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THE EFFECTS OF DEBRIEFING ON DIAGNOSTIC REASONING DEVELOPMENT IN FAMILY NURSING PRACTITIONER STUDENTS

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THE EFFECTS OF DEBRIEFING ON DIAGNOSTIC REASONING DEVELOPMENT IN FAMILY NURSING PRACTITIONER STUDENTS

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ABSTRACT

This dissertation explores the effect of simulation and the debriefing method of Debriefing for Meaningful Learning (DML) on diagnostic reasoning development in family nurse practitioner students (FNP-s) as measured by the diagnostic thinking inventory (DTI). A total of 13 FNP-s participated in this exploratory descriptive pilot study. All students completed both the pre-DTI survey prior to the start of the study, and the post DTI survey at the study conclusion followed by the Debriefing Assessment for Simulation in Healthcare-Student Version (DASH-SV) survey. Students participated in three urgent care simulations followed by the debriefing method of DML.

The results of this study used mean comparisons in a repeated measure analysis given the small sample size. Dependent groups *t* tests revealed significant gains on the knowledge subscale but not on the flexibility items of the DTI, suggesting that the improvement in diagnostic thinking skills evidenced in this sample was due to the increase in knowledge gained from participation in the simulations and associated DML debriefings but not to any significant changes in the flexibility subscales.

The effect of the simulations followed by DML method was also evaluated on reaction time (RT) indices. Although the total DTI scores did not show evidence of a significant improvement in time related to the RT to the diagnostic questions, the knowledge subscale of the DTI showed evidence of a significant improvement in RT. The observation that these FNP-s responded to the knowledge subscale of the DTI significantly faster after the intervention than before, provides additional evidence that suggests that the diagnostic knowledge of these FNP-s was improved by this intervention. Knowledge (non-analytic reasoning) was improved by participation in the simulations followed by DML as evidenced by improvement in knowledge decision efficiency (shorter RTs) in this subscale, however, there was not a similar improvement in the RTs in the overall total DTI scores or in the flexibility subscale. Overall

scores on this debriefing method using the DASH-SV were positive. Simulation with the debriefing method of DML was found to significantly increase knowledge structure in this small sample of FNP-s.

To my loving husband, my partner and my friend. Thank-you for being there and supporting me by listening to my ideas, thoughts, arguments and conclusions, even though you could not understand much of what I was discussing. To my parents, thank you for instilling a love of reading, inquiry and learning in me as a child. Your love and support of me throughout the years has meant more than I can say.

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CHAPTER ONE

Introduction

Introduction to the Topic

In 2000, the Institute of Medicine (IOM) released a report based on data obtained from medical records of patients treated in New York hospitals in 1984 estimating that as many as 98,000 patients are harmed each year in the United States healthcare system due to medical errors. This report did not include errors due to omissions (James, 2013). Recommendations from the IOM stated that there must be a cultural change within healthcare practice to address these errors (Crawford & Lopez, 2014).

In an updated review of studies from 2006 to 2011 that examined patient harm associated with hospital care, statistical analysis concluded that the number of early deaths associated with preventable harm was estimated at more than 210,000 lethal patient events per year. The statistical analysis included errors of omissions, failure to follow medical guidelines, errors of commission, and failure to make life saving diagnoses. A "weight of the evidence" approach was further used in this study, which estimated a two-fold increase in the extrapolated statistics with a final estimate of 440,000 patient adverse events per year occurring in hospitals (James, 2013).

The IOM released a report in 2015 recommending improving diagnostic errors in healthcare and focused one of their recommendations on improving accuracy of diagnosis through processes that improve diagnostic reasoning. Failures in diagnostics occur for multiple reasons including provider biased heuristics (mental shortcuts in decision-making that can generate errors), fatigue, flawed patient-provider encounters, improper performance issues and interpretation of test results, inadequate follow-up, contextual error, communication and/or collaboration among specialties, and insufficient reflective processes of the healthcare provider (Fisher & Rourke, 2016; Singh, Schiff, Graber, Onakpoya, & Thompson, 2016). In this report the IOM (2015) concluded that based on available data in diagnostic errors, most patients would likely have an occurrence of diagnostic error in their lifetime.

Diagnostic reasoning is a multi-faceted cognitive skill that is essential to develop in nurse practitioner (NP) students to improve the ability to reach a correct clinical diagnosis. Critical thinking in the contextual domain is needed to advance to diagnostic reasoning and this requires dual processes in cognition (non-analytic and analytic) and reflective practices (Durham, Fowler & Kennedy, 2014). Educational practices that promote knowledge acquisition, feedback, and reflective practice can improve reliability in diagnostic reasoning (Singh et al., 2016). Educational institutions have a responsibility to educate and train NP students in diagnostic reasoning and application to ensure safe clinical practice. Little is known about training NP students in diagnostic reasoning and little research data is available on how this is taught in NP programs.

Background

Diagnostic errors are positioned to become the next important topic to address in patient safety initiatives (McDonald et al., 2013). However, despite the known relationships of diagnostic errors causing potential harm to patients, approaches to preventing errors in diagnosis have been poorly studied (McDonald et al., 2013; Institute of Medicine [IOM], 2015). In an analysis of malpractice claim data from the National Practitioner Data Bank from 1986-2010, diagnostic errors compared to other health related errors were the leading cause of death and disability in patient claim data and accounted for the highest monetary awards (Tehrani et al., 2013). Specific claim data related to NPs in this report showed failure to diagnose and delays in diagnosis were the most frequent malpractice claims against NPs and were awarded the highest dollar amounts (Miller, 2011).

Specific occurrences of patient harm specific to NP malpractice claims have increased by 19% since 2009 and resulted in high indemnity payments to injured plaintiffs for failures in treatment in the following order of occurrence: failure to diagnose or provide the correct diagnosis, treatment and care management, medication prescribing, equipment related and monitoring (CNA and NSO, 2012; Leigh & Flynn, 2013; Miller, 2013). These failures occurred in the required scientific core competencies of diagnosis, treatment and medication management of patients issued by the National Organization of Nurse Practitioner Faculties (NONPF); domain one core competencies in management of patient health/illness status; issued by the American Association of Colleges of Nursing (AACN) and graduate-level patient safety competencies issued by AACN and the Quality and Safety Education for Nurses (QSEN) in a combined educational consortium statement (American Association of Colleges of Nursing [AACN], 2011; AACN, 2012; National Organization of Nurse Practitioner Faculties [NONPF], 2014). Additionally, recent malpractice cases have shown that healthcare providers may be criminally charged for mistakes regarding medication errors that cause adverse events that result in death (Philipsen, 2011).

In relation to diagnosis, three category errors are common in all healthcare providers: *context errors* that fail to consider other diagnostic possibilities; *availability failures* where a familiar diagnosis is chosen and a rare diagnosis is not considered; and *premature closure* that occur by not identifying appropriate differential diagnoses (Miller, 2013). Diagnostic errors in NP practice have been poorly studied; therefore, the only data available related to errors in diagnostic reasoning is extrapolated from NP malpractice claims.

Nurse practitioners practice in complex environments that require developed critical thinking and diagnostic reasoning skills to effectively diagnose patient care problems. However, novice NP students can find the transition from bedside nurse to advanced practice provider a difficult adjustment (Durham, Fowler, & Kennedy, 2014). Thinking about patient care problems requires a switch from formulating nursing diagnosis to medical diagnosis. Cognitive and metacognitive practices that are related to heuristics, perception (explicit and implicit memory), and reflection to analyze decisions must be developed in the student to incorporate patient-centered care in diagnostic reasoning and to avoid diagnostic error (Singh et al., 2016; Scordo, 2014).

Benner's (1984) educational nursing theory describes early transitional knowledge acquisition in terms of novice (step by step rules following didactic instruction); to intermediate exploration and application; to development of expertise in practice (Benner, 1984). However, this model may not best illustrate the novice-to-expert transition needed to develop diagnostic reasoning in NP students. Newer studies in medicine discuss cognitive reasoning through a *Dual Process Theory* (DPT) of cognition that may be more appropriate for application in exploring diagnostic reasoning development among NP students. Effective interactions in cognitive reasoning development between intuition, non-analytical and analytical reasoning, and metacognition are critical and if poorly developed can lead to diagnostic errors regardless of contextual knowledge, and can be lacking even in expertise (Pelaccia, Tardif, Triby, & Charlin, 2011).

Critical thinking is a learned skill and requires knowledge of context and the development of thought, ability, affective dimension and intellectual standards (Martin, 2002). Diagnostic reasoning uses cognitive (inductive and deductive) and metacognitive (reflective) processes based on critical thinking conclusions to arrive at or eliminate a diagnostic decision within the context of diagnosis. This thinking process is dynamic and continually revised based on new information (Simmons, 2010). The processes of critical thinking, diagnostic reasoning and diagnostic decision making or judgment are interrelated and produce an outcome in healthcare that generates an optimal plan of management for patient care.

The two major themes in cognitive psychology describing cognitive processes used in diagnostic reasoning are the *Social Expected Utility Theory* (SEUT) and the *Information Processing Theory* (IPT). SEUT describes a process of how decisions should be made by expressing a statistical mathematical probability that determines judgment quality and decision accuracy (Dowding & Thompson, 2003). This may not be applicable to novice learners due to limited knowledge and experience. IPT or the hypothetico-deductive theory states decision making is a cognitive process that collects data, weighs alternatives, forms a hypothesis and determines a final judgment through scientific evidence and explains how decisions are made not how they should to be made (Simmons, 2010). IPT states only a limited amount of information can be stored and retrieved from short term memory. Other information is retained in long-term memory and may be difficult to retrieve. Hypothetico-deductive reasoning has been criticized on the belief that it only takes into account a single pathology in which all features can be explained by one diagnosis (Groves, 2007). This may not be relevant in the complex healthcare environment in which healthcare professionals now practice.

The psychological approach in the cognitive literature applied to diagnostic reasoning selects a limited number of proposed diagnoses based on the problem, collects focused data and applies dual-process systems in cognition with non-analytic (heuristic) and analytical reasoning that are interdependent and integrated. Non-analytic cognitive processes are rapid-recall, pattern-based thinking that can be affected by emotions and embeds the subjective knowledge of the clinician within the clinical context from prior experience (Ritter, 2003). Analytical reasoning is deliberate, logical, focused, and slower to consider alternative diagnoses, and requires increased cognitive functions in working memory that are thought to occur when patterns are not clear or to check and override non-analytic reasoning through reflection or metacognitive processes.

Recommendations from the IOM (2015) include that educators ensure that curricula address performance in the diagnostic process including diagnostic reasoning, teamwork, communicating with patients, collaborating with other healthcare professionals, and appropriate use of diagnostic tools. Educators should employ approaches in diagnostics that are aligned with evidence from the learning sciences and implement practices to promote feedback on diagnostic performance (Institute of Medicine [IOM], 2015). Focused data collection, analysis, physical assessment, diagnostic hypothesis generation, differentials related to data when analysis is not clear, clinical decision, assessment, and adjustment through diagnostic reasoning of the clinical decision-making all must occur through metacognitive practice (Simmons, 2010). This study will explore simulation and debriefing practices in NP students to improve diagnostic development which can assist educators to develop curricula focusing on diagnostic reasoning. The National League of Nursing (NLN) research priorities for 2016-2019 address the need to explore the use of simulation experiences on student learning affecting clinical practice (National League for Nursing [NLN], 2016).

Problem Statement

Diagnostic reasoning is a multi-faceted cognitive skill that is essential to help NP students develop to ensure they are able to correctly diagnose medical problems and conditions. Educational practices that facilitate diagnostic reasoning development in NP students have been poorly studied. Diagnostic reasoning involves cognitive and metacognitive practices that, if deficient, can lead to diagnostic errors in patient care and poor outcomes. Critical thinking within the contextual domain is needed to advance to diagnostic reasoning which requires dual processes in cognition (non-analytic and analytic) and reflective practices (Durham, Fowler, & Kennedy, 2014). Intuitive pattern recognition based on repetitive behaviors or prior experiences (heuristics) leads to expertise in that context but can also lead to diagnostic errors due to premature closure (Ark, Brooks, & Eva, 2007). Diagnostic errors are defined as missed, delayed or wrong diagnoses contributing to disability and death as patient care outcomes (Singh et al., 2016). Cognitive errors in diagnostics relate to impaired context or knowledge, heuristics or faulty intuition, and/or mental shortcuts that identify patterns present in certain diseases but may fail to consider atypical presentations or focus on distractors in patient presentations (Croskerry, 2013). Premature closure can occur when reflective practices are not utilized to review presentations of disease. The facilitation of diagnostic reasoning through reflective practices used in debriefing after simulation may improve cognitive and metacognitive abilities in NP students that can reduce diagnostic errors.

Purpose Statement

The purpose of this descriptive, exploratory study is to explore, describe and measure the effect of *Debriefing for Meaningful Learning®* (DML) on the development of diagnostic reasoning in NP students during simulated patient care scenarios. Debriefing for meaningful learning is a structured debriefing tool that is used to uncover the thinking by students after participating in simulation and has been used to facilitate clinical reasoning in undergraduate nursing students. Debriefing is described by Dreifuerst (2009) as an intentional intuitive process based on experiential learning that facilitates reflective learning by uncovering the reasons for the thinking involved (Dreifuerst, 2009). The reflective process utilized in DML is a structured debriefing method using Socratic questioning of students to uncover thinking. Socratic questioning is an approach in education that allows students to uncover thinking and arrive at a specific awareness through reflection on their reasoning (Dreifuerst, 2009).

