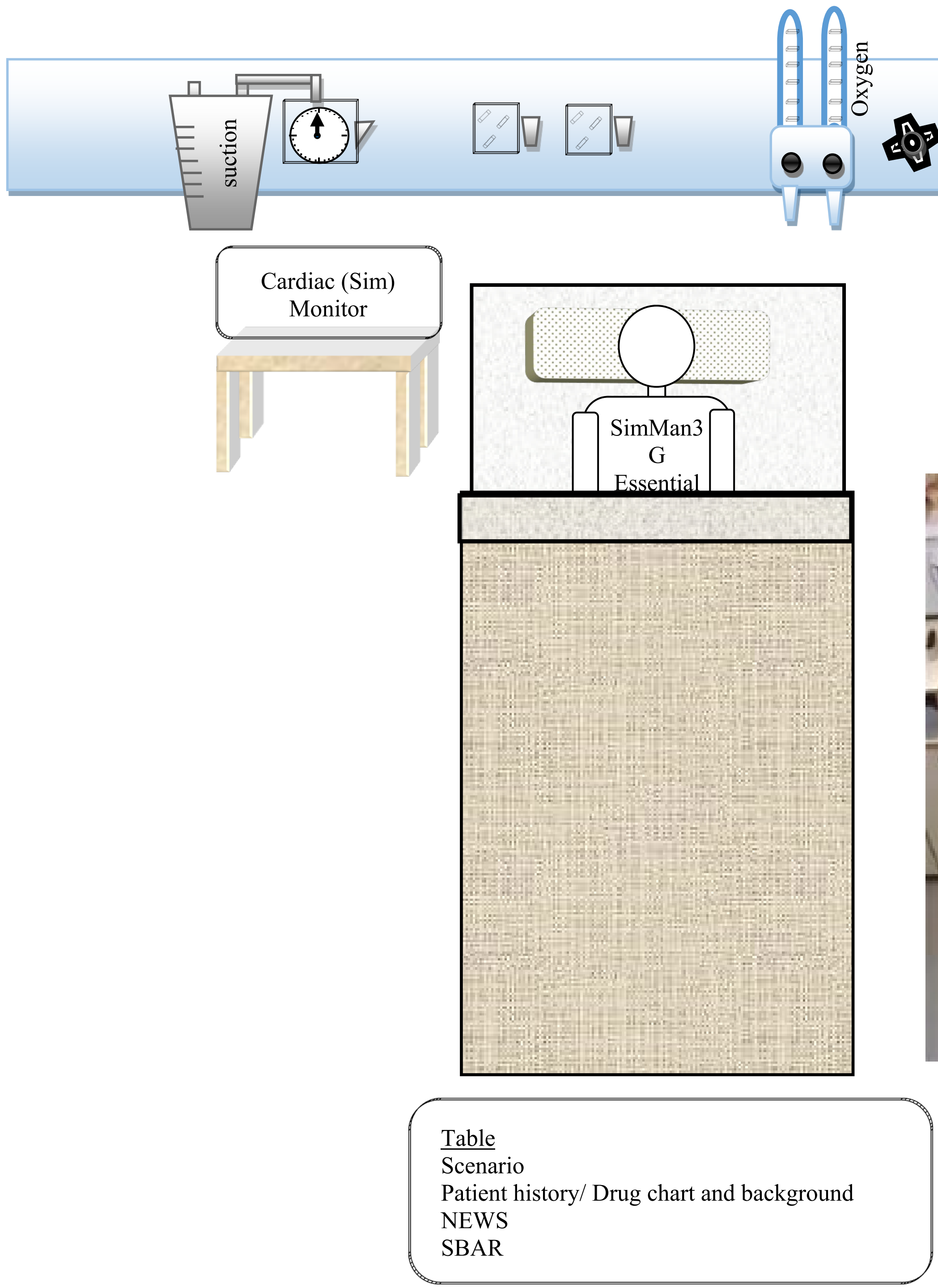
Source of biases from Croskerry (2002)

Appendix 7: Strategies to reduce cognitive errors

Strategy Number	Strategy
1	• Awareness about biases, potential errors and consequences of errors. Recognize when particular type of decision making is failing. • Education: different decision-making theories, biases and strategies to reduce potential errors. • Repeat decision making activities with different tasks and different situations and identify your potential/actual errors, dominant type of decision making. • Consider the personal accountability to reduce potential errors and increase clinical effectiveness and its impact on improving patient's care and safety.
2	• Do your own assessment • Complete a full but focused assessment before making decision. • Caution with previous diagnosis, suggestions or impression from other colleagues and/or patients and their families. • Take a short pause and think time before you decide
3	• Do not rely extensively on readily available data follow an objective and systematic way of gathering information. • Forcing strategy to use a structural data acquisition, processing and reasoning using provided stages and ABCDE. • Careful review of the evidence, use of trends and graphics
4	• Consider including and excluding the context or background to see atypical but important signs that may produce different possibilities.
5	• Question the soundness of your decision • Try to justify your decision to yourself • Consider the opposite: search for signs that confirm opposite decision to your first impression or initial decision
6	Reduce reliance on memory by: • Decision support systems such as reminders, posters, decision rules • Follow pathways, algorithm and protocols to reduce variation in patient care • Use checklist
7	• Avoid cognitive overload, tiredness, fatigue, sleep deprivation (shift scheduling, work pattern) • Reduce interruption *Benefits: Enhance information processing by increasing attention, memory performance and executive control.*
8	• Recalibrate your decision making and reduce your biases through reflection on previous decisions: complexity of the task, uncertainty of the situation, type of errors and accuracy of the produced decision. • Be mindful when taking decision and ask yourself about your awareness of the situation and the decision you made. • Seek feedback about your decisions made from colleagues, superiors or educators
9	• Simulation of realistic scenarios videotaped debriefing sessions and guided reflection focused on reasoning and decision-making processes and associated biases.

Sources: Trowbridge, R. (2008); Graber and Croskerry (2011); Croskerry, Singhal and Mamede (2013) and Graber et al 2014

Appendix 8: Station design: Acute ward design



Appendix 9: Clinical scenario and background

1. Clinical scenario (clinical situation)

Participant role: You are the ward nurse who just took over from recovery staff

> **Carol Stone 65-year-old female admitted to an acute ward post hip replacement surgery. Carol received 800 mls of Hartmann's solution intra-operatively. Post operatively, her doctor continued the Hartmann's solution at a rate of 50ml per hour via an infusion pump and she was started on blood transfusion due to low Haemoglobin (Hb) level. She just arrived into your ward and she has a fast respiratory and heart rate. She is complaining of being breathless and getting anxious. Carol reported to you that she was frequently coughing last week.**

2. **Background**: part of the patient's file

Name:	Carol Stone	**Height**	165 cm
Age:	65 years	**Weight**	78kg
DoB	04th July 1950	**BMI**	29
Gender	Female	**Hosp. No:** 241245b	**NHS Number:** 301401501

Address 26 Jesus Street Cambridge CB1 1FT	**GP Practice:** Dr. Sharma Cornwell Medical Practice 22 High Lane Cambridge, CB1 1PT

Past medical/surgical history:

- Ex-smoker stopped in May-2014 [½ pack of cigarettes a day]
- Hypertension, high cholesterol, NSTEMI -May 2014 had PPCI and 2 stents in place.
- Osteoporosis
- Appendectomy in 1994

Allergy

Unknown

Medications:

Aspirin 75mg OD; Clopidogrel 75mg OD; Rampril 2. 5mg OD; Amlodipine 5 mg OD Atorvastatin 10 mg OD; Bendroflumethiazide 5 mg OD

Reason for admission

Fall down two days ago at her home and fracture her hip, admitted to surgical ward in preparation for hip replacement.