Educational practices using simulation and debriefing can approach fidelity to real clinical situations and transfer to patient populations to reduce error. However, simulation and debriefing approaches related to teaching and learning in NP students to enhance diagnostic reasoning has not been fully explored (Giddens, Lauzon-Clabo, Morton, Jeffries, Jones, & Ryan, 2014). Simulation and debriefing provides structured clinical experiences for healthcare professionals to gain experience and learn in safe environments that permits practice and protects the public from harm (Crawford & Lopez, 2014).

Aims of Research

This study may support improved teaching and learning practices using simulation and debriefing to foster diagnostic reasoning ability and diminish failures in diagnosis in NP students. Research studies identifying educational practices to teach diagnostic reasoning to NP students are lacking and methods to teach diagnostic ability have been limited to medical studies (Myung, Kang, Phyo, Shin, & Park, 2013; Norman & Eva, 2010). The diagnostic thinking inventory (DTI) has been used as a tool in medicine to measure development of diagnostic thinking ability in medical students and is divided into two subscales that measure knowledge structure and flexibility in thinking that can show changes in diagnostic reasoning ability (Bordage, Grant, & Marsden, 1990) Traditional methods of apprentice-type clinical rotations, case studies and presentations may lack sufficient depth and breadth in developing diagnostic ability and lack immediate expert feedback in decision-making (Lange et al., 1997). NP's have unique roles that combine the competencies of nursing practice with those of medical diagnostic skills. A call to action by the National League of Nursing (NLN) Board of Governors in June of 2015 described the need for theory- based methods of healthcare debriefing to be utilized across the curriculum in nursing programs. This call to action was reinforced by the International Nursing Association for Clinical Simulation and Learning (INACSL). The NLN describes debriefing as a critical conversation that reframes learning involved in the simulation to identify and clarify perceptions and assumptions of the student related to the educational objective. Debriefing techniques are critical to advance learners reflection and stimulate critical conversations that give meaning to a given clinical situation that is unique to the patient's situation (National League of Nursing Board of Governors [NLN], 2015).

Nurse practitioner students in primary practice (including family, pediatric, adult-gerontology, and women's health specialties) comprise 84% of nurse practitioner graduates. Data released by the AACN and the NONPF in 2012 indicated there was a total of 11,764 NP primary care graduates, an 18.6 percent increase from 9,708 NP primary care graduates in 2009 (American Association of Colleges of Nursing and National Organization of Nurse Practitioner Faculties [AACN and NONPF], 2012-2013).

A recent convergence of national healthcare leaders in advanced practice nursing education identified key changes needed in NP clinical educational practices (Giddens et al., 2014). Key changes identified were development of standardized preclinical preparation that includes simulation activities, standardized student assessments measured at the onset of the program and throughout academic progression, identification of gaps and elimination of redundancy in clinical education, innovative educational practices that involve standardized patients, and high fidelity simulations and "entrustable professional activities" (EPA) that translate competencies into clinical practice (Giddens et al., 2014). An EPA is defined as a practice area or ability that can be entrusted to a student once competence has been demonstrated (Giddens et al., 2014).

Research Questions:

1. Does the educational practice of simulation with debriefing for meaningful learning (DML) method change the diagnostic reasoning ability in family nurse practitioner students (FNP-s) as measured by the diagnostic thinking inventory's (DTI) total score?
    a. Does the educational practice of simulation with the DML method change the diagnostic reasoning ability in FNP-s as measured by the DTI in the subscale of knowledge structure?

b. Does the educational practice of simulation with the DML method change the diagnostic reasoning ability in FNP-s as measured by the DTI in the subscale of flexibility in thinking?

2. Does the use of the DML method after simulation cause a change in the response time from the pre-testing diagnostic thinking inventory (DTI) to the post testing DTI in the total score?

   a. Does the use of the DML method after simulation cause a change in the response time from the pre-testing diagnostic thinking inventory (DTI) to the post-testing DTI in the subscale of knowledge structure?

   b. Does the use of the DML method after simulation cause a change in the response time from the pre-testing diagnostic thinking inventory (DTI) to the post-testing DTI in the subscale flexibility in thinking?

3. How satisfied are FNP-s with the DML method in improving their performance during the simulation as measured by the debriefing assessment for simulation in healthcare student survey (DASH-SV)? (Simon, Raemer, & Rudolph, 2011).

4. Does registered nurse specialty practice area and years of practice as a registered nurse yield differences in the diagnostic reasoning ability of FNP-s as measured by the DTI total scores?

   a. Does registered nurse specialty practice area and years of practice as a registered nurse yield differences in the diagnostic reasoning ability of FNP-s as measured by the DTI scores in the knowledge structure subscale?

   b. Does registered nurse specialty practice area and years of practice as a registered nurse yield differences in the diagnostic reasoning ability of FNP-s as measured by the DTI scores in the flexibility subscales?

Definition of Terms

For the purpose of this study terms are defined as follows:

Diagnostic reasoning. Terms synonymous with diagnostic reasoning in the medical literature include clinical reasoning, medical problem solving, and clinical decision-making. For the purpose of this study diagnostic reasoning will be used and measured by the diagnostic thinking inventory (Bordage et al., 1990; Simmons, 2010).

Metacognition. Higher-ordered thinking that enables understanding, analysis and active control of one's thought processes (Marcum, 2012).

Simulation. Simulation training has been an established educational strategy used in medical education, military and aviation for many years and has become an integral part of undergraduate nursing education. Simulation involves simulated clinical scenarios or skill facilitation and training using high fidelity mannequins, specialized simulation equipment, computer-based programs or standardized patients (Issenberg et al., 2002). High fidelity mannequins will be used in this study.

Debriefing. Debriefing is the process incorporated after simulation activities where faculty and students re-examine what occurred during the clinical simulation encounter. The Debriefing for Meaningful Learning method will be used in this study (Dreifuerst, 2012).

Standards of simulation. The International Nursing Association for Clinical Simulation Learning (INACSL) responded to the lack of standardization in simulation practices by defining best practices in simulation that were revised in 2013, expanded in 2015 and revised and simplified in 2016. These standards provide a foundation for common language, simulation design and specific core properties, objectives and outcome evaluation and standard behaviors of facilitators and learners ("Standards of best practice: Simulation," 2016).

Diagnostic thinking inventory. The DTI is a self-reported survey of 41 items that measures a total score (low to high) and two sub-scale scores (low to high) related to diagnostic thinking. The two sub-scales are the degree of knowledge structure in memory related to illness categories and the degree of flexibility in thinking or the ability to think critically (Bordage, Grant, & Marsden, 1990).

Debriefing for simulation in healthcare. The debriefing for simulation in healthcare student version (DASH-SV) is a student assessment of the debriefing method after a simulation-based experience. The survey rates the overall effectiveness of the debriefing on a seven-point scale that ranges from extremely ineffective or detrimental to extremely effective or outstanding. The DASH-SV will be used in this study to measure satisfaction with the debriefing method (Simon et al., 2010).

Pilot study. The definition of a pilot study is a small-scale feasibility study that involves preliminary research that is conducted prior to a larger phase study. This will be a pilot study of FNP-s (Morris & Rosenbloom, 2017).

Introduction to Conceptual Frameworks

Dual Process Theory of Cognition (DPTC). Cognitive psychologists have studied how medical clinicians diagnostically reason and DPTC has been widely accepted in medicine and describes two processes of reasoning (Croskerry, 2009; Durning, Dong, & Artino, 2015; Evans, 2003; Evans, 2007; Evans & Stanovich, 2013; Marcum, 2012; Osman, 2004; Pelaccia et al., 2011).

System 1 (S1) is an automatic, non-analytical, rapid intuitive process with minimal use of cognitive demand and is sometimes described as implicit thinking that relies on pattern matching and recognition. This is thought to be characteristic of expert thinking that develops through the use of deliberate or repetitive practices in medicine (Ericsson, 2008). System 2 (S2) thinking is analytical, hypothetical, and slower which uses cognitive deduction to fit information within known and appropriate schemas and is referred to as explicit (Evans, 2003). Combined use of dual processes may be more beneficial to manage complex diagnostic reasoning (Marcum, 2012).

Marcum (2012) describes an integrated DPTC and metacognition that starts with non-analytical thinking in intuitive or implicit cognition. In this proposed model an experienced clinician assesses a patient's presenting symptoms and other clinical signs triggering non-analytical or S1 thinking. However, if a diagnosis is not evident further analytical processes S2 are triggered to arrive at a diagnosis. Metacognition is used to monitor and regulate diagnostic reasoning by using reflection on new and previous knowledge to assess decisions about one's own thinking based on these two systems (Pelaccia et al., 2011). Pattern recognition, schema, repetitive practice, reflection and perception are recurring themes that support cognitive growth in diagnostic reasoning (Marcum, 2012). Cognitive and affective biases are thought to be affected in S1 reasoning and corrected by S2 through analytic and reflective practices (Croskerry, 2009). S1 (low-level control) is activated by gut feelings or hunches. S2 (high-level analytical-theory based control) is activated if the noetic feelings in S1 are thought to be wrong or uncertainty occurs. Diagnostic reasoning using DPTC is the cognitive process that leads to the decision-making or diagnosis. Modifiers within S1 can trigger S2 analytical reasoning when patterns don't match or surveillance and reassessment is needed for a blending of both systems (Croskerry, 2009). DPTC and metacognition maps two levels regulating the reasoning from emotions (low-level) to analytical (high-level) (Marcum, 2012).

The history of DPTC cognition in the non-analytical frame refers back to ancient evolution and is independent of language, intelligence or working memory or knowledge. S1 cognition is based on experience, pattern recognition, schema, scripts and experiential knowledge based on an implicit process of unconscious cognition described but not explained in “knowing how” (Marcum, 2012). S2 is an analytical process of cognition that is unique to humans and depends on language that involves abstract and analytical reasoning with inductive and deductive conclusions. Contained in S2 are two parts involving an algorithmic and a reflective mind. This process uses working memory within a specific context of knowledge and is the process of “knowing that” or “knowing what” to do (Marcum, 2012).

Jeffries Simulation Theory (JST). The theoretical framework that is frequently applied to simulation education practices is based on Jeffries’s Simulation Theory (JST) (Jeffries, 2016). Jeffries’ (2016) describes a middle range theory that predicts student outcomes with appropriate design- based educational practices used within the simulation experience. JST (2016) is not specific to nursing and may be applied across many contexts that are not nursing specific. The theory constructs include theoretical foundations in the constructivist, sociocultural and learner-centered theories that define characteristics for simulation. These measures include contextual factors, background that includes goals within the curriculum, design, simulation experience describing the environment, facilitator and educational strategies, participant attributes and outcomes (Jeffries, 2016).

Jeffries’ conceptual framework was reviewed by the National League of Nursing (NLN) project in 2010 by a panel that examined current evidence to support the original framework. Empirical adequacy of the framework was validated based on strong theoretical and empirical evidence involving the concepts of educational practices related to simulation design and variables used in simulation learning (LaFond & Van Hulle Vincent, 2013). Challenges to the framework were discussed in O'Donnell, Decker, Howard, Levett-Jones, and Miller (2014) and were related to the inconsistencies of the constructs presented in research studies through the use of inconsistent terminology with differing definitions. Supportive evidence evaluated the construct as heavily weighted in knowledge acquisition, satisfaction, clinical skill attainment, and weakest for critical thinking, clinical judgment, and confidence (O'Donnell, Decker, Howard, Levett-Jones, & Miller, 2014). Conclusions by the NLN stated the need to standardize terms and provide descriptions of constructs and outcomes that were being reported in the simulation literature (Cant & Cooper, 2009; Smith & Roehrs, 2009) and these were further defined and clarified in 2016 by the NLN in JST (Jeffries, 2016). Future research is needed to validate how learning outcomes are affected by using the NLN and JST (Mariani & Doolen, 2016).

The relationship between frameworks (DPTC and JST) within the research study is related to the educational simulation concepts described in Jeffries (2016) as an experiential learning exercise that involves a process of engagement of students that builds on prior learning through constructivist, sociocultural and learner-centered approaches. This allows the learner to assimilate and accommodate learning through exploration of conflict and to then apply resolution through a reflective debriefing practice (DML). Simulation incorporates and integrates all aspects of cognition through tactile, affective, visual and auditory domains. DPTC describes cognition linking implicit and explicit reasoning through intuition, and pattern recognition that may occur in the pre-debriefing and active simulation phase as the student receives information about the simulation and the learning objectives and applies non-analytic reasoning. Learners may utilize both non-analytic and analytic processes when coming to a diagnosis throughout the simulation experience. These processes can be affected by bias, faulty data gathering, contextual error or premature closure causing error that may be corrected through the debiasing strategies in DML to reveal metacognitive errors. The critical steps identified in debiasing strategies to mitigate cognitive failures include the ability to engage in metacognitive tasks, mindfulness and self-reflection that may cultivate diagnostic reasoning formation in novice clinicians (Croskerry, 2013). DML utilizes the processes of engagement of students through a reflective evaluation of the clinical scenario to explore the experience and actions presented in the simulation using guided reflection by the facilitator. This allows the students to explain, elaborate and explore their diagnostic reasoning (non-analytic or analytic) while the facilitator uses a white board to present a visual process in mapping of their concepts. Framing the clinical situation differently extends the debriefing to allow assimilation and accommodation to different clinical scenarios if other diagnostic factors were present. The relationship between the DPT, JST and DML method involved in this study with the DTI is through the self-reported survey data obtained from the student's diagnostic thinking prior to and after the repeated measures intervention of simulation and DML to determine changes in diagnostic reasoning ability and/or response times. The integration of these relationships is described in Figure 1.

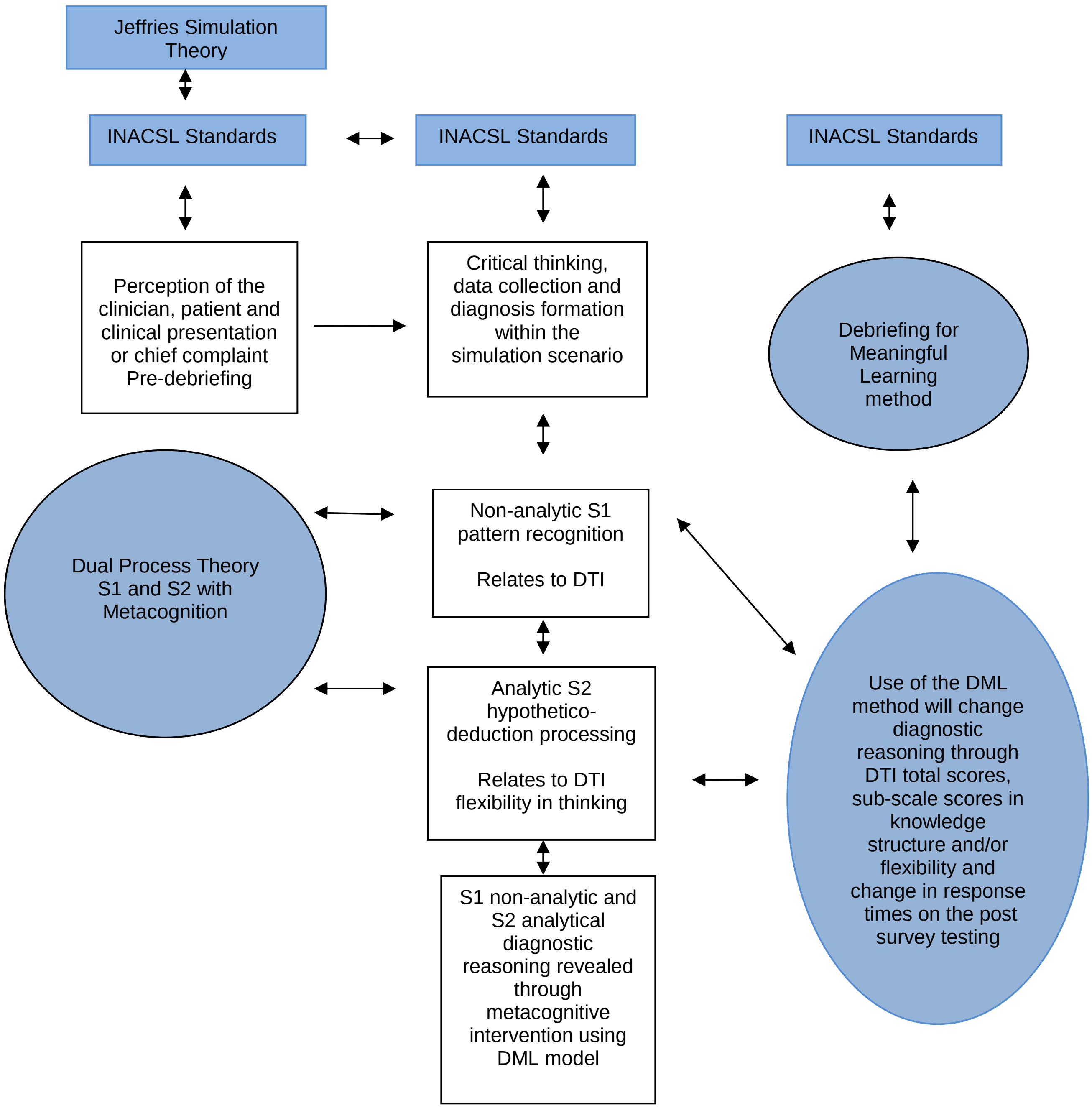


Figure 1: Integration of JST, INACSL Standards, DPTC and DML.

Scope and Nature of the Study

Little is known about the development of diagnostic ability in NP students and educational practices in clinical rotations, case studies and seminars may lack significant learning, reflection, and feedback that are required to advance diagnostic reasoning ability and avoid diagnostic error (Lange et al., 1997). Nursing theoretical models in cognition may not be appropriate due to the diagnostics required in nurse practitioner practice.

This research will be an exploratory, descriptive pilot study using a convenience sampling of NP students in the specialty of FNP. The inclusion criteria will be study participants who are registered nurses in the second clinical rotation of their graduate coursework, who have completed the core NP courses of advanced health assessment, advanced pharmacology, advanced pathophysiology and have completed one clinical rotation. Demographic data will be collected related to undergraduate college experience (accelerated or traditional), prior college degrees unrelated to nursing, year of graduation, years of practice as a registered nurse, and registered nurse specialty practice areas.

The FNP-s in groups of two to four will participate in a series of simulations (3) in the same order of simulations rotating roles of FNP leader, assistant and observer. Utilizing complex patient cases that involve both non-analytic and analytic diagnostic reasoning they will then participate in DML. Prior to the series of simulations, the FNP-s will complete informed consent, demographic data, and the DTI to provide a baseline measurement in diagnostic thinking. This will be retested at the conclusion of the pilot study. Quantitative measurements will involve total scores on the DTI and subscale scores in knowledge structure and flexibility pre-intervention and any changes after the three simulations with DML in the post-intervention scores. Changes in response time of the DTI in total score and subscale scores in knowledge structure and flexibility will be measured from pretest to post-intervention. The DASH-SV will be administered at the completion of the study to measure student satisfaction with the DML method of debriefing. Demographic data in registered nurse specialty areas, and years of practice as a registered nurse will be assessed to determine any differences in the diagnostic reasoning ability in FNP-s measured by the DTI total scores, knowledge structure and flexibility subscales before and after the interventions.

Assumptions

The assumptions related to this research are the following:

- That simulation with the DML method will change diagnostic reasoning ability in FNP students.
- Well-designed simulation educational practices through the use of JST and INACSL standards will change diagnostic reasoning ability in FNP students.
- DPT with metacognition describes the development of diagnostic reasoning ability and can be applied to correct diagnostic error through a reflective process using DML.

Limitations

This will be an exploratory, descriptive pilot study using a small convenience sample of FNPs and results may not be generalized to other NP students in different specialty practices. Because the DTI is a self-reported quantitative survey of student's diagnostic thinking ability the pre and post testing may be subject to inherent bias by the participants, survey questions may not be answered honestly, or students may fail to complete parts of or the total of the post-survey DTI. FNPs may fail to complete all or part of the DASH-SV survey. Timing of the study within the FNPs curriculum, the number of the simulations and DML, and specific FNP cohort may be a factor and not generalize across curriculums. The progression of diagnostic reasoning development may not be related to the intervention but through clinical rotations, and program continuance.

Significance of the Study

Continued focus on safety and quality outcomes in healthcare practice require educational programs to explore alternative teaching and learning interventions that are translational to improve clinical practice at the point of care. In a review of clinical decision-making and judgment used in nursing, Thompson, Aitken, Doran and Dowding (2013) advanced an agenda of research for nursing education to examine how nurses make judgements and decisions. Nursing practice involves varied clinical decisions that affect safety and quality in patient care (Thompson, Aitken, Doran, & Dowding, 2013). If diagnostic decisions are flawed, errors in diagnostic reasoning can cause failures in diagnosis, treatment and recognition of deterioration that can delay or omit administration of curative or life sustaining treatment. Studies on diagnostic reasoning involving decision-making in nurse practitioner students are limited to small samples, methodological flaws in study designs, and lack of outcome measures. Theories of judgement and decision-making in other fields that foster diagnostic reasoning especially in medicine may potentially be adapted to describe and evaluate decision-making in nursing, and in particular NP students (Thompson et al., 2013). Simulation and debriefing is an emerging field of study in educational practice of NP students and best practices to facilitate diagnostic reasoning development in NP students is not known. This study will describe and explore through the use of a pilot sample of FNP-s if the use of simulation with the DML method has an effect on diagnostic reasoning development in NP students. The use of a pilot sample of FNP-s will examine and inform the feasibility of this intervention and identify modifications needed prior to conducting a larger scale study (Leon, Davis, & Kraemer, 2011)

Summary of the Chapter

This exploratory descriptive pilot study will assist nurse educators to determine best practices in debriefing that facilitate diagnostic reasoning and cognitive patterns utilized in FNP-s.

Nurse practitioner students are unique because they present with contextual knowledge developed from previous nursing experiences that may lead to cognitive error and may not have fully developed metacognitive practices that are necessary for diagnostic reasoning to prevent error. The Institute of Medicine (2015) recently identified diagnostic errors in healthcare to involve failures to establish an accurate and timely diagnosis for the patient's healthcare problem, and failure to communicate the problem to the patient. Therefore, the identification of best practices in debriefing to enhance development of diagnostic reasoning and knowledge gains in FNP-s through reflective practices can assist nurse educators to develop curriculum that focus on educational strategies to avoid cognitive errors that contribute to patient harm. Utilizing simulation and DML as an educational strategy may assist in cognitive and metacognitive growth in diagnostic reasoning behaviors in FNP-s.

CHAPTER TWO: LITERATURE REVIEW

Introduction

Diagnostic reasoning is essential across healthcare disciplines involving diagnoses and transcends provider domains in healthcare practice. Nurse practitioners (NP's) use diagnostic reasoning to assign diagnoses to patients under their care to effectively design treatment plans that impact positive patient outcomes. Diagnostic reasoning is a critical concept in NP practice that NP students (NP-s) must develop to effectively practice within the context of their domain. Teaching and learning practices in nursing education require the development of diagnostic reasoning in NP-s to prevent errors in diagnosis and prevent harm to patients. Nurse practitioners are employed in dynamic and complex working environments that may require critical and life saving measures. Failure to reason through complex medical problems and present safe clinical judgments can result in failure to recognize and treat deteriorating patient conditions (Lapkin, Jones, Bellchambers, & Fernandez, 2010).

The American Association of Colleges of Nursing (AACN), the National Organization of Nurse Practitioner Faculties (NONPF) and Quality and Safety Education for Nurses (QSEN) define competencies for NP education. Specific competencies addressed in this research relate to AACN core competencies in assessment of health status, NONPF scientific foundations, and QSEN graduate competencies through the process of reflective practice in patient centered care, and safety practices addressing error reduction (American Association of Colleges of Nursing [AACN], 2016; American Association of Colleges of Nursing [AACN], 2012). The Institute of Medicine (IOM) issued a report in 2015 that called for improvements in the diagnostic process in healthcare through broad goals that include effective teamwork, professional education, and training in the diagnostic process, and the development of techniques and approaches to identify reduce and learn from errors (Institute of Medicine [IOM], 2015).