3. **Patient profile contain**: patient's history, drug chart and NEWS score

Appendix 10: Checklist: scenario progression, task analysis, symptoms and actions

Carol Stone 65-year-old female admitted to acute ward post hip replacement surgery. Carol received 800 mls of Hartmann's solution intra-operatively. Post operatively doctor continued the Hartmann's solution at a rate of 50ml per hour via an infusion pump and she was started on blood transfusion due to low Hb level. She just arrived at your ward and she has a fast respiratory and heart rate. She is complaining of being breathless and getting anxious. Carol reported to you that she was frequently coughing last week and she had heart attack last year.

	Signs and symptoms	Symptoms Analysis	Identify the problems	Action and decisions	Evaluate & reassess
Airway	✓ Speaking clearly in full sentences	Airway patent	No issues	Positioning	Maintain airway patency
Breathing	✓ **RR 23** ✓ **SpO2 93% on 2 L/min nasal cannula** ✓ **Fine crackles and wheeze** ✓ symmetrical chest movement equal air entry ✓ No tracheal deviation	RR high SpO2 is low on O2 therapy Crackle and wheeze Normal air entry	<u>considering the context:</u> The patient is hypovolaemic with vasodilatory issues such as sepsis pulmonary oedema and allergic reaction. This match with patient context as post op, have been coughing and receiving blood. Possible cardiac failure <u>Excluding context:</u> Hb dilution due fluid replacement, hypervolaemia, reacted to other drugs or material.	Closely monitor SpO2 and change to simple mask if required to achieve target SpO2	SpO2 94-98%
Circulation	✓ **HR 110, ST** ✓ Strong pulse ✓ BP 100/50 ✓ CRT 3 Sec ✓ **Fluid balance -400ml, UOP** ✓ **200 for the last 6 hrs** ✓ **Temp 37.9 C** ✓ **Hb level 75 g/l, on blood** transfusion from recovery. ✓ **Flashing red** ✓ Drain 50ml over the last 6hrs ✓ 2 cannulas size 18 & 20	HR high, Strength is N BP low Diastolic, CRT slightly prolonged, Negative fluid balance, UOP 33 ml/hr might low depend on Weigh, Temperature high, Drainage rate normal Hb level low		Stop blood transfusion and seek medical review. Fluid replacement and maintenance. Insert urinary catheter if not inserted. Monitor vital signs every 15 minute during transfusion. Monitor UOP NEWS score, escalate using SBAR	BP HR UOP CRT Hb level Temp Drainage
Disability	✓Alert AVPU: A ✓Glucose 9.3mmol/l ✓ **Pain score 3/10 hip site**	Normal cognitive status Normal Glucose Severity of pain - mild		Monitor cognitive status & severity of pain Administer prescribed analgesia. Communicating and reassuring patient	AVPU: A Severity of pain reduced
Exposure	✓Dry surgical site, RadiVac attached. ✓ **Flashing red**	Normal surgical site, High temp		Close monitoring of skin colour every 15 minutes	Skin colour is not getting worse

Blood transfusion is stopped and medical staffs are informed

Blood transfusion is not stopped or medical staffs are not informed – significant deterioration before arrest page 3

	Signs and symptoms	Symptoms Analysis	Identify the problems	Action and decisions	Evaluate & reassess
Airway	✓ **Broken sentences** **Slight Swelling in the lips**	Still airway patent but at high risk	High risk of block due to swelling	Call for help Inform anesthetist and medical staff. To establish airway.	Severity of swelling, ability to maintain airway patency
Breathing	✓ **RR 28 using accessory muscles** ✓ **SpO2 86%.** ✓ **crackle and sever wheeze**	RR high and increased breathing effort SpO2 low	The significantly deteriorated vital signs, itchy rashes and other associate signs confirm the patient is having anaphylactic reaction likely to blood transfusion with hypovolaemia due to this reaction or due to dehydration/bleeding from operation	Change to non-rebreathe mask. Closely monitor SpO2 and breathing effort.	SpO2 94-98%
Circulation	✓ **HR 125, ST** ✓ **fast, thready pulse** ✓ **BP 85/40** ✓ **CRT 4 Sec** ✓ **Temp 39.1 C** ✓**Shivering** ✓ **itchy skin rash** ✓ **UOP 20ml/hr** ✓ **Drainage not changed**	HR high BP low, CRT prolonged, UOP low depend on weight, Temp high, Drainage rate normal		Ensure blood transfusion is stopped, line aspirate and then flush with saline. The need for adrenaline IM injection and senior staff Fluid resuscitation using crystalloid only Close monitoring using cardiac monitor Crash trolley and anaphylactic box Antipyretic	BP HR UOP CRT Hb level Temp ECG Blood investigations Drainage amount
Disability	✓ **Very distressed & agitated** ✓**Glucose 10 mmols / l** ✓ Pain score 3/10 ✓around the surgery site	Distressed due to reduced brain perfusion. High glucose stress response Severity of pain - mild		Monitor cognitive status. Administer prescribed analgesia and monitor severity of pain. reassurance	AVPU: A and reduced stress. Severity of pain reduced
Exposure	✓**itchy rashes** ✓ **swelling in the lips**	Normal surgical site High temp		Anaphylactic algorithm	Skin colour is not getting worse

Debriefing and Debiasing

Recognise and treat anaphylaxis
Patient stablise
End of simulation

	Signs and symptoms	Symptoms Analysis	Identify the problems	Action and decisions	Evaluate & reassess
Airway	**difficulty to speak, lips significantly swollen**	Complete airway obstruction	Medical emergency complete airway obstruction	Call for help Inform anesthetist and medical staff. To establish airway.	Establish secure airway ASAP by medical staff
Breathing	✓ **RR 32 using accessory muscles** ✓ **SpO2 81%.** ✓ **crackles, wheeze**	RR very high and significant increase breathing effort SpO2 very low	*Inability to breath spontaneously*	Change to non-rebreathe mask. Closely monitor SpO2 and prepare for intubation o/and trachy.	Mechanical ventilation SpO2 94-98%
Circulation	✓ **HR 132, ST** ✓ **fast, thready pulse** ✓ **BP 70/35** ✓ **CRT 5 Sec** ✓ **Temp 39.8 C** ✓**Shivering** ✓ **itchy skin rash** ✓ **UOP 10 ml/hr** ✓ **Drainage not changed**	HR very high BP very low, CRT prolonged, UOP very low, Temp high, Drainage rate no-changes	*Severe anaphylactic reaction to blood products*	Ensure blood transfusion is stopped, line aspirate and then flush with saline. adrenaline IM injection with doctor prescription Fluid resuscitation using crystalloid only Close monitoring using cardiac monitor Crash trolley and anaphylactic box Critical care Antipyretic	Stablise haemodynamic BP HR UOP CRT Hb level Temp ECG Blood investigations Drainage amount
Disability	✓ **AVPU: V, drowsy and agitated** ✓**Glucose 10.3 mmols / l** ✓ Pain score 3/10 around hip	Significant reduction in brain perfusion. Severity of pain - mild		Monitor cognitive status Administer prescribed analgesia and monitor severity of pain. reassurance	Likely to be sedated.
Exposure	✓**itchy rashes every where** ✓ **swelling in the lips**	Normal surgical site High temp		Anaphylactic algorithm	Skin colour is not getting worse