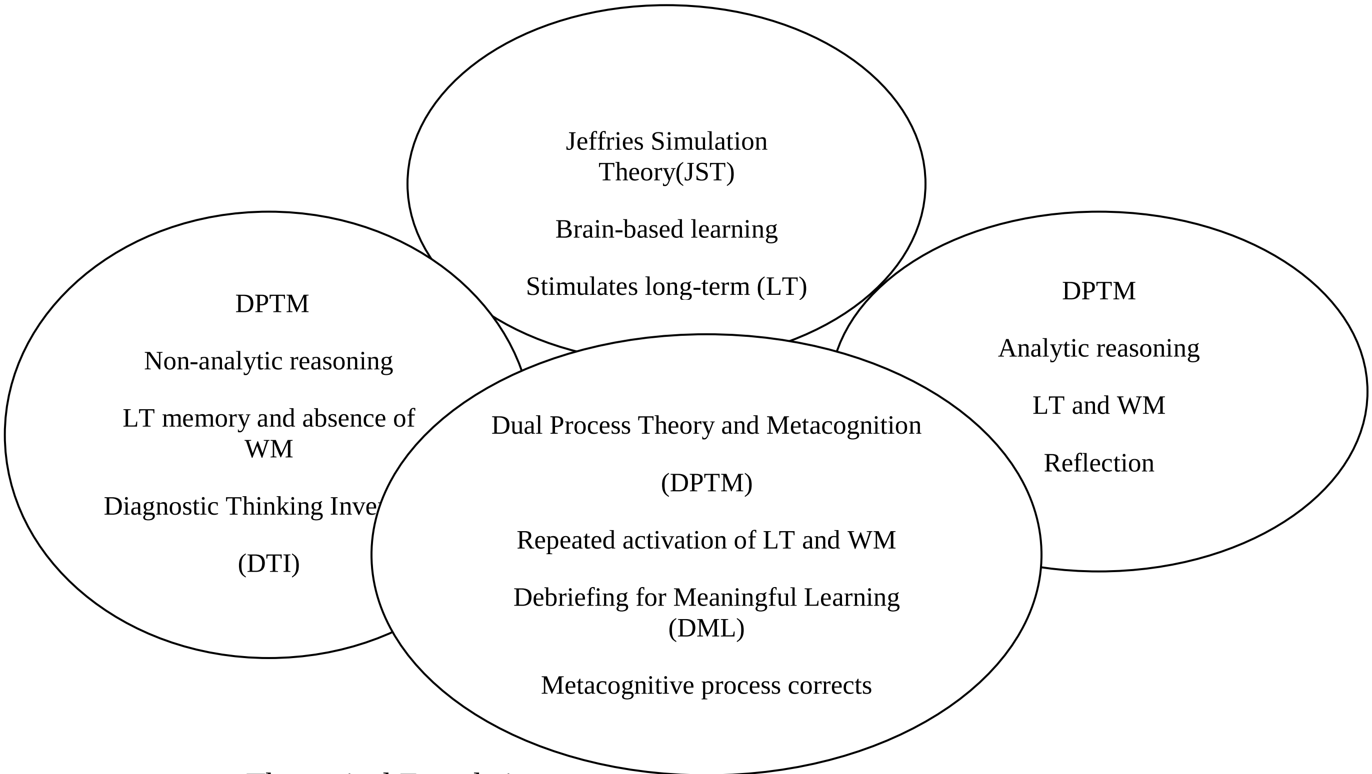
The complexity that exists in healthcare today requires higher ordered critical thinking, diagnostic reasoning, and critical reflection. The ability to think critically involves complex cognitive processes that apply contextual knowledge, evaluation of data, inductive and deductive analysis, perception, implicit and explicit cognition, the ability to challenge assumptions, and critical reflective practice (Benner, Hughes, & Sutphen, 2008). This chapter will define the conceptual models applied to these cognitive processes and explain their relationship to the proposed study.

Literature Search Strategy

The purpose of this literature review is to explore the current state of NP student education related to teaching and learning practices applied to diagnostic reasoning, simulation, and debriefing practices to identify gaps present in the literature, determine what is known about these topics, and how the proposed research can add to the topic. A comprehensive computer-assisted literature search using library sources was performed using the databases of CINAHL, Ovid, Education Research Complete, ERIC, Medline, PsycINFO, ProQuest, and Google Scholar up to December 2016.

This literature review includes research published in the psychological, medical, and nursing literature that examines the use of simulation and debriefing as a means for enhancing diagnostic reasoning. Empirical studies using randomized control trials, quasi-experimental design, convenience samples, mixed method research and qualitative design were included, in addition to relevant theoretical articles and/or articles relating to cognitive reasoning on this topic (Whittemore & Knafl, 2005). Clinical and diagnostic reasoning is synonymous in the medical and nursing literature and for this literature review the terminology *diagnostic reasoning* will be utilized. All articles that described simulation methodology, debriefing and concepts related to clinical or diagnostic reasoning were considered for inclusion. Search words utilized were: simulation education, debriefing methods, diagnostic or clinical reasoning and clinical or diagnostic reasoning instruments. Purposive sampling was then applied to include: nurse, NP, NP-s, advanced practice nursing, medical residents, physician assistants and medical students. The initial search dates for inclusion were from 1999 to 2016 which returned over 3000 articles. The search dates where then delimited to 2002-2016 due to the volume of research returned. Data was further limited to peer –reviewed journals and English language and duplicates were discarded. Dissertations were scanned for the purpose statements and a total of 422 articles were reviewed for inclusion in this research study. Inclusion criteria included studies with outcome data related to diagnostic or clinical reasoning, debriefing effects in NP, medicine and nursing students. There was no research found that specifically measured simulation and debriefing practices as a learning strategy to measure or advance diagnostic reasoning in NP-s. The conceptual model for this study is shown below in Figure 2.

Conceptual Model



Theoretical Foundation

Figure 2: JST, DPTM and the Relationships to DML, DTI and Mitigation of Diagnostic Error.

Jeffries Simulation Theory

The National League for Nursing (NLN) Jeffries Simulation Theory is a middle range theory that has specific applications related to nursing simulation education (LaFond & Van Hulle Vincent, 2013). The development of this theory came through funding offered by Laerdal Medical Corporation to the NLN in 2003 to develop and test models using simulation that promoted education in nursing practice (Jeffries, 2016). The origins of the NLN/Jeffries theory began as a conceptual framework developed through a review of the literature that examined constructs involved in simulation education and describe a descriptive view within a framework with consistent terminology of constructs. The original framework developed in 2005 described constructs in teacher, student, and educational practices involving outcomes and design characteristics (Jeffries, 2005). The framework then moved towards a descriptive theory in 2013 through the delineation and clarification of each concept within the framework providing a description of the relationships among the constructs through an exhaustive review of the literature. In 2016 additional constructs were added and the framework was deemed a theory. The additional constructs address circumstances and settings of the simulation, the use of formative or summative evaluation and descriptions of background, specific objectives, and expectations of the simulation experience placed within the larger curriculum with resource allocation of time and equipment (Jeffries, 2016).

This theory addresses components in simulation education that involve contextual factors, background, simulation design, simulation experience, facilitator, educational strategies, participant, and outcomes. Best practices supported by research in simulation from the medical literature include feedback, repetitive practice, curriculum integration, different ranges of difficulty, learning strategies, clinical variation, controlled simulation environment, individualized learning, defined outcomes and validity of the simulator (McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011).

Context/Background

The addition of context and background to the simulation framework occurred through a synthesis of the literature and key discussions of experts in simulation. Contextual factors that affect simulation involve settings in which simulation occurs in educational or practice areas and whether the simulation involves objective measurements in summative or formative evaluation. Background considers contexts that involve expectations of the simulation design and the perspective within the larger educational curriculum. This includes specific resources utilized in time, and equipment to fully develop and implement simulation education (Jeffries, 2016).

Simulation Design Components

The best practices identified in this theory for simulation design involve simulation characteristics that have well defined learning objectives, identification of the level of fidelity that is consistent, and context approaches that are realistic and authentic. The approaches to fidelity should range from low to high, depend on learning objectives, student support, debriefing practices, and problem-solving through scenario complexity (Jeffries, 2016).

Simulation Experience

This component describes the simulation experience as an experiential learning centered activity in an engaging environment that maintains trust, and collaboration between the participant and facilitator, and addresses the following educational practice components:

1. Active learning strategies through the use of student interactivity and engagement practices.
2. Feedback during the simulation that involves conceptual or reality clues to assist in the navigation of the simulation or immediately after the debriefing involving participant, peer or facilitator feedback to improve participant learning, and performance.
3. Student and faculty interaction that is learner centered, and meet specific participants learning needs. Interaction can include collaboration between the participant, and facilitator in the planning, implementation and evaluation of the simulation activity.
4. Collaboration in the simulation inspires interactivity between and among groups.
5. High expectations with defined participant objectives and attainment of mastery learning.
6. Diverse learning that involves a range of learning objectives to capture clinical variations from simple to complex, involving both group, and individualized learning, and involving multiple learning strategies.

7. Time on task can involve repetitive or deliberate practice with the use of specific sequencing of activities depending on learning objectives that have a clear beginning and ending (Jeffries, 2016).

Facilitator

The facilitator role requires the facilitator to have knowledge of theoretical and pedagogical contexts within simulation education, provides protection and guidance to participants, and maintains a safe learning environment that facilitates discovery and reduces obstacles (Jeffries, 2016).

Participant

Participants involved in the simulation education include variables in characteristics related to age, gender, readiness to learn, goals, preparedness, tolerance for ambiguity, self-confidence, learning style, cognitive load, and level of anxiety components (Jeffries, 2016). Participants involved in the simulation should have motivation, enthusiasm, and willingness to participate utilizing professionalism and realism within the role assignment to develop skills.

Outcomes

Outcomes within the simulation are separated into three components that involve the participant, the patient or care receiver, and outcomes at the system level (Jeffries, 2016). The outcomes at the system level include changes in practice, and cost-utility and at the care receiver level improved healthcare practices. The outcomes involving the participant include emotions, satisfaction, knowledge, skills, and attitudes with transfer of learning to the clinical environment (Jeffries, 2016).

Dual Process Theory

Clinical reasoning theories have been studied over many years by different professionals and involve a number of different perspectives (Round, 2001). A reasonable agreement across many disciplines is that reasoning associated with diagnosis is a multidimensional, multifaceted process that involves Dual Process Theory (DPT). The fundamentals involving DPT applicable to medicine evolved in the 1970s and 1980s by cognitive scientists to determine how physicians problem solve to arrive at a diagnoses in a clinical case (Round, 2001). The Information Processing Theory (IPT) was developed which stated that due to the limited size of working memory (WM) data is gathered in chunks using short-term memory, guided by context or content, and organized by previous constructed knowledge in long-term memory (Simon & Newell, 1971). Theorists believed the diagnostic process was shaped by a foundation of structured knowledge that was content and context specific and driven by the experience of the clinician to determine accuracy in judgments (Round, 2001). In recent years cognitive psychologists have generally accepted two distinct cognitive systems that underlie reasoning and judgment (Evans, 2003; Marcum, 2012).

Evans and Stanovich (2013) two well-known cognitive psychologists conducted extensive research in dual process and dual type theories of cognition and clarified a number of constructs related to Type 1 and Type 2 system processes (previously referred to as System 1 or non-analytic and System 2 analytic). Dual processes or dual -type systems assume the action of a cognitive task and suggest two forms of processing that contribute to decision-making or behavior that may overlap. These systems are distinct and involve type 1 processes which are largely intuitive, and type 2 processes which are largely analytic, and reflective. The defining feature of type 1 processes is the absence of WM, and type 2 which requires WM, mental replications, and cognitive decoupling or hypothetical thinking (Evans & Stanovich, 2013). Individual differences exist in working memory capacity, which influence intelligence, decision-making, and reasoning ability in specific conditions, however differences also exist in heuristics (experience), and bias beliefs which generally are unconscious and associative. When these beliefs are uncorrected errors in diagnostic reasoning can occur (Evans, 2007). The following table outlines the constructs:

Table 1

Dual Process Theory

Type 1 processes (intuitive)	Type 2 processes (analytic/reflective)
Fast	Slow
High capacity	Capacity limited
Parallel	Serial
Unconscious	Conscious
Biased responses	Normative responses
Contextualized	Abstract
Automatic	Controlled
Associative	Rule-based
Experienced-based decision making	Consequential decision making
Consequential decision making	Correlated with cognitive ability

Note. Adapted from Evans and Stanovich, 2013

Within type 1 processes The Autonomous Set of Systems (TASS) describes domain specific processes such as language, perception, associative experiences, and implicit thinking. The cognitive process availability of type 1 is thought to be determined by reasoning skill, associated stimulus, automatic skills, priming, framing, and cueing of patterns or most prominent features. Type 1 processes are signaled automatically by context or perceptual involvement and form the basis for heuristic or intuitive responses in judgment and decisions (Thompson, 2009). Physical conditions or affective domains can affect these signals. Type 2 processes use WM, mental replications, and cognitive decoupling through an analytical mode using explicit thinking to monitor the cognitive outputs produced in type one. Triggering of this process or the ability to inhibit type 1 remains unclear but is thought to be related to awareness (monitoring), cognitive ability (IQ), retrieval of implicit thinking, noetic feelings, cognitive divergence or the thought to reanalyze a problem through a reflective mind (Proust, 2015; Thompson, 2009). Clinicians thought to rely exclusively on type 1 or type 2 processes are prone to commit diagnostic reasoning errors, and using a combination of both types with reflective practices may decrease the occurrence of diagnostic errors (Norman & Eva, 2010).

Metacognition. Metacognitive processes have been postulated as a mechanism to monitor and regulate reasoning presented in type 1 or type 2 systems through the use of second-order judgments (i.e., I believe, and I know) or self-evaluative approaches that consist of two levels. These two levels contain the capacity of control to regulate cognitive activities, and the capacity of feedback affecting the control to regulate the level of the outcome and provide evaluative feedback (Marcum, 2012). This control and feedback allows the individual to think about one's thinking, evaluate cognition, and develop self-knowledge about one's own thinking processes. In Marcum's (2012) model of DPT and metacognition, intuitive, non-analytic and analytic processes describe an open-ended cyclic continuous spiral of metacognition in which type 1 and type 2 processes feedback into each other enhancing synergy and reflection. Pattern recognition utilized in non-analytic reasoning is reflected through a metacognitive model that reinforces previous patterns or produces triggering of analytic processes through dissonance that reinforce further metacognition (Marcum, 2012). The integration within this model of type 1 and type 2 processes with metacognition addresses the controversy of clinical experience verses expertise because expertise involves more than just clinical experience and suggests metacognitive processes (Marcum, 2012;

Pelaccia, Tardif, Triby, & Charlin, 2011). Dual Process Theory with Metacognition model is described below in Figure 3.

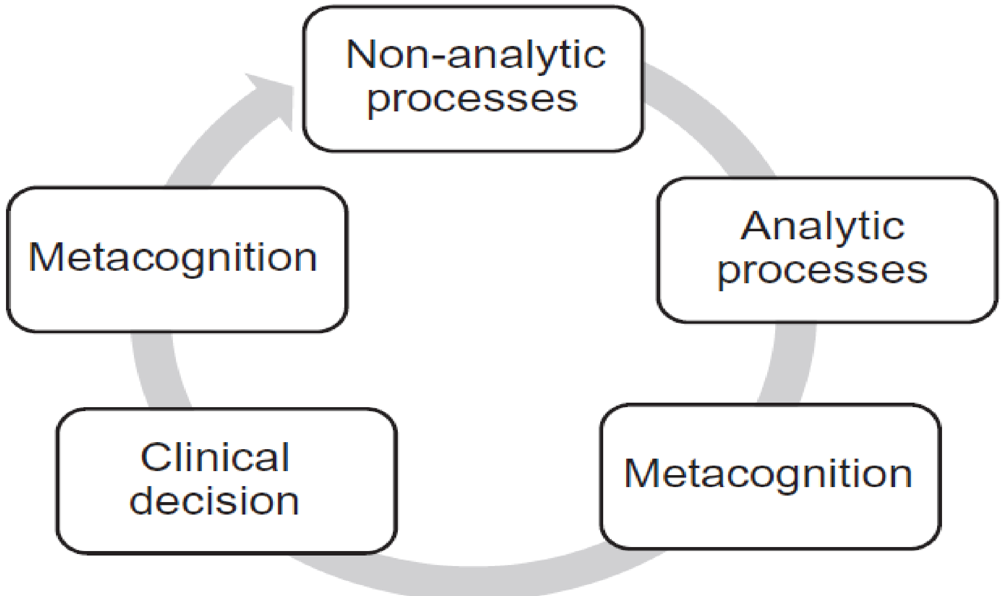


Figure 3: DPT and Metacognition (Marcum, 2012).

Diagnostic Reasoning Concepts in the Psychological, Nursing and Medical Literature

This literature review discusses the evolution of diagnostic (clinical) reasoning from a nursing and medical perspective. Conceptual definitions within the professional nursing and medical literature are varied in relation to diagnostic reasoning and conclusions are reached related to the terminology and meaning of the evolving cognitive processes that are used to develop diagnostics in NP students. General consensus in the professional literature is that diagnostic reasoning is specific to practice context and combines the synthesis of knowledge using cognitive and metacognitive processes (Braude, 2012; Marcum, 2012; Pelaccia, Tardif, Triby, & Charlin, 2011; Simmons, 2010). Diagnostic reasoning processes depend on cognitive, metacognitive, psychomotor and affective skills to synthesize data collected to arrive at a clinical decision. Best practices in teaching and learning diagnostic reasoning to NP students is not known and requires a review of the nursing and medical literature.

The definitions of diagnostic reasoning are varied throughout the medical and nursing literature but carry a consistent theme that describes a complex cognitive process that is strategic and reflective in relation to specific content, and requires the development of both cognitive and metacognitive skills (Su, Osisek, & Starnes, 2005). Simmons (2010) defines the evolution of decision making in the healthcare profession as starting with the application of critical thinking that is affected by emotional intelligence, heuristics (experience), cognitive ability (intelligence), cognitive bias, and skill level. Essential elements needed to reason are critical thinking, information gathering, cognition, clues, educational context, experience, short and long-term memory, and perceived need for action (Simmons, 2010). Cognitive processes that formulate attributes in diagnostic reasoning involve data analysis, deliberation, heuristics, intuition, cognition, metacognition, logic, and information processing.

Tanner's (2006) conceptual model of clinical judgment development in nursing uses interchangeable terms such as critical thinking, problem solving and decision making, and consists of five assumptions on how nurses think. These assumptions are reflective of patient-centered care, and practice-based education, and involve nurse's knowledge, clinical experience, the process of knowing the patient, individual reasoning patterns, and reflective practices of the nurse (Tanner, 2006). These concepts influence reasoning and if poorly developed can lead to cognitive and metacognitive error, and bias. Reasoning is defined as a flexible cognitive process by which nurses and other clinicians make their judgements using a deliberate process generating alternative hypotheses that are weighted by evidence, recognized by patterns and developed based on heuristics, reflective ability, and self-knowledge. *Reflection-on-action and reflection- in–action* described by Tanner (2006) are synergistic with Dreifuerst's (2012) method of Debriefing for

Meaningful Learning® (DML) to advance reasoning skills in undergraduate nursing students (Dreifuerst, 2012). Nurse practitioners obtain contextual knowledge in their undergraduate and/or graduate training and their thought processes are influenced by reasoning development based on their experiences, perception, and background knowledge (Ritter, 2003). Critical thinking, contextual knowledge, knowing the patient, and weighing evidence are all reasoning attributes that include reflective ability on and in action, self- knowledge, practice- based heuristics, and pattern recognition or intuition (Elstein, 2009; Evans, 2008; Ritter, 2003; Tanner, 2006).

Diagnostic reasoning processes in medicine use cause and effect relationships based on pathophysiology, clinical presentation, symptoms, and diagnostic data thought to be related to analytic reasoning, but are criticized by the failure to explain abnormal presentations of disease not represented in textbook readings (Marcum, 2012; Pelaccia et al., 2011). Causality in diagnostic reasoning considers the cause and effect relationship between variables and narrows clinical decisions using a Bayesian approach. Decision analysis research on Bayesian analysis and Bayes rule describes a quantitative approach based on probability in diagnostic problem-solving, and information storage in memory. Bayes method is used in compiled testing strategies in medicine (Kassirer, 2010).

Kassirer (2010) describes diagnostic reasoning from a historical perspective in medicine using earlier studies in psychology that focused on what expert clinicians do to solve health problems. These observations were based on earlier theories of a cognitive process that described thinking and clinical recall however these theories were labeled unreliable by cognitive scientists as research expanded through Barrows and Bennett (1972) and others who described concepts used in diagnostic thinking as containing cue recognition, hypothesis generation, integration of cues, hypothesis, and hypothesis evaluation resulting in a final diagnosis. This evolved into the hypothetico-deductive theory. Additional research followed that described a knowledge driven model in diagnostic thinking ability based on the organization and obtainability of stored memory, and recognition of forceful features within the patient's history and presentation that are continuously modified based on new information (Bordage, Grant, & Marsden, 1990; Jones, 1997). The incorporation of stored memory and knowledge and follow up of forceful features is thought to explain the differences in excellent and weaker clinicians to solve problems (Jones, 1997). The development of a quantitative tool to measure diagnostic thinking by Bordage, Grant and Marston (1990) sought to differentiate excellent from weaker diagnosticians by measuring their knowledge and flexibility in diagnostic thinking. Excellent problem solvers relied on organization and content of knowledge (hypothetico-deductive knowledge driven model) and flexibility in thinking (forceful features that shift thinking). These processes relate to dual processing models using metacognition through non-analytic (knowledge and structure) and analytic (flexibility and reflection) in thinking. The diagnostic reasoning sequencing of steps in generating diagnostic hypotheses is based on focused clinical data gathering, hypothesis generation, further focused data collection, refinement and generation of diagnosis, and differentials. Differential diagnostics is thought to be related to short-term memory use which has limited memory capacity and is involved in the cognitive deletion, and refinement thought to be related to analytic reasoning use (Kassirer, 2010).

Perception in diagnostic reasoning relates to a structure in thinking ability assimilated from experiences within the person not fully explained by current theories. Subjective perception in cognition combines emotion and intent with intellectual processes involving ethics, knowledge and recognition of justified good judgement (Braude, 2012). This requires ethical and moral objective self-examination of the clinician on their reasoning patterns which can be explored through reflective practices. Phronesis (emotional intelligence) has been advocated by Braude (2012) as an important concept that affects diagnostic reasoning because the components of "affect, emotion, executive attention, rational cognition, intuition, statistics, technical expertise and nosological categories are all validly part of practical wisdom" (Braude, 2012, p. 947). Phronesis link virtues in science, intellect, speculative truth, intuitive wisdom, and art with moral virtues in temperance, and courage and may explain concepts in the development of expertise in diagnostic reasoning (Braude, 2012). Simulation involves a pre-debriefing phase that can affect perception and influence the learner before the start of the simulation, and induce bias and error if debasing strategies are not utilized.

Cognitive error can result from inappropriate triggering of intuitive heuristics, subjective bias, faulty data collection, inaccurate framing of a problem, and premature closure (Croskerry, 2001; IIgen et al., 2012). Metacognitive strategies may be effective to develop in practice to avoid cognitive error and may serve as an activation to use analytic reasoning (Bond et al., 2006; Mamede, Schmidt, Rikers, Penaforte, & Cuelho-Filho, 2007; Mamede, Schmidt, & Rikers, 2007). Diagnostic reasoning described by Kassirer (2010) advocates the use of cognitive strategies to foster development in the diagnostic process by increasing information of errors, judgment, and reasoning development through the use of facilitated reflective discussion (Kassirer, 2010). This can be accomplished through debriefing strategies that foster this development.

Elstein (2009) explored a historical perspective in diagnostic thinking through the review of major scientific findings found in medical problem-solving research over the past 30 years. Elstein (2009) described case study analysis, simulation education, hypothetico-deductive models, and diagnostic reasoning errors that effect diagnostic reasoning in the health profession. Case study analysis showed that diagnostic reasoning conclusions of expert diagnosticians were not significantly better than non-experts. Examination of the hypothetico-deductive model found that three to five diagnostic hypotheses were considered simultaneously in experts linking diagnostic reasoning and short-term memory size. Expertise was found to be content or case specific and related to prior experience, pattern recognition, repeated practice, feedback and retrospective identification and evaluation of errors. Further research into medical problem solving examined the role of repeated practice and experience in the development of structure in long-term memory with most researchers placing emphasis on knowledge structure and rapid retrieval then on a formal reasoning process. However, novice clinicians in medicine are more likely to use analytic strategies until knowledge and expertise have developed (Elstein, 2009).

Errors in diagnostic reasoning described by Elstein (2009) occur through premature closure, inaccurate pattern recognition, ineffective clue gathering, inadequate or inaccurate integration of data, anchoring, availability, ineffective framing, subjective bias, overconfidence and errors of omission. Remedies to limit diagnostic error are the use of reflection, consultation, decision analysis, support systems, and debasing strategies utilizing metacognition that specifically focus on knowledge deficiencies, overconfidence, and premature closure in diagnostics through improved feedback (reflection-beyond-action) and practicing reflection- in- action (Elstein, 2009; Rajkomar & Dhaliwal, 2011). These concepts relate to the DML method of debriefing.

Diagnostic Reasoning Involving Dual Process Theory and the Diagnostic Thinking Inventory

Research in expert NP diagnostic reasoning showed that diagnostic thinking relied on a combination of Information Processing Theory (IPT) (Simon & Newell, 1971) and Hermeneutics. In a qualitative content analysis by Ritter (2003) the concepts of clinical judgement, problem-solving and intuition were explored in expert NP's to examine diagnostic reasoning. Expert NP diagnostic reasoning processes were examined in relation to either IPT (analytic) or Hermeneutics (perceptual awareness and intuition) or a combination of both. Information Processing Theory is used predominantly in medical research and describes how physicians reason through problem-solving and describes the gathering of clusters of clues stored in short-term memory that are generated by fact gathering; organization and retrieval of the clues occur from further fact gathering from long term memory; data is organization from the clue chunking, and hypotheses generation is developed. Further data gathering is completed if needed, and evaluation of the hypothesis occurs to rule in or out decisions (Ritter, 2003; Simon & Newell, 1971). Hermeneutics combines concepts of perceptual awareness of a situation that interprets and converts similarities based on prior pattern recognition and the "human capacity of "fuzzy" resemblance or memory despite marked differences in situations" (Ritter, 2003, p. 138). Flawed hermeneutical (intuition) reasoning can contribute to diagnostic errors by causing premature closure in diagnostics or inducing subjective prejudice. Think aloud diagnostic reasoning was performed by ten NP experts involving two case studies using the IPT and hermeneutical models. Results were recorded and transcribed and themes were analyzed and identified. Outcomes showed that expert NP diagnostic reasoning used a blending of both models that current models in diagnostic reasoning at that time failed to explain.