Recognise cardiac arrest and call for help/ 2222
End of simulation

Debriefing and Debiasing

Appendix 11: Observation and think aloud schedule

Preparation and pre-briefing

- Consent and quantitative pre-test already completed
- Student filled demographics
- 10-15 minutes of brief rehearsal and warm up period
- Orientation to the simulation laboratory, equipment and High Fidelity Simulator (HFS)

Concurrent Think aloud

- 15-20 minutes of concurrent think aloud in managing an acutely ill patient using HFS. Video recorded for debrief and analysis. Field notes using appendix 10

Debriefing and feedback (retrospective think aloud)

- Students reviewed different segments of the recorded video and records immediately after their performance.
- The researcher facilitated retrospective think aloud using open ended-questions.
- Students reviewed the observation chart and made comments on key assessment and actions for further clarification.
- Students given feedback about their performance
- Duration: 15-25 minutes of

Debiasing

- A list of cognitive biases and key strategies was given to each student
- Each student tried to identify the key cognitive biases with the researcher support.

Appendix 12: an example of Health Science Reasoning Test (HSRT)

The Health Sciences Reasoning Test is copyright-protected, fee-for-use, intellectual property of Insight Assessment, a division of California Academic Press. Publication of the items or sample from the test is prohibited. Information regarding use of this instrument can be obtained from the company at their website: https://www.insightassessment.com/Products/Products-Summary/Critical-Thinking-Skills-Tests/Health-Sciences-Reasoning-Test-HSRT

Examples of HSRT questions as provided from Insight Assessment.

Insight Assessment provided the following examples of HSRT questions.
For Sample Questions 1 and 2 Please consider this information:
A scientific study compared two matched groups of college women. The women in both groups were presented with information about the benefits of a healthy diet and regular exercise. The women in one group were paired up with one another and encouraged to work as two-person teams to help each other stick with the recommended healthy regimen of smart eating and regular vigorous exercise. The women in the other group were encouraged to use the same recommended regimen, but they were also advised to work at it individually, rather than with a partner or teammate. After 50 days the physical health and the well-being of all the women in both groups were evaluated. On average the women in the first group (with teammates) showed a 26 point improvement in measures of cardiopulmonary capacity, body strength, body fat reduction, and sense of well-being. On average the women in the other group (encouraged to work as individuals) showed a 17 point improvement on those same measures. Using statistical analyses the researchers determined that the probability that a difference of this size had occurred by chance was less than one in 1000.

Sample Thinking Skills Question #1

If true, these research findings would tend to support which of the following assertions?

A. college woman cannot achieve optimal health functioning without a teammate.
B. Universities should require all students living in campus residence halls to participate in a health regime of smart eating and regular vigorous exercise.
C. A healthy diet will cause one to have better mental health and physical strength.
D. This research study was funded by a corporation that makes exercise apparel.
E. A regimen of smart eating and regular exercise is related to better health.

Sample Thinking Skills Question #2.

If the information given in the case above were true, which of the following hypotheses would not need to be ruled out in order to confidently claim that for the majority of young adults a regimen of smart eating and regular vigorous exercise will result in significant improvements in one's overall health.

A. This study was about women, the findings cannot be generalized to include men.

B. Since the study began to solicit willing participants before the Research Ethics Review Committee of the college gave the research project its formal approval to gather data, the findings are invalid.
C. Some women in the study over-reported their compliance with the eating and exercise regimen, which led the researchers to underestimate the full impact of the regimen.
D. Since many of those studied described themselves as overweight or out of shape when the study began, a similar regimen will not benefit people who are healthier to start with.
E. The performance tests used to evaluate the health and well-being of females may not be appropriate for evaluating the health and well-being of males.

Appendix 13: Follow up Interview schedule

Introduction and warm up	• Thank you for attending this interview • Explaining the purpose of the interview and it will last approximately 15 minutes and not more than 30 minutes • Confirming and obtaining fresh consent • Assuring participants that they will remain anonymous. • Explain that I will audio-record the interview and if they are happy with that. • Explain to them that they can interrupt and stop the interview at any point and no need to give reason • How are you today?
Main questions	1. Can you tell me how did you find the simulation experience? 2. What aspect/s of the simulation experience did you find most useful? Why did you find this aspect most interesting? 3. How did the simulation experience impact on the way you make decision? 4. What errors/biases did you notice yourself making in clinical practice? 5. Which type of decision making you predominately use in clinical practice? 6. How effective do you find this type of decision making? 7. Can you tell me how did you find being aware about cognitive biases? 8. Do you have an example of clinical situation, where a bias may have impacted on your decision making? 9. How do you make decisions about your patient in clinical practice?
Closing	• Anything else do you want to add • You have any question please do not hesitate to contact me, use my contacts in the PIS form. • Thank you for taking part in this study

Appendix 14: Demographics Questionnaire

Participant code………………

Demographics Questionnaire

1. **Gender**
   □ Male □ Female

2. **Age:……………………years**
3. **Highest level of education before your current nursing course**
   □ A-level or/ and access courses or equivalent □ Bachelor of Science □ Post-graduate

4. **Ethnicity**
   □ White
   □ Mixed/ multiple ethnic groups [White and Black Caribbean, White and Asian, White and Black African]
   □ Asian/Asian British
   □ Black/African/Caribbean/Black British
   □ Other Ethnic Group

5. **Previous experience in health care settings before and during your nursing study**
   □ Clinical role:……………………… □ Non clinical role:………………………
   □No previous experience in health care settings, go to question 6.

6. **Years of previous experience in health care settings before and during your nursing study**
   □ In clinical role:…………………… □ In non clinical role:………………………

7. **Type of clinical placement during your study**
   □ Mixed [Medical and surgical] without emergency or intensive care
   □ Mixed [Medical and surgical] with emergency care
   □ Mixed [Medical and surgical] with intensive care
   □ Mixed [Medical and surgical] with emergency and intensive care

8. How many hours did you sleep last night?
□ 5 hours or less than 5 hours □ 6-8 hours □ more than 8 hours

9. Do you feel tired? □ Yes □ No

10. Do you have any learning difficulties? □ Yes □ No
…………………………………………

11. English is your first language? □ Yes □ No

Appendix 15: Ethical approval

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16th July 2015

Naim Abdulmohdi

Dear Naim

Principal Investigator: **Naim Abdulmohdi**

DREP number: **SNM/DREP/14-014**

Project Title: **Using scenario based simulation of 'deteriorated patients' to develop nursing students' clinical reasoning and decision-making abilities.**

I am pleased to inform you that your ethics application has been approved by the Faculty Research Ethics Panel (FREP) under the terms of Anglia Ruskin University's Research Ethics Policy (Dated 23/6/14, Version 1).

Ethical approval is given for a period of 3 years from 16th July 2015.