King (2006) examined diagnostic reasoning skills in experienced NPs' and NP-s to determine factors that may have an effect on diagnostic reasoning. This exploratory quantitative research examined the relationship of diagnostic ability and intuition between years of NP experience, age, diagnostic ability, intuition, grade-point average, and registered nursing experience (type and years of practice) in NP students and experienced NPs. Three tools were used in this study; the Nurse Practitioner Problem Set (NPSS), the Diagnostic Thinking Inventory (DTI) (Bordage, Grant & Marsden, 1990), which measured diagnostic ability and the Acknowledging Use of Intuition Nursing Scale (AUIS) (Rew, 2000) that measured intuition. The NPSS had participants answer questions from 30 scenarios taken from a national adult specialty NP certification exam and provide a correct diagnosis from four choices. Bordage, Grant and Marsden (1990) developed the DTI to assess available stored structured memory and flexibility in thinking applied during the diagnostic event through a self-reported survey. Flexibility in thinking contains 21 items with scores ranges from 21 to 126. Knowledge structure in memory contains 20 items with a score range of 20 to 120. Higher scores on the DTI in both categories relate to increased cognitive diagnostic ability and provide a quantitative measure of overall diagnostic ability (Bordage et.al, 1990). The DTI measures structure (knowledge and pattern recognition) and flexibility (hypo-deductive reasoning) in diagnostic thinking, and has been utilized to measure diagnostic thinking ability in medicine and other healthcare disciplines (Bordage et.al, 1990; Gehlhar, Klimke-Jung, Stosch, & Fischer, 2014; Goss, Reid, Dodds, & McColl, 2011). The last instrument measured the use of intuition with the AUIS. A total of 164 practicing NPs recruited at a large regional conference and 65 NP-s recruited at two educational universities completed these three survey instruments. Results showed there was a statistically significant relationship between increased diagnostic skill performance $r\ (223) = .17$, ($p <.01$) and increased experience measured by the NPPS. The DTI was also positively and statistically significant $r\ (215) = .26$ ($p < .01$) with NP's job experience (>5 years) and there was a negative correlation between diagnostic skills (NPPS and DTI) and intuition $r\ (226) = -.21$, ($p <.01$). Diagnostic ability, measured by the NPPS and DTI, were found to be statistically significantly decreased in NP students' ($p < .01$) with decreased age (was not quantified) and increased use of intuition correlating to decreased scores on the DTI in this group ($p <.01$). Nurse practitioners were found to use intuition significantly less than NP students' ($p <.01$). The author suggested that the DTI was a useful quantitative measure of NP diagnostic reasoning skills and that the tool should be used for further research in educational settings (King, 2006).

Diagnostic reasoning involves contextual knowledge to arrive at a diagnosis and involves both non-analytic pattern recognition (fast, effortless thinking) and analytic thinking which is conscious, effortful, and slower. In a study by Durning et al., (2016) dual process theory (DPT) was tested to analyze the two dimensions of cognition measured by the DTI. Dual process theory is described in both medical and nonmedical contexts, and represents two forms of reasoning that may overlap (Eva, Hatala, LeBlanc, & Brooks, 2007; Pelaccia, Tardif, Triby, & Charlin, 2011) and has been widely accepted in the medical literature (Croskerry, 2009; Elstein, 2009; Evans, 2003). Non-analytic reasoning involves pattern recognition and cluster clues that formulate structure in memory that is subconscious, intuitive, high-capacity and rapid thinking. Reasoning using non-analytic processes is thought to be predominantly utilized by experienced clinicians or experts and relates to organizational knowledge size, structure, and accessibility of working memory (Groves, 2007). Both novice and experts identify forceful or key features but key differences in the reasoning process are due to modifications in knowledge structures that occur due to repeated activation during clinical experiences and require limited reflection (Evans, 2003; Groves, 2007). In contrast, analytic thinking is conscious, uniquely human, slow, and deliberate and utilizes central WM permitting abstract, flexibility, and hypo-deductive reasoning not attained by non-analytical reasoning (Evans, 2003).

The link between DPT and the DTI has not been previously explained, and this study sought to provide a biologic correlation related to diagnostic reasoning by the assessment of fMRI and DTI performance (Durning et al., 2016). The hypothesis was that non-analytic reasoning would be related to knowledge and structure in memory, organized into cluster clues, and analytic reasoning would involve flexibility in thinking that compares and contrasts options in diagnosis specific to the clinical situation. Flexibility in thinking requires different strategies utilizing creativity (abstract), uncertainty, and the ability to examine reflection in and on action (Durning et al., 2016).

Recent studies in neuroimaging suggest that creative behavior and generation of analytic thinking require activation of self-monitoring regions in the brain located in the medial frontal cortex and deactivation involves cognitive control regions located in the lateral frontal cortex. Deactivation in the lateral frontal regions and activation in the medial frontal regions were examined during analytic reasoning in this study (Durning et al., 2016). Further issues in this study explored how non-analytic and analytic diagnostic reasoning contribute to diagnostic thinking by examining the activation and shifting changes in the prefrontal cortex network during analytic reasoning, the occurrence of shift changes between the lateral, medial frontal, temporal and parietal areas thought to show activation during focused attention and internal self -reflection in experts (Durning et al., 2016).

Associations between DPT and DTI during fMRI scanning were explored in seventeen board-certified internal medicine physicians answering a total of 32 multiple-choice questions (MCQ) taken from a national medical board review, testing core domains in internal medicine. Participants were given 60 seconds to read the questions and push a button to move onto an answer option. This phase involved a cognitive control because engagement in answering a question may involve reflecting on that answer during reading. Following the reading of questions participants were given seven seconds to answer what the most likely diagnosis was or were asked a diagnostic related question. This phase was used to show a correlation between both non-analytic and analytical reasoning. The reflective phase followed these two phases and asked the participants to reflect on how they arrived at the diagnosis for the question item, which was thought to require analytical reasoning. Shortly following the fMRI phase the DTI was completed and no statistically significant correlation between the answers to the MCQ, and DTI scores were found, (average total scores on DTI were 161 with a SD of 7.18 and range of 147-175, and mean number of correct responses on the MCQ was 18.5/32 with a range of 15-25). However, significant results occurred ($p < 0.05$) through covariate analysis in the DTI flexibility in thinking with positive activation shown in the bilateral regions of the ventromedial prefrontal cortex (vmPFC), and the right para hippocampal gyrus and, the DTI structure in knowledge with fMRI positive activation ($p < 0.05$) in the left inferior parietal lobule (IPL), left vmPFC and left dorsolateral prefrontal cortex (dlPFC).

Covariate analysis of the total DTI scores showed positive activation (p <0.05) in the dlPFC and deactivation in the left ventrolateral and dorsomedial prefrontal cortex confirming that deactivation in the lateral frontal regions and activation in the medial frontal regions occur during analytic reasoning (Durning et al., 2016).

Durning et al., (2016) provides evidence that structure in memory requires retrieving stored knowledge during the clinical event while flexibility shows variability in the prefrontal cortex based on cognitive demands (WM). Brain processes during fMRI correlated with the two dimensions of the DTI during the fMRI phases and showed that each DTI component (knowledge structure and flexibility) had distinct functional neuro-anatomic activation patterns in the prefrontal cortex. The authors hypothesized that variations occurred in the prefrontal cortex due to the cognitive demands involving DPT using either analytic or non-analytic reasoning associated with flexibility, memory structure or both (Durning et al., 2016). This study suggests support of DPT and suggests scientific biologic validity of the DTI.

In a study using medical residents and the intervention of diagnostic teaching rounds, diagnostic reasoning improvements were measured using the DTI (Stieger, Praschinger, Kletter, & Kainberger, 2009). Diagnostic thinking of medical residents was measured in a pre and post-test design prior to and after a four-month case series module using diagnostic rounds. A total of 23 clinical cases were presented and medical residents provided diagnosis and decisions on patient care management. The cases were discussed by experts in various disciplines and gave immediate feedback on the resident's diagnosis and differentials. At the end of the four-month module, the post-testing DTI was administered and results were compared to the pre-test DTI scores. Significant gains were shown in total scores of the DTI ($p < 0.001$) and in subscale scores in flexibility and knowledge structure ($p < 0.001$) in diagnostic thinking from the pre- DTI testing to the post -test scores (Stieger, et al., 2009). This study controlled for clinical experiences by reviewing clinical logbooks provided by the participants and gains in DTI scores were shown to be independent of clinical and medical experiences. This study supports reflection and feedback in a group process format to develop knowledge structure and flexibility in diagnostic thinking further validating this tool.

Diagnostic Reasoning, Working Memory and Long-term Memory

Long term and working memory and their relation to diagnostic reasoning have been considered separate topics in the literature however, the implication in newer experimental and theoretical models has shown they are interdependent through a relationship between dual tasks. Processing of dual tasks requires the use of manipulation, access and coordination of long term memory (LTM) to integrate new context. Accessing LTM is critical for clinicians to mobilize schemas, or recognize patterns utilized in the diagnostic reasoning process (Hruska et al., 2015).

Mobilization of LTM requires working memory (WM). The neural locus of control for WM in the brain is located in the central prefrontal cortex and controls retrieval and access to LTM. Other specific locations that may be important to WM include the dorsolateral prefrontal cortex (DLPFC) and the ventrolateral prefrontal cortex (VLPFC). The DLPFC maintains goals and executive control while the VLPFC maintains attention and simple memory recall through phonological and visuospatial processes. The functioning of working memory in cognition is thought to develop expertise in diagnostic reasoning (Hruska et al., 2015).

Hruska et al. (2015) used functional magnetic resonance imaging (fMRI) to measure WM and brain activity used during diagnostic reasoning in novice medical students verses expert physicians. The purpose of the study was two-fold; to identify neural areas of activation associated with diagnostic reasoning and to measure the difference in neural activation between novice and experts. Diagnostic reasoning was tested using simple and complex case presentations solved during a one-hour scanning using fMRI. The study compared ten second year medical residents' and ten expert physician's fMRI brain scans while they reasoned through eight easy and eight complex case scenarios to arrive at a diagnosis. Details on the cases were not presented to the participants prior to scanning.

During scanning participants read sixteen randomized clinical cases during a single fMRI scanning session. The simple cases contained written data that was congruent with the analytical data and lab values. The complex cases contained data conflicting with the analytical data and lab values. The initial analysis focused on the results of group activation maps in the brain identified during fMRI scanning that belonged to the novices and then the experts to identify regions that contained differential activation maps between simple and complex cases. These group activation maps were analyzed in novices and experts and found that reading clinical cases invoked multiple neural activations in occipital, prefrontal, parietal and temporal cortical regions in both groups. Increased activation in the prefrontal cortex was found in novices compared to experts in both simple and complex cases. This suggests that novices use increased amounts of WM during diagnostic reasoning which correlates to analytic thinking. Expert clinicians showed variance in the activation of regions in the human prefrontal cortex associated with WM during diagnostic reasoning suggesting an important relationship between WM and diagnostic reasoning. The authors concluded that WM may be utilized differently based on expertise and, may be utilized less in experts, or activation of WM may be a measure of the diagnostic reasoning process (Hruska et al., 2015). Biological differences were seen in fMRI imaging of WM between novice and expert clinicians and suggest different neural map activation in the brain during diagnostic reasoning. This study supports dual process theories and the importance of WM development in pattern recognition through repeated practice to develop expertise.

Studies Examining DPT and, Diagnostic Bias and Error

Dual Process Theory (DPT) and metacognition are important cognitive processes emerging in the medical literature to explain the clinical cognition involved in diagnostic reasoning (Pelaccia, Tardif, Triby, & Charlin, 2011). According to most researchers in diagnostic reasoning the two systems in DPT are jointly involved in diagnostic decisions but may vary depending on the situation or level of expertise of the individual and it remains unclear how one system may dominant over the other or if systems are combined in certain situations (Pelaccia et al., 2011). Studies in medicine have shown that novice practitioners utilize analytical thinking modes prominently until thinking becomes focused, autonomic, unconscious, and independent with the ability to filter out data that is not disease specific, or confounding and that shows concordance with established presentations of specific illnesses (Fisher & Rourke, 2016); however other studies suggest that differences in diagnostic reasoning related to qualified experts may result from improved experience not improved reasoning abilities (Croskerry, 2009; Elstein, 2009; Norman & Eva, 2010; Norman, Young, & Brooks, 2007; Round, 2001).

Specific attributes that effect diagnostic reasoning and can influence diagnostic error include emotional intelligence, heuristics, cognitive ability, perception, cognitive bias and skill level (Braude, 2012; Croskerry, 2009). However, the manner in which knowledge is arranged in long-term, short-term, and working memory facilitates accurate diagnostic reasoning that is different in novices' verses experts (Hruska et al., 2015). Errors are thought to develop from inappropriate triggering of non-analytic reasoning not corrected by analytical reasoning. Metacognition is discussed as a reflective strategy to mitigate errors in diagnosis along with emotional detachment, objective examination of beliefs, and perspective swapping (Kassirer, 2010). Facilitation of cognitive development in diagnostic reasoning or prevention of cognitive error in NP students is not known.

Maintaining a balance in cognitive processes between non-analytical and analytical reasoning as opposed to only one level of cognition was found beneficial in a study by Eva, Hatala, LeBlanc and Brooks (2007). This study explored the complex relationships between non-analytical pattern recognition and analytical reasoning with pattern recognition by introducing instruction in diagnostic reasoning verses no instruction and by the introduction of correct and incorrect bias using diagnostic suggestions in undergraduate psychology students.

Students were trained to diagnose ten cardiac conditions via electrocardiogram (ECG) presentation. Both studies involved three phases in training, practice and testing. In the first phase 30 students had no introduced bias but were instructed to use familiar pattern recognition combined with careful consideration (analytic) reasoning of the presenting ECG features. The other 30 students had no introduced bias or analytic reasoning instruction prior to diagnosing presenting ECG features. The group provided with analytic reasoning instruction out-performed the group given no instruction ($p < 0.01$) in accuracy. The phase continued with fifteen students from the analytic reasoning and no reasoning group instructed toward a diagnosis by presenting a contrary symptomatic feature (bias). The accuracy rate between the analytic reasoning/bias group did not differ from the analytic reasoning/no bias group ($p > 0.6$) but accuracy rates were lower in the no reasoning/ bias group compared to the no reasoning/ no bias group ($p < 0.6$) (Eva et al., 2007).

In the second phase 48 students were divided into two groups of 24 and half received instruction to use analytic reasoning and half received no analytic reasoning instruction. Six ECG's were presented that included two with bias, two with incorrect bias and two without bias toward a correct diagnosis. ANOVA testing revealed that the method of instruction combined with correct bias and incorrect bias were not statistically significant but planned comparison of this result revealed a statistically significant difference in analytic reasoning verses no analytic reasoning within the incorrect bias group ($p < 0.05$). There was a statistically significant difference between the no analytic reasoning/bias correct and bias incorrect groups ($p < 0.05$). There was no statistically significant difference ($p > 0.25$) in the correct and incorrect bias groups with analytic reasoning (Eva et al., 2007).

This study supports analytic reasoning instruction to recognize bias in novice clinicians related to pattern recognition. Tenuous balance exists when preconception is introduced into presenting clinical data that can affect diagnostic reasoning. This further supports DPT in non-analytic pattern recognition and analytical cognitive processing that may prevent or mitigate cognitive error (Eva et al., 2007).

In a study by Schiff et al. (2009) diagnostic error reporting in perceived causes, frequency and seriousness were analyzed in 583 physicians from 22 institutions using a written six-item survey. Results showed that 28% of errors were rated by the physicians as major, 41% were rated as moderate and 31% were described as insignificant. Common causes of error in missed or delayed diagnosis occurred in the following categories: pulmonary embolism (4.5%), drug reactions or overdoses (4.5%), lung cancer (3.9%), colorectal cancer (3.3%), acute coronary syndrome (3.1%), breast cancer (3.1%), and stroke (2.6%). Most diagnostic errors occurred in failure to order required tests or inadequate follow-up (44%), diagnostic assessment errors with premature closure or anchoring of the current diagnosis (32%), inadequate history taking (10%), physical examination (10%), and missed referral to other consultants (3%) (Schiff et al., 2009). Diagnostic assessment errors, premature closing and anchoring can be targeted through DPT using simulation with DML to mitigate diagnostic errors.

In a study by Myung et al. (2013) the use of analytic reasoning instruction was used to mitigate bias through the use of reflection on an alternative diagnosis using an analytic process. This study was performed at a medical school in 145 fourth year medical students who were randomly assigned to the analytic reasoning group (n= 65) or the control group (n= 80). The students participated in four case studies over three days utilizing standardized patients. The analytic reasoning group was asked to provide a list of diagnosis and differentials using a table designed to enhance analytic reasoning. They completed the table with associated signs and symptoms compatible with or differing from each diagnosis and then listed the most probable diagnosis. The control group was only required to provide the most probable diagnosis with no use of the table. Diagnostic mean accuracy scores were significantly higher in the analytic reasoning group than in the control group (3.40 ± 0.66 versus 3.05 ± 0.98; $p = 0.011$) (Myung, Kang, Phyo, Shin, & Park, 2013).

Diagnostic Reasoning, Conjunction Fallacy, and Response Time in Testing

Recent research on diagnostic reasoning has shown that cognitive processes may rely more on non-analytic reasoning instead of analytic reasoning. This is thought to occur through the basic tenet of rational thought relying on probability in the face of uncertainty (representativeness) that can led to errors in probability or the conjunction fallacy. This is thought to occur more in expert clinicians than novices (Rao, 2009). Cognitive errors caused by representativeness, impulsive rules associated with a recent case, premature closure, an unlikely diagnosis or atypical presentation can result from faulty development of diagnostic reasoning in the clinician (Croskerry, 2013).

De Neys (2006) examined a fundamental rule of probability (the conjunction fallacy) in 189 first year participants in the department of social sciences of a large university. The conjunction fallacy in probability states the occurrence of two events combined (or two clinical symptoms) cannot exceed either of its elements. *Conjunction fallacy* is (probability) testing that describes non-analytic reasoning inferring (incorrectly) that an event is more probable or likely to be selected than only one of its conjuncts because non-analytic reasoning may be subject to preconceived ideas about the person or situation. This study explored the different involvement of executive WM resource involvement in non-analytic and analytic cognitive processing by giving participants a conjunction-reasoning problem (De Neys, 2006). Students were given a total of four problems that involved two conjunction fallacies and two selection tasks (a correct answer of a standard reasoning task). Exam response times were recorded to separate out interference time from reading time. The hypothesis was that dual process frameworks involving an analytic response (type 2) would predict longer exam times in answering the questions due to a separation of contextualized context from superficial context and a non-analytic response (type 1) would result in a faster response time in answering the exam questions. Results showed that participants who gave the correct response on the conjunction problems had significantly longer response times (p <001) (type 2 analytic reasoning) then participants who committed the conjunction fallacy (type 1 non-analytic reasoning) that showed shorter response times (De Neys, 2006). Contextual problem solving may reveal differences in non-analytic and analytic reasoning through test response time differences.

Rao (2009) conducted research on 134 beginning medical students by giving them a clinical case vignette and asking students to estimate the probability through percentages of a student having a common cold by assigning percentages to six symptom categories. The answer choices were (a) runny nose and diarrhea, (b) fatigue, (c) diarrhea, (d) ear pain and shortness of breath, (e) sore throat, (f) headache. A violation of the conjunction fallacy occurred if students assigned a lower percentage to diarrhea, than runny nose and diarrhea regardless of the other answer percentage values. The conjunction rule was violated by 47.8 % of the students and rates did not differ related to prior education, age or sex but this rate was lower when compared to earlier research performed in expert clinicians on conjunction fallacy violation (Rao, 2009; Tversky & Kahneman, 1983).

Further research by Charness, Karni and Levin (2009) examined the conjunction fallacy and tested conditions in which violation of the principal may be lower or substantially decreased. This study involved 361 general study students at a university randomized into (3) treatment groups who were given a probability example involving a conjunction fallacy and incentives ($4.00) or no incentives for a correct answer. The (3) treatment groups where further divided into individuals, pairs or trios of participants. Error rates related to conjunction fallacy violation were single student/no incentives (58%), pairs of students/no incentives (48%), and trios of students/no incentives (25%) compared to single student/incentives (33%), pairs of students/incentives (13.2%), and trios of students/incentives (10.4%). Their findings showed that mild incentives and the ability to consult with groups substantially lowered the risk of committing the conjunction fallacy. Consultation in groups with or without incentives showed decreased error rates through the introduction of social interaction in decision-making (Charness et al., 2009).

Simulation and Debriefing Practices to Teach Diagnostic Reasoning

Educational reform is needed in nursing education that embraces teaching and learning practices using information technology (Cardoza, 2011; Rogers, 2015). The use of simulation is gaining acceptance in the neuroscience literature of brain-based learning. Brain-based biochemical reactions affect cognitive processes and foster connections between learning and brain circuitry (Cardoza, 2011). Action learning through simulation increases the brain's biochemical energy and supports cognitive and experiential learning through an orchestrated immersion in a complicated scenario (Kolb & Kolb, 2008; Rogers, 2015). Multidimensional connections occur in the brain during critical thinking and diagnostic reasoning in non-analytical and analytical cognition that involve tactile, visual, affective, and auditory learning domains which simulation and debriefing practices support (Kolb & Kolb, 2005; Rogers, 2015).

Learning experiences in high fidelity patient simulation (HFPS) use scaffolding of prior learning to cultivate thinking that may trigger anticipated predicted or imagined perception to encourage deductions and responses (Cardoza, 2011). Brain mapping and cognitive research shows the brain continuously tries to predict what will happen using a prediction error and is highly responsive when the prediction does not occur. Prediction error causes more dopamine and adrenaline to be released from the brain stimulating arousal. The use of simulation pedagogy with increasing complex responses of the HFPS can produce a positive or negative prediction error and increase students' cognitive learning and retention (Cardoza, 2011). Emotionally arousing stimuli enhances LTM of the preceding stimuli and repeated instruction strengthens memories and neurobiological processes that transform the collection of experiences over time into concrete learning (cluster clues stored in structured memory) (Anderson, 2006). Brain-mapping studies support simulation teaching and learning activities with reflective debriefing practices to advance to a higher level of learning that supports metacognition. Reflective practitioners demonstrate higher level thinking that is associated with quality patient outcomes (Dreifuerst, 2015).

Students must develop critical thinking skills in order to effectively develop diagnostic reasoning skills and solidify cognitive reasoning processes in cognition, metacognition and WM to assemble scaffolding of new knowledge and experiences. Lapkin, Levett- Jones, Bellchambers and Fernandez (2010) examined the effectiveness of high fidelity simulation manikins (HFSM) in undergraduate nursing students to teach diagnostic reasoning skills in a systematic review that included eight studies. Interestingly, the authors fail to note if debriefing practices were utilized and results of the review were inconclusive regarding the effectiveness of simulation in teaching diagnostic reasoning, however simulation showed improved knowledge acquisition, critical thinking and student satisfaction (Lapkin et al., 2010). Skills are required to develop diagnostic reasoning ability and simulation engages students. The absence of a debriefing method may have contributed to the lack of development in diagnostic reasoning skills supporting continued research in debriefing best practices to develop diagnostic reasoning skills.

Improvement in the NONPF core educational competencies using simulation involving medically complex cases was seen in a study by Kesten, Brown and Meeker (2015). In this repeated measures pilot study, NP students were assessed using a new instrument, developed by the authors, called the APRN EVAL tool. This tool assessed improvement of specific core educational competencies listed by NONPF in: approach to the patient, assessment and management of the patient, leadership, delegation, collaboration, and professionalism. Complex medical cases were presented using simulation at four intervals over a six-month period with groups of four NP students. The number of students participating in this pilot study was not provided. The learning objectives included subjective and objective data collection, diagnostic testing, interpretation of results, development of differential diagnosis, and structured debriefing practice (Kesten, Brown, & Meeker, 2015). Mean scores were evaluated using paired t- testing at each sampling interval using the APRN EVAL tool. A longitudinal total score model was calculated using *p*-values to determine if there was statistical significance upon completion of the four complex cases. Outcomes found significant statistical improvement ($p < .0001$) in the NONPF core educational competencies (Kesten, Brown & Meeker, 2015). Limitations included the lack of pretesting prior to the intervention, and the inability to measure if gains occurred over the time frame of the study due to clinical learning. Diagnostic reasoning in this study was not measured but is implied in the NONPF competency of scientific foundations, leadership and development of independent practice ability [NONPF], 2014).

Structured Debriefing Practices

Metacognitive strategies involving debriefing practices to develop reflective thinking are occurring in the simulation literature. Reflective thinking is associated with the work of John

Dewey, a prominent twentieth century educator, reformer and philosopher, who believed that learning should be logical, and relevant to the student and within their contextual domain (Kolb, 1984). Dewey believed that participation in learning was essential to stimulate conflict and discussion that reconstructs experience through reflection. Central to participation is the belief that acquired experience leads to continuity in interaction that fosters self-efficacy through continued learning (Kolb, 1984).

Debriefing practices following simulation have received increased interest through research showing structured debriefing enhances learner performance and diagnostic reasoning skills through reflective practice (Dreifuerst, 2009; Kuiper & Pesut, 2004). The practice of debriefing engages students in conversations that are critical to uncover thinking occurring in actions during simulation training. The use of structured debriefing allows reframing of situations, reflection and dialogue to guide diagnostic reasoning cognition and clarifies new learning through a reflective process (Dreifuerst, 2015). Structured debriefing can foster development in forward thinking processes related to diagnosis and anticipate intentional or unintentional outcomes through assisting structural changes in memory (Mamede et al., 2012). Common beliefs regarding simulation education among researchers show that cognition does not occur exclusively within the hands-on portion of simulation but in the debriefing component which produces the valuable gains in knowledge and assists in the development of diagnostic reasoning (Lusk & Fater, 2013; Mariani, Cantrell, & Meakim, 2014; Neill & Wotton, 2011; Shinnick, Woo, Horwich, & Steadman, 2011). Themes in best practice debriefing include the role of teacher as facilitator, a safe, nonjudgmental environment, and the ability of the facilitator to listen, redirect and encourage self-reflection. Active participation in debriefing must be well planned, allow adequate time and, have logical learning objectives to transfer learning applicable to other situations (Fey, Scrandis, Daniels, & Haut, 2014; Lusk & Fater, 2013).