It is your responsibility to ensure that you comply with Anglia Ruskin University's Research Ethics Policy and the Code of Practice for Applying for Ethical Approval at Anglia Ruskin University, including the following.

- The procedure for submitting substantial amendments to the committee, should there be any changes to your research. You cannot implement these amendments until you have received approval from DREP for them.
- The procedure for reporting adverse events and incidents.
- The Data Protection Act (1998) and any other legislation relevant to your research. You must also ensure that you are aware of any emerging legislation relating to your research and make any changes to your study (which you will need to obtain ethical approval for) to comply with this.
- Obtaining any further ethical approval required from the organisation or country (if not carrying out research in the UK) where you will be carrying the research out. Please ensure that you send the DREP copies of this documentation if required, prior to starting your research.
- Any laws of the country where you are carrying the research and obtaining any other approvals or permissions that are required.

Continued………

- Any professional codes of conduct relating to research or requirements from your funding body (please note that for externally funded research, a Project Risk Assessment must have been carried out prior to starting the research).
- Completing a Risk Assessment (Health and Safety) if required and updating this annually or if any aspects of your study change which affect this.
- Notifying the DREP Secretary when your study has ended.

Please also note that your research may be subject to random monitoring.

Should you have any queries, please do not hesitate to contact me. May I wish you the best of luck with your research.

Yours sincerely,

Sarah Redsell

Cc Eddie Wallis-Redworth/Stewart Piper/Amanda Drye (DREP Reviewers)
Sharon Andrew (Supervisor)
Beverley Pascoe (RESC Secretary)

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Appendix 16: Participant information sheet for phase 1

PARTICIPANT INFORMATION SHEET

Title of project:
Using scenario based simulation of ‘deteriorating patients’ to develop nursing students’ clinical reasoning and decision-making skills. Phase 1

Invitation to participate
I am currently studying for my PhD at Anglia Ruskin University where I am also a Senior Lecturer. I would like to invite you to take part in my research by participating in the testing of a clinical scenario about how to manage a clinically deteriorating patient using a clinical decision making (CDM)-Focused Human Patient Simulation experience.

Purpose and value of the study
In my study I am interested in exploring nursing students’ style of making clinical decisions and how they reason their actions. Clinical reasoning is considered an essential skill in developing nursing practical competency, central to nursing professional practice and a key to the recognition and management of deteriorating patients. A number of clinical studies found that nurses with effective clinical reasoning skills have a positive impact on the patient outcome. In the UK nursing students’ clinical reasoning level and the impact of simulation on improving nurses’ clinical reasoning is not yet clear.

Why you have been invited to take part?
You have been invited to participate in this research because you are a third-year student in the last 6 months of your study. Your opinion and participation will be valuable to inform the tool design and its usefulness in training and clinical practice.

What will happen if you agree to take part? This study has two phases.
Phase 1
If you decided to take part in this study, you will meet the researcher and participate in this study. This will take up to two hours. Initially you will complete a short data collection form and a pre-test before the experiment, and then you will be oriented to the simulation environment and key clinical approach in response to the acutely deteriorating patient before participating in the scenario. The experiment focuses on responding to a scenario- based acutely ill patient using human patient simulator (HPS). You will talk through your actions using “think aloud” about how you would recognise and respond to the symptoms of deterioration. The experiment will last between 10-15 minutes and a debrief session of similar duration will follow the simulation experience to reflect on this experience and the possible strategies that may enhance your clinical decision making. A post-test will be used to assess any differences. The experiment will be video recorded to analyse the different approaches and modes of decision making used by the participants.

After 4-6 weeks of clinical practice the researcher will invite you to attend an individual interview to seek your opinion about the usefulness of the simulated experience for your clinical practice. This will enable the researcher to collect feedback about how to enhance the simulation experience design. The interview will be audio recorded to assist with analysis of your feedback.

What will happen to the results of the study?
The result of this phase will inform the development of a teaching and learning tool that will help future nurses identify their mode of decision making and how to enhance their skills and subsequently increase their clinical effectiveness. The results of the whole project will be discussed in my PhD thesis. Initially the results of the research will be disseminated locally. Results will be available for you to see. I intend to publish the results of the research in relevant nursing/educational literature. I will also be presenting findings at relevant conferences. You will not be identified in any publication, presentation or report.

Source of funding for the research
The researcher has received a small amount of funding from Anglia Teaching and Learning to buy access to the clinical reasoning test and to offer some compensation for participants' travel and time taken to participate in the study.

Can you refuse to take part?
You have the right to refuse in taking part in this study at any time without explanation.
You have the right to omit or refuse to answer or respond to any question that is asked of you.

Can you withdraw at any time?
You may decide to stop being a part of the research study at any time without explanation. You have the right to ask that any data you have supplied to that point be withdrawn /destroyed.

What are the risks and precautions that need to be taken?
There are no known risks for you in taking part in this study, nor any special precautions to take before, during or after taking part in this study. However, if you become distressed during the simulation, the researcher will stop the scenario immediately. The researcher will only resume the simulation after a break, when you feel ready and only after careful considerations and assessment to ensure that the signs and cause of distress have been resolved. You always will have the right to withdraw at any time as explained above. To further address this potential risk there are support services that you can freely access the Counselling and Wellbeing services on 0845 196 6700 / 6701and their website is http://www.mentalhealthmatters.com/

Agreement to participate in this research should not compromise your legal rights should something go wrong
Taking part in this study will not compromise your legal rights should something go wrong and then you may have grounds for legal action for compensation against Anglia Ruskin University but you may have to pay your legal costs.

What will happen to any information collected from you?
All information which is collected from you during the course of this research will be kept strictly confidential.

What are the benefits from taking part?
Although there are no known personal benefits for you in taking part of this study, it would be a useful learning experience for you to add in your curriculum vitae (CV). Since this study will take a total of three hours from your time, for the simulation and the follow up interview, and it requires from you to travel to Anglia Ruskin University clinical laboratory at Cambridge, a gift voucher of £20 will be given to the participant at the end of the study as a token of thanks the undertaking time to travel and participate in this study.

Will your participation in the project be kept confidential?

All participants will be anonymous and given a research code, known only to the researcher (for example Participant No.1, 2, 3) and will only be referred to by this number. A list identifying participants to the research codes data will be held on a password protected computer accessed only by the researcher hard paper data will be stored in a locked cabinet, within locked office, accessed only by the researcher. Any electronic data about your participation will be stored on a password protected computer known only by researcher. The pre-and post- test is administered by a specialist company called "Insight Assessment, LLC" that own the test. Participant's data will be coded and entered to the system by the researcher who will give each participant a unique code to protect their anonymity and match the tests results. The test result is saved in an account for the researcher. This account is restricted, password protected, and can only be accessed by the researcher and the "Insight Assessment, LLC" staff with administration level, for trouble shooting purposes. "Insight Assessment, LLC" computers are password protect and located within an area that can only be accessed by "Insight Assessment, LLC" staff.