A study assessing knowledge gains in heart failure care in undergraduate nursing found significant increases in knowledge using simulation, repeated measures and structured debriefing compared to repeated measure simulation alone (Shinnick et al., 2011). Mariani, et al., (2013) used structured debriefing to measure student's diagnostic reasoning through the use of the Lasater Clinical Judgment Rubric (LCJR) (Lasater, 2007). Diagnostic reasoning and clinical judgment were used interchangeably throughout the study because judgment informs reasoning and reasoning informs judgment (Lasater, 2007, Tanner, 2006). The authors used the DML method in the intervention group and measured clinical judgment outcomes using the LCJR. DML is a structured debriefing method that reframes clinical situations through reflection and dialogue that guides cognition in reasoning and fosters new learning (Dreifuerst, 2015). Structured debriefing develops forward thinking to anticipate outcomes and identifies gaps in the assumptions of students as they begin to apply new knowledge. This DML method uses Socratic questioning of the students to answer the "who, what, where, how and why" (Dreifuerst, 2015, p.268), to stimulate reflection and dialogue by applying reflection-in-action, reflection-on-action, and reflection-beyond-action that incorporates assimilation and accommodation into the debriefing process through six phases. The engagement phase follows the conclusion of the simulation and begins with a welcome to debriefing and introduction of the worksheet to the students that begins with concepts of emotion and self-reflection. The evaluation phase breaks the scenario down individually by asking questions on who the patient was, what happened, and what comes to your mind as you think about the experience. This develops thinking in action related to the patient scenario using a student tool to critique and guide each student through reflection. Questions are open-ended and contain phrases such as what went well, why it went well, asks why a certain action was taken to assist reflection on diagnostic decisions by uncovering thinking and asking what could be done differently and why, prompting thinking- on- actions. The instructor facilitates the group reflection through the explore phase by discussing, and prioritizing the patient's story through framing the clinical issues and engaging students using Socratic questioning. The students recall the patient's story and the focus of the issues. Review is completed through the perspective of their roles and observations. A white board is used to conceptually map out care including central issues, problems discovered from central issues, diagnosis, differentials, areas of concern and decision-making points. The explain phase is a continuation of the explore phase and uses elaboration and explanation of the clinical decisions made where the instructor challenges any *taken for granted* assumptions and exploits the use of deduction, induction, and analysis to develop diagnostic reasoning skills (Dreifuerst, 2015). Errors are corrected and explained and questions of "what if ", "tell me more", how, when and why are utilized. The elaborate phase compliments parts of the simulation that went well and emphasizes links to knowledge, application and diagnostic reasoning concepts. The extend/evaluate phase uses framing to describe the clinical simulation differently by extending and expanding on what was learned to facilitate thinking–beyond- action and involves exploratory questioning on how things would be different if the clinical situation changed. Students can adapt thinking through anticipation of new contexts and apply learning to represent higher levels of cognition attributed to experts (Dreifuerst, 2015). This may assist to advance knowledge structure and flexibility in diagnostic thinking. Mariani (2013) used a mixed method, quasi-experimental design with a control arm that used standard debriefing (that was not defined in this study) and an intervention arm using the DML method after the two clinical simulation experiences. A convenience sample of 86 junior level baccalaureate nursing students enrolled in a medical surgical nursing program were randomly assigned to either the intervention or the control arm of the study. There were (n=42) in the intervention group and (n=42) in the control group. Students' clinical judgment abilities were assessed at the end of each simulation experience and prior to the debriefing. After the first simulation the LCJR was completed by members of the research team and course faculty to address interrater reliability of the clinical faculty. Clinical faculty rating was used in this study and the intra-rater reliability was high ($r = .92$; $p < .01$) using Pearson correlation. After the second simulation, members of the research team evaluated students in the four components of clinical judgment that included noticing, interpreting, responding and reflecting. The LCJR uses a checklist that rates eleven behaviors within these categories to calculate clinical judgment scores. The possible scoring on the LCJR ranges from 11 to 44 with higher scores indicating higher measures of clinical judgment (Lasater, 2007). Focus groups were conducted with all students in both groups, and audiovisual recording with notes were utilized by the research team, transcribed, and analyzed for recurring themes (Mariani et al., 2013).

Results showed that mean clinical judgment scores in the intervention group were higher than the mean scores in the control group, however the difference did not reach statistical significance. Data obtained during the focus group interviews revealed structured debriefing sessions addressed emotions, were learner-focused, and improved knowledge, and technical skills (Mariani, et al., 2013).

Studies in undergraduate nursing using simulation, and the DML method to measure clinical reasoning showed significant gains in clinical reasoning measured by the Health Science Reasoning Test (HRST) in undergraduate nursing (Dreifuerst, 2012; Forneris et al., 2015). The studies used pre-testing with adequate delay in post-testing of the HSRT and compared the method of DML with the Debriefing Assessment for Simulation in Healthcare- Student Version (DASH-SV). The HRST is a validated multiple-choice test that was designed to assess critical thinking skills in health science undergraduate and graduate students. This tool measures the strengths and weaknesses of an individual's judgment and reflective ability and does not require healthcare knowledge (Dreifuerst, 2012; Forneris et al., 2015). The DASH-SV is a standardized debriefing tool that rates six key elements of the debriefing including instructor ability, learning environment, organization, engaging discussions, identification of performance gaps, and assistance with sustaining good performance (Dreifuerst, 2012 ; Forneris et al., 2015). Both of these tools have established content and construct validity with internal consistency between the ranges of .77 to .84 (Dreifuerst, 2012, Forneris et al., 2015). Outcomes showed significant gains in reasoning measured by the HRST tool using DML in undergraduate nursing students.

A qualitative study by Miloslavsky et al. (2012) in clinical decision-making skills of medical interns using simulation, repetitive practice and case structured debriefing specifically addressed perceived gains in diagnosis, patient management, communication and professionalism. Surveys were distributed to rate the simulation experiences to perceived gains in differential diagnosis ability and patient management strategies with an additional open-ended survey asking questions describing the strengths, weaknesses and changes needed in the educational intervention. Consistent themes showed gains in diagnostic reasoning through deliberate practice and structured debriefing. The open-ended question survey described strengths of simulation with the use of deliberate practice, team-based case solving, and immediate structured debriefing. Improvements involved the need for expert debriefing with multiple facilitators and increased time spent in debriefing so deeper meaning of the material could be understood. This study used a small sample size, using medical residents to debrief instead of experts, and had no theoretical model (Miloslavsky et al., 2012). Unresolved issues remain in the time needed and the method of debriefing to facilitate diagnostic reasoning.

In a study by Mamede et al. (2012) the use of structured reflection on diagnosis generation and differentials involving clinical cases in forth year medical students was investigated. Three phases were involved measuring knowledge acquisition during the learning phase, an immediate diagnostic performance test, and a delayed diagnostic performance test administered one week later. Forty-six participants diagnosed six clinical cases in the learning phase under three different experimental conditions. The three experimental conditions involved a learning phase with case presentation and generation of the first diagnosis stressing accuracy and speed, followed by completion of a word puzzle to minimize the likelihood of participants engaging in reflection. The next phase involved a learning phase with participants reading the case, writing down the most likely diagnosis then reflecting on an alternative diagnosis before providing a final diagnosis followed by completion of a word puzzle to minimize the likelihood of participants engaging in reflection. The last phase involved a learning phase with structured reflection where participants read the case and wrote down the most likely diagnosis then followed a structured reflection procedure that required case description listing what supported, did not support, or were expected to be present but were not in the case study to support their diagnosis. They then listed a differential diagnosis using the same procedure to support, not support, or expected findings to be present but were not in the case study to draw a conclusion and rank the diagnosis possibility. This reflective phase emphasized students recognizing contradictory or absent findings in the case based on their own reflection. The maximum amount of time allowed for each case was seven minutes in all experimental phases. All phases were followed by an immediate knowledge and a delayed knowledge test administered one week later. Instructor feedback was given only after the study was completed. The knowledge test consisted of diagnosing four different cases of diseases based on the six clinical cases presented in each learning phase. Participants' clinical experiences with the diseases in the case studies were evaluated prior to the learning phase and did not differ among the students in each experimental phase. Results showed that students within the structured reflection phase performed lower (not statistically significant) than those in the immediate diagnosis and differential diagnosis phases in both the learning phase and on the immediate knowledge-testing phase. However, students in the structured reflection phase out performed those in the immediate diagnosis and differential diagnosis phases on the delayed test given one week later and this difference was statistically significant (p <0.01) (Mamede et al., 2012). This suggests that diagnostic reasoning occurs through knowledge expansion, restructuring, and organization with the use of repeated application assisting the development of illness scripts or cluster clues and structured reflection performed by the student may foster diagnostic competence (Mamede et al., 2012).

Cicero, et al., (2012) assessed pediatric disaster triage through the intervention of multiple patient simulations, triage algorithms, and structured debriefing to assess if this educational strategy would improve retention and proficiency over time. A total of (n=54) medical residents in pediatric and internal medicine participated in an initial simulation, a second simulation one week later, than a third simulation five-months later. All simulations were different, and targeted standard triage algorithms involved in pediatric disasters. Structured debriefing followed all three simulations and was described as: identification of gaps between the performance and objectives, discussion of emotions and cognitive reasons, discussion of gaps and feedback and closure of gaps with targeted instruction. Didactic teaching was given prior to the first simulation and pretesting was completed prior to the start of the educational intervention using a multiple choice exam and survey instrument which was re-administered after each simulation and debriefing training. Of note in this study, the evaluation tools were not validated, and the simulation designs used were evaluated by a modified Delphi technique not described in this study. Results comparing the pre-testing and post-testing showed improvements after the first simulation and structured debriefing (p <.0001) at week one (p <.0001) and after the five-month simulation (p <.0001) showing improvement that was sustained after five months. The authors determined that structured debriefing was a key component in simulation education that improved and maintained triage accuracy over six months (Cicero et al., 2012).

In a study by Mompoint-Williams et al. (2014), the authors used simulation to prepare adult-gerontology NP-s prior to their Objective Structured Clinical Examination (OSCE) and surveyed students on their satisfaction and perception using simulation learning. The outcomes showed students were satisfied with simulation learning, felt better prepared for the OSCE, had decreased anxiety, and felt that simulation learning improved critical thinking by using a collaborative group process (Mompoint-Williams, Brooks, Lee, Watts, & Moss, 2014).

Simulation, Deliberate Practice and Limited Debriefing

Studies using simulation and *deliberate practice* in medical students and NP-s for cardiopulmonary skills assessment using a simulator named "Harvey" showed statistically significant outcomes ($p<.0001$) in Issenberg et al., 2002, and ($p < 0.5$) in Jeffries et al., 2011, in knowledge, OSCE, satisfaction, confidence, and self-efficacy (Jeffries et al., 2011; Issenberg et al., 2002). Deliberate practice is based on the theory of expertise and is described as a "systemic, recursive, approach to developing mastery of the representative tasks of a domain" (Chee, 2014, p. 250). Both studies were well-designed, and used multi-center sites that utilized pre- testing and assessed outcomes in diagnostic reasoning using OSCE and post-testing knowledge exams. Limitations included the small sample size, debriefing was not used, and measurements in knowledge retention overtime were not performed. However, a study using a similar design in NP students, but decreased deliberate practice hours showed improvement in knowledge and satisfaction ($p < .05$) but no difference in confidence levels (Tiffen et al., 2011). This may be related to the decreased deliberate practice hours, and the lack of structured debriefing.

Themes in the medical literature are consistent with simulation, deliberate or repetitive practice, and debriefing that is not structured or described. Diagnostic reasoning has usually been measured through clinical or didactic knowledge testing in the medical literature using simulation. Most of the studies in medicine evaluated procedural skills and cardiac life support training in resuscitation using evaluation methods of pre and post- test designs or OSCE involving contextual knowledge (Bender, Kennally, Shields, & Overly, 2014; Sawyer et al., 2011; Wayne et al., 2005).

Synthesis and Critique of Research Findings

Diagnostic reasoning is a complex process that involves continued cognition through multiple systems that starts with critical thinking on knowledge context and patient presentation. However, the manner in which context is arranged in long-term, short-term and working memory may relate to knowledge structure in memory and this may facilitate accurate diagnostic reasoning that is different in students verses experts. Flexibility in diagnostic thinking may relate to both non-analytic and analytic reasoning with metacognition strategies being triggered. Cognitive and metacognition are important processes that impact development of diagnostic reasoning and may mitigate diagnostic error or bias. The addition of perception in the clinician may contribute or negate diagnostic error that may be corrected through reflection on implicit biases. The process of diagnostic reasoning in novices can be developed to connect and integrate networks of information to foster development in knowledge structure and flexibility to advance pattern recognition, memory, analytical reasoning, and metacognitive practices to foster reflection on thinking.

The failure of diagnostic reasoning processes is a concern as the affect can result in poor patient outcomes or significant disability. Important concepts that are recurring themes related to diagnostic reasoning involve educational context, cluster clues, working memory, long term memory, pattern recognition, intuition, heuristics, repetitive practice, and metacognition which are synergistic with dual process theory and metacognition. Diagnostic reasoning needs to be studied in healthcare education to determine best practices to guide the development of multidimensional thinking in cognition. Interrelated cognitive and metacognitive processes and the application to diagnostic reasoning are more focused in the medical literature then nursing and are not fully developed or explained in NP-s. Assessment of diagnostic reasoning is poorly defined because of the difficulties in measuring an internal mental process that is complex and not directly measurable through objective measures (Durning et al., 2013)

The literature