If you require further information please contact

Naim Abdulmohdi, PhD students. Tel: ; Email:

Dr Sharon Andrew, Professor of Nursing, Doctoral Supervisor
Tel: ; Email:

Thank you for taking the time to read this information sheet.
YOU WILL BE GIVEN A COPY OF THIS TO KEEP,
TOGETHER WITH A COPY OF YOUR CONSENT FORM

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Appendix 17: Participant information sheet for phase 2

PARTICIPANT INFORMATION SHEET

Title of project:
Using scenario based simulation of 'deteriorating patients' to develop nursing students' clinical reasoning and decision-making skills. Phase 2

Invitation to participate
I am currently studying for my PhD at Anglia Ruskin University where I am also a Senior Lecturer. I would like to invite you to take part in my research by participating in the second phase of my study by attending a brief follow up interview. The aim of this one to one interview is to discuss your thoughts and feelings about the simulation experience you had and whether it impacted on your clinical practice.

Purpose and value of the study
In my study I am interested in exploring nursing students' style of making clinical decisions and how they reason their actions. Clinical reasoning is considered an essential skill in developing nursing practical competency, central to nursing professional practice and a key to the recognition and management of deteriorating patients. A number of clinical studies found that nurses with effective clinical reasoning skills have a positive impact on the patient outcome. In the UK nursing students' clinical reasoning level and the impact of simulation on improving nurses' clinical reasoning is not yet clear. Your feedback about the simulated experience is valuable to assess whether the skills and strategies learned from the simulation experience can be translated to clinical practice.

Why you have been invited to take part?
You have been invited to participate in this research because you are a third-year student in the last 6 months of your study. Your opinion and participation will be valuable to inform the tool design and its usefulness in training and clinical practice.
Also it will help us to assess the impact of structured simulation experience on attaining clinical reasoning skills and improving decision making skills.

What will happen if you agree to take part? This study has two phases.
Phase 2
If you decided to take part in the second phase of this study, after 4-6 weeks of clinical practice, post the first phase of this study, the researcher will invite you to attend an individual interview. The aim of this interview is to seek your opinion about the usefulness of the simulated experience to your clinical practice. The interview will be audio recorded and will last up to an hour.

What will happen to the results of the study?
The result of this phase will inform the development of a teaching and learning tool that will help future nurses identify their mode of decision making and how to enhance their skills and subsequently increase their clinical effectiveness.
The results of the whole project will be discussed in my PhD thesis.
Initially the results of the research will be disseminated locally. Results will be available for you to see. I intend to publish the results of the research in relevant nursing/educational literature. I will also be presenting findings at relevant conferences. You will not be identified in any publication, presentation or report.

Source of funding for the research
The researcher has received a small amount of funding from Anglia Teaching and Learning to buy access to the clinical reasoning test and to offer some compensation for participants' travel and time taken to participate in the study.

Can you refuse to take part?
You have the right to refuse in taking part in this study at any time without explanation. You have the right to omit or refuse to answer or respond to any question that is asked of you.

Can you withdraw at any time?
You may decide to stop being a part of the research study at any time without explanation. You have the right to ask that any data you have supplied to that point be withdrawn /destroyed.

What are the risks involved and precautions that need to be taken?
There are no known risks for you in taking part in this study, nor any special precautions to take before, during or after taking part in this study. However, if you become distressed during the simulation, the researcher will stop the scenario immediately. The researcher will only resume the simulation after a break, when you feel ready and only after careful considerations and assessment to ensure that the signs and cause of distress have been resolved. You always will have the right to withdraw at any time as explained above.
To further address this potential risk there are support services that you can freely access the Counselling and Wellbeing services on 0845 196 6700 / 6701and their website is http://www.mentalhealthmatters.com/

Agreement to participate in this research should not compromise your legal rights should something go wrong
Taking part in this study will not compromise your legal rights should something go wrong and then you may have grounds for legal action for compensation against Anglia Ruskin University but you may have to pay your legal costs.

What will happen to any information collected from you?
All information which is collected from you during the course of this research will be kept strictly confidential.

What are the benefits from taking part?
Although there are no known personal benefits for you in taking part of this study, participating in this study would be a useful learning experience for you to add in your curriculum vitae (CV).
Since this study will take a total of three hours from your time, for the simulation and the follow up interview, and it requires from you to travel to Anglia Ruskin University clinical laboratory at Cambridge, a gift voucher of £20 will be given to the participant to compensate for travel and time for participation in this study.

Will your participation in the project be kept confidential?
All participants will be anonymous and given a research code, known only to the researcher (for example Participant No.1, 2, 3) and will only be referred to by this number. A list identifying participants to the research codes data will be held on a password protected computer accessed only by the researcher hard paper data will be stored in a locked cabinet, within locked office, accessed only by researcher. Any electronic data about your participation will be stored on a password protected computer known only by researcher. The pre and post- test is administered by a specialist company called "Insight Assessment, LLC" that own the test. Participant's data will be coded and entered to the

system by the researcher who will give each participant a unique code to protect their anonymity and match the tests results. The test result is saved in an account for the researcher. This account is restricted, password protected, and can only be accessed by the researcher and the “Insight Assessment, LLC” staff with administration level, for trouble shooting purposes. “Insight Assessment, LLC” computers are password protect and located within an area that can only be accessed by “Insight Assessment, LLC” staff.

If you require further information please contact
Naim Abdulmohdi, PhD student. Tel: ; Email:

Dr Sharon Andrew, Professor of Nursing, Doctoral Supervisor
Tel: ; Email:
Thank you for taking the time to read this information sheet.
YOU WILL BE GIVEN A COPY OF THIS TO KEEP,
TOGETHER WITH A COPY OF YOUR CONSENT FORM

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Appendix 18: A Participant Consent Form Phase 1

A Participant Consent Form

NAME OF PARTICIPANT:

Title of the project: Using scenario based simulation of 'deteriorating patients' to develop nursing students' clinical reasoning and decision-making skills. Phase 1

Main investigator and contact details: Naim Abdulmohdi, PhD student
East Road Campus, Young street site
Cambridge
CB1 1PT
Tel:
Email:

1. I agree to take part in the above research. I have read the Participant Information Sheet which is attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.

2. I understand my participation will be video recording as part of this study and I agree to participate.

3. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.

4. I have been informed that the confidentiality of the information I provide will be safeguarded.

5. I am free to ask any questions at any time before and during the study.

6. I have been provided with a copy of this form and the Participant Information Sheet.

7. I agree to the University[1] processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of participant (print)…………………………Signed………………..….Date………………

Name of witness (print)……………………………..Signed………………..….Date………………

[1] "The University" includes Anglia Ruskin University and its partner colleges

YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project:

I WISH TO WITHDRAW FROM THIS STUDY

Signed: ___________________________________ Date: _____________________

Appendix 19: A Participant Consent Form Phase 2

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A Participant Consent Form

NAME OF PARTICIPANT:

Title of the project: Using scenario based simulation of 'deteriorating patients' to develop nursing students' clinical reasoning and decision-making skills. Phase 2

Main investigator and contact details: Naim Abdulmohdi, PhD student
East Road Campus, Young street site
Cambridge
CB1 1PT
Tel:
Email:

1. I agree to take part in the above research and for the interview to be audio-recorded. I have read the Participant Information Sheet which is attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.
2. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.
3. I have been informed that the confidentiality of the information I provide will be safeguarded.
4. I am free to ask any questions at any time before and during the study.
5. I have been provided with a copy of this form and the Participant Information Sheet.
6. I agree to the University[2] processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of participant (print)………………………….Signed…………………..….Date………………

Name of witness (print)……………………………..Signed…………………..….Date………………

[2] "The University" includes Anglia Ruskin University and its partner colleges

YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project:

I WISH TO WITHDRAW FROM THIS STUDY

Signed: ___________________________________ Date: ______________________

Appendix 20: An example of transcription from concurrent TA

Black: participant **_italic and bold: patient_** **L: Line**

Time (minutes)	Content of concurrent think aloud
0	L001: When did that blood transfusion start? L002: Do you have Hb level? L003 how are you feeling? ***Response: I have pain in my leg and I fell of short of breath***
1.00	L004: you just come back from operation, L005: Do you know where you are? I am in a hospital? L006: Do you know which one you are in? ***Response: Yes***
2.00	L007: I going to do a set of observation
2.05	L008: if that is alright with you and L009: to check what is going on L010: Her temperature 37.9
3.00	L011: I am going to check your blood pressure?
3.20	L012: Blood pressure is 100/50 L013: Checking radial pulse L014: Strong pulse with rate of 110bpm L015: I am going to check your breathing L016: Respiratory Rate 23 L017: Do you find it difficult to breath ***Response: heavy breathing response in full sentence*** L018: How much oxygen?
5.35	L019: you are on 5 litres
7.00	L020: do you have any pain carol? ***Response: Yes in my hip,*** L021: Did you have pain killer, ***Response Yes paracetamol*** L022: I am thinking if you can take more L023: let me review your drug chart. L024: you have received paracetamol earlier L025: Do you have any allergies, ***Response: no*** L026: ok no known allergy L027: I am going to conclude my assessment

	L028: The patient airway is clear and
8.30	L029: she is speaking in full sentences
8.35	L030: Breathing is quite rapid and shallow
	L031: she on 5 litres
	L032: Oh forgot sat
	L033: Sat is now 93% and
	L034: according to the drug chart, target is 94-98%
	L035: Carol can you take slow deep breath for me
	L036: Ok I will need to sit..,
	L037: let me check the wound site if that is ok
	L038: it is in your right hip?
	L039: I can’t see any bleeding and little in the drain
	L040: nothing unusual I the site.
	L041: carrying on with my assessment,
	L042: her breathing;
	L043: she has wheezing sounds and little like striders,
	L044: however, she is cognitive awake
	L045: Can you hearing me Carol?
	L046: Saturation is 93%,
	L047: do you have a history of COPD?
	Response: no
	L048: as per her history no COPD
	L049: she had Acute Coronary Syndrome and
10.40	L050: it looks like most of her drugs have been stopped this morning

Appendix 21: An example of coding nursing concepts and their frequencies from a participant

Time (minutes)	Content of concurrent think aloud	Concept coding
2.05	L008: if that is alright with you and	L08-015 Circulation
	L009: to check what is going on	
	L010: Her temperature 37.9	
3.00	L011: I am going to check your blood pressure?	
3.20	L012: Blood pressure is 100/50	
	L013: Checking radial pulse	
	L014: Strong pulse with rate of 110bpm	
	L015: I am going to check your breathing	L015-019 Breathing
	L016: Respiratory Rate 23	
	L017: Do you find it difficult to breath	
	Response: heavy breathing response in full sentence	
	L018: How much oxygen?	
5.35	L019: you are on 5 litres	
	L020: do you have any pain carol?	
7.00	***Response: Yes, in my hip,***	L020-024 Disability [eliminating pain as cause of breathing symptoms]
	L021: Did you have pain killer,	
	Response Yes paracetamol	
	L022: I am thinking if you can take more	
	L023: let me review your drug chart.	
	L024: you have received paracetamol earlier	
	L025: Do you have any allergies,	
	Response: no	L025-036 Breathing
	L026: ok no known allergy	
	L027: I am going to conclude my assessment	
	L028: The patient airway is clear and	
8.30	L029: she is speaking in full sentences	
	L030: Breathing is quite rapid and shallow	
	L031: she on 5 litres	
	L032: Oh forgot sat	
	L033: Sat is now 93% and	
	L034: according to the drug chart, target is 94-98%	
	L035: Carol can you take slow deep breath for me	
	L036: Ok I will need to sit..,	
9.30	L037: let me check the wound site if that is ok	L037-040 Circulation
	L038: it is in your right hip?	
	L039: I can't see any bleeding and little in the drain	
	L040: nothing unusual I the site.	
	L041: carrying on with my assessment.	

An example of the frequencies of nursing concept based on the section above

Nursing concept	Frequency
Airway	0
Breathing	2
Circulation	2
Disability	1
Exposure	0

Appendix 22: An example of exported part from NVivo for coding operator diagnose

<Internals\\Concurrent Think aloud\\B1 con TA NVIVO> - § 3 references coded [1.12% Coverage]

Reference 1

L076: Infusion are running at steady rate
L077: I am thinking about hypovolemia
L078: due to her surgery and

Reference 2

L105: Ok 10 minutes I did her temperature,
L106: let me check your temperature again
L107: it is 38.5c, that is high!
L108: I am thinking about sepsis
L127: So this rolling out bleeding and hypovolaemia,
L128: no signs that I can see of losing fluid,

Reference 3

L175: She is already on Antibiotic; Tazocin
L176: but is due in 6 hours,
L177: so I need to speak to the doctors
L178: as it looks to me, this is an infection
L180: as having high temperature
L181: and high HR,
L182: low BP

This participant used operator diagnose on three occasions as identified in the references above. Therefore, the frequency of occurrence of this operator for this participant was 3.

Appendix 23: An example of coding and counting the frequency of cognitive operators

Content (verbal report)	Coded Nursing Concept	Coded cognitive Operator
L001: Mrs Stone how are you? **Response: I feel short of breath and I have this pain** L002: I think you might be due for some paracetamol L003: you could have that for the pain L004: the patient is talking to me, L005: so she is alert and responding, L006: her airway is clear while talking to me. L007: Her saturation was 95% which is ok L008: that is within normal range L009: as be her chart. L010: Ok those observations were at 0900 o clock not now, L011: so I need set of observations.	*Airway* *Breathing*	*L001 collect* *L002-003 Act* *L004 collect* *L005 interpret* *L006: infer* *L007: interpret* *L008: interpret* *L009- L010: review* *L011: Plan*
L012: so her BP pressure is 100/50, L013: Ok her pulse is 110. L014: and her saturation is 93% L015 on 5 litres normal mask, it is not ideal L016: as she is having a lot of oxygen. L017: What is her Hb level now? **Response: 75 as in the theatre record** L018: ok 75 g L019: and her blood transfusion, L020: this is the first bag. **Response: Yes** L021: Ok I am jumping from A to C. hmm L022: airway is clear, L023: breathing is fast, L024: but bilateral chest movement, L025: so she has not have any collapsed lung L026: or anything like pneumothorax L027: where about is the pain **Response: in my right hip** L028: so the pain is not coming from the chest, L029: that would be due to her operation L030: and so she need more analgesia L031: to control her pain	*Circulation* *Breathing* *Circulation* *Airway* *Breathing* *Disability*	*L012-L013 collect* *L014: collect* *L015-L016: relate* *L017-L018: Collect* *L019-L020: collect* *L022: infer* *L023: interpret* *L024: collect* *L025: interpret* *L026: infer* *L027: collect* *L028: infer* *L029: rationale* *L030: course of action* *L031: rationale*
L032: Circulation, the pulse L033: she has got high pulse L034: she is compensating L035: as she low blood volume L036: because she has low Hb L037: so suffer some haemorrhage	*Circulation*	*L032 collect* *L033-interpret* *L034-rationale* *L035-relate* *L036-rationale* *037: diagnose 1*

L038: while she was in theatre L039: what was the blood pressure, L040: so it is 103/50, L041: she is maintaining her BP L042: because of the high pulse. L043: Her spo2 is going down L044: because of the low Hb L045: which should be corrected by the blood transfusion. L046: She has got fluid running as well, L047: she already had 900 ml.	*Breathing* *Circulation*	*L038: relate* *L039-40: collect* *L041-42: rationale* *L43: interpret* *L044: relate* *L045: rationale* *L046: collect* *L047: collect*
L048: Ok, I need to check the temperature, L049: ok *it is 37.9c* L050: So that increased since the morning, L051: she is on prophylactic antibiotic for her surgery. L052: I am just.. L053: How long that blood has been running for? **Response: almost one hour** L054: so that should be fine, L055: in term if she is having anaphylaxis or any of that. L056: So she did not have any problem in the last 45 minutes L057: then that should be ok. L058: What else and then L059: Disability, L060: what is her blood sugar	*Disability*	*L048: plan* *L049: collect* *L050-051: relate* *L053: collect* *L054-l055: infer* *L056: rationale* *L057: infer* *L058-59: plan* *L060: collect*

An example of counting operators' frequencies based on the section above This was done in NVivo and then manually checked using word documents by adding the finding from each participants in tables

Operator name	Frequency of each operator used by this participant in the section above
Plan	3
Review	1
Collect	15
Interpret	7
Relate	5
Infer	6
Rationale	7
Match	0
Predict	0
Diagnose	1
Goal	0
Course	1
Act	1
Evaluate	0

Appendix 24: Frequency and timing of type of CDM and reasoning

Student Code	**Type of CDM and reasoning: Concurrent TA data for all students**										
A1	Forward	Forward	Backward	Forward	Backward	Backward	Forward	Forward	Backward	Backward	Forward
B1	Forward	Automated	Backward	Forward	Forward	Forward	Backward	Forward	Backward		
C1	Forward	Automated			Backward	Backward		Pattern	Pattern		
D1	Forward	Automated	Backward	Backward		Forward	Forward	Backward	Backward	Forward	
E1	Forward	Backward	Automated	Forward		Forward	Forward	Backward	Backward	Pattern	
F1	Forward	Backward		Forward	Backward	Forward	Forward	Backward			
G1	Forward	Automated	Forward	Forward		Forward	Forward	Backward	Forward	Backward	Backward
H1	Forward			Forward	Backward		Forward	Forward	Backward	Pattern	
I1	Forward		Forward	Backward		Forward		Forward	Backward	Pattern	
K1	Forward	Automated	Forward				Forward			Pattern	
L1	Forward	Automated	Backward	Backward	Forward			Forward			
M1	Forward	Automated	Forward	Forward		Forward	Backward	Forward	Backward	Pattern	
N1	Forward	Automated	Forward		Forward			Forward			
O1	Forward	Automated	Forward	Backward		Pattern	Forward		Forward		
P1	Forward	Automated	Forward		Backward	Forward		Forward		Pattern	Forward
Q1	Forward	Pattern	Backward		Backward	Forward		Backward			
R1	Forward	Automated	Forward	Forward	Forward	Backward	Backward	Forward	Forward	Forward	Forward
T1	Forward	Automated	Forward	Backward		Backward	Forward	Pattern	Forward	Backward	
U1	Forward	Automated	Forward		Pattern	Backward		Forward	Pattern		
V1	Forward	Automated	Forward		Forward	Forward			Forward		
W1	Forward	Automated	Forward	Backward	Forward		Forward			Pattern	Forward
X1	Forward	Automated	Backward		Forward		Backward		Pattern	Forward	
Y1	Forward	Backward		Forward	Backward	Forward	Backward	Pattern	Forward	Backward	
	Beginning of TA protocol				Middle of the protocol			End of the TA protocol			

Appendix 25: Concepts and related cues used by participants

Category	Type of Cue used	Related clinical problems identified
Airway	Ability to speak full sentence	Compromised airway
	Alertness	
	Tracheal deviation	
	Air entry and chest movement	
	History of airway diseases	
	Effects of drugs	
Breathing	Respiratory rate	Difficulty of breathing
	Depth of breathing	Pneumothorax
	Effort of breathing including shortness of breath	Pulmonary oedema
	Breathing sounds- wheeze	Hypoxia/ hypoxaemia
	Oxygen saturation	Pulmonary embolism
	Oxygen therapy	Respiratory failure
	History of lung disease	
	Previous and current medications	
	Smoking	
	Skin colour	
	Arterial blood gas	
Circulation	Heart rate	Hypovolaemia or internal bleeding
	Blood pressure	Sepsis
	Capillary refill time	
	Temperature	Dehydration due to sepsis
	Skin colour	Chest infection
	Cardiac rhythm using ECG	Anaphylactic or allergic reaction
	Urine output	Acute Kidney injury
		Cardiac problem
	Patient weight	Fluid overload
	Urine colour	Respiratory failure
	Fluid balance	
	Blood transfusion	
	Intravenous fluid therapy	
	Drains output	
	History of cardiac diseases	
	Blood levels	
	Type of blood group	
	Wound site assessment for bleeding	
	Wound site assessment for bleeding infection	
	Time of transfusion	
Disability	Level of consciousness	Pain
	Serum glucose level	
	Effect of medication	
	Pain assessment	Cause for breathing difficulty
	Level and type of analgesia	
	Level of anxiety and distress	

Exposure	Skin colour	
	Rash	Assessment of allergic reaction and sepsis
	Surgical site	
	Drainage bag	Assessment of hypovolaemia
	Medications	

Appendix 26: Type of cues (confirmatory and dis-confirmatory)

Confirmatory cues	Total average collected	Average usage when main problem is solved	Average usage when main problem is not solved
Ability to speak (airway patency)	1.65	**1.70**	1.6
Respiratory rate	0.96	.43	1.4
O2 saturation	1.87	**1.93**	1.78
Breathing sounds	.52	.43	.67
Effort of breathing and shortness of breath	1.56	.95	1.56
Pulse rate	1.45	1.36	1.67
Blood pressure	1.43	1.36	1.56
Capillary refill time	.22	.14	.33
Presence of rash	.48	**.57**	.33
Temperature	1.30	1.29	1.33
Time of transfusion	.61	**.71**	.44
Total	12.05	10.87	12.67
Dis-confirmatory cues	**Total average collected**	**Average usage when main problem is solved**	**Average usage when main problem is not solved**
Urine output	.82	**.86**	.78
Fluid balance	.61	.57	.67
Drainage and wound site	.91	**1**	.78
Consciousness level	.57	**.57**	.56
Serum glucose level	.43	.29	.67
Haemoglobin level	.48	.21	.89
Pain from surgical site	1.09	1.07	1.11
Medications	0.22	.21	.22
Total	5.13	4.78	5.68
Number in bold appeared to contribute more in solving the main problem.			

Appendix 27: The effect of CDM processes on HSRT score

Factor: CDM processes	**HSRT sub-score**	Analysis results
	Induction	Forward: r = -.33, p =.06, backward r= .29, p= .09 Pattern r =.39, **p =.034**, automated r= -.24, p=.13 Adjusted R^2= .129, F (4, n= 18) =1.81, p= .17 Forward β = - .19, p=.44, backward =.28, p= .20 Pattern β = .29, p=.23, automated = -.14, p= .57
	Deduction	Forward: r = -.1, p =.65, backward r= .57, **p= .004** Pattern r = -.002, p =.50, automated r= -.33 , p= .06 Adjusted R^2= .25, F (4, n= 18) =2.8, **p= .057** forward β = - .20, p=.39, backward =.56, **p= .012** Pattern β = - .095, p=.67, automated =.14, p= .50
	Analysis	Forward r = .22, p =.16, backward r= .48, **p= .01** Pattern r = -.14, p =.27, automated r= -.15, p= .24 Adjusted R^2= .095, F (4, n= 18) =1.58, p= .22 Forward β = .14, p=.58, backward =.46, **p= .05** Pattern β = - .05, p=.83, automated =-.05, p= .82
	Inference	Forward r = .09, p =.34, backward r= .36 , **p= .046** Pattern r = -.03, p =.15, automated r=-.23 , p= .45 Adjusted R^2= -.026, F (4, n= 18) =.86, p= .51 Forward β = .14, p=.61, backward =.30, p= .21 Pattern β = - .10, p=.69, automated =-.17, p= .48
	Evaluation	Forward r = -.14, p =.27, backward r= .24 , p= .14 Pattern r = .27, p =.10, automated r= -.29, p= .09 Adjusted R^2= .005, F (4, n= 18) =1.03 , p= .42 Forward β = -.04 , p=.89, backward =.17, p= .56 Pattern β = .30, p=.26, automated =-.24, p= .31

Appendix 28: Initial descriptive code from the thematic analysis

Initial codes	Rearranged codes and initial grouping	Sub-themes	Final themes
1. Reflecting 2. Helps in preparing to appropriately response in a specific situation 3. Enhancing sense of professional responsibility 4. Increase awareness about level of knowledge 5. Recalling and visualisation promotes self- evaluation 6. Useful in enhancing clinical experience in decision making 7. Awareness about the conscious and unconscious decision 8. Increase awareness to work in a methodical way 9. Reviewing and analysing performance 10. Actively involved by seeing and doing without help 11. Observing self and evaluating self-performance 12. Debriefing 13. Enhancing hypothesis generation 14. Effects of patient care 15. Changing way of thinking 16. Awareness about cognitive biases 17. Useful in enhancing clinical experience for future practice 18. Proximity to real world of practice 19. A learning opportunity to enhance experience 20. The need for simulated practice to enhance clinical performance 21. Confidence 22. Application and changing practice 23. Routine and automated practice 24. Awareness about being fixated	1. Reflecting 4. Increase awareness about the level of knowledge 5. Recalling and visualisation promotes self-evaluation 9. Reviewing and analysing performance 10. Active participation: involved by seeing and doing without help 11. Usefulness in observing self and self-evaluation 12. Debriefing	Learning through active participation Learning through reflection and self-evaluation Learning through debrief and feedback	**Promoting active and reflective learning**
	8. Increase awareness to work in a methodical way 13. Enhancing hypothesis generation 15. Changing way of thinking 21. Confidence in CDM	Recognise the importance to use a methodical approach Improving diagnostic skills Changing way of thinking Increase confidence	**Fostering CDM skills Development**
	7. Awareness about conscious and unconscious decisions 23. Routine and automated practice	Awareness about the types of decision making	**Recognition of the types of CDM**
	14. Effect on patient care 16. Increase awareness about cognitive biases 24. Awareness about being fixated 25. Awareness about jumping to conclusion	Awareness about cognitive biases Awareness of the impact of biases on practice	**Recognition of cognitive biases**
	2. Helps in preparing to appropriately response in a specific situation 3. Enhancing sense of professional responsibility 6. Useful in enhancing clinical experience in decision making 17. Useful in enhancing clinical experience for preparation for future practice 18. Proximity to real world of practice	Good preparation for clinical practice Application of theory to practice	**Integrating theory into practice**

25. Awareness about jumping to conclusion	19. A learning opportunity to enhance experience 20. The need for simulated practice to enhance clinical performance 22. Application and changing practice		

Appendix 29: Biases observation tool

Instructions: Complete this self-assessment before debriefing. Reflect on your performance and score yourself on a scale of 5, with 1 is poor and 5 is excellent performance. Under each behaviour a list of cognitive errors. Please circle **Yes** or **No** whether any of the following error occurred in your performance during simulation experience.

Circle	Behaviour	Poor / Excellent
	1. Correctly following evidence based protocols/pathway in a timely manner (such as early warning score or ABCDE)	1 2 3 4 5 Comments:
Yes No	Lack of knowledge about conditions or protocols	
Yes No	Omission bias: hesitation to perform particular intervention worrying about the consequences	
Yes No	Commission bias: performing unindicted deviating from protocol, tendency to action rather than inaction, due to pressure from other or desperation	
	2. **Demonstrate good data gathering skills and accurately identifying and weighting right cues**	1 2 3 4 5 Comments:
Yes No	Order effects: tendency to miss vital and relevant clues due to the order of gathered data	
Yes No	Premature closure: reaching conclusions before all the information are obtained or accept first plausible diagnosis.	
Yes No	Framing: fixated on prior decisions from others without adequate evidence	
	3. Accurately interpreting and relating relevant cues, matching pattern and demonstrating good diagnostic skills.	1 2 3 4 5 Comments:
Yes No	Representativeness bias: tendency to use typical presentation of clinical problem to reach diagnosis without considering possible alternative.	
Yes No	Confirmation bias: Seeking only data that confirms the desired or suspected problem. Or modifying interpretation of data to fit with initial prediction or selected diagnosis.	
Yes No	Availability bias: tendency for things to be judged more frequent if they come readily in mind and insufficient attention to that is not immediately present.	
	4. Demonstrate awareness about contextual factors and maintain situational awareness.	1 2 3 4 5 Comments:
Yes No	Context error: wrong perception or misinterpretation of critical cues due to background noise or interruption or lack situational awareness.	

Yes No	Anchoring bias: fixated on one issue at the expense of understanding the whole situation. Tram-lining, tunnel vision or first impression and loss of situational awareness	
	5. Accurately prioritizing the most critical care needs first.	1 2 3 4 5 Comments:
	6. **Response and initiate *appropriate* treatment/ intervention or action in a *timely* manner** (such as clinical interventions or escalating care)	1 2 3 4 5 Comments:
Yes No Yes No	Overconfidence bias: you believe you can eventually manage the situation without help. Not recognizing the need for help or our tendency to fail. Omission bias: hesitation to perform intervention warning about the consequences or lack confidence.	
	7. Demonstrate good evaluation and decision-making skills if therapies failed	1 2 3 4 5 Comments:
Yes No Yes No	Hindsight: not recognizing that no other outcome could possibly have occurred Sunk cost: failing to give up a failing therapy, intervention or plan and continue pursing lead, diagnosis or plan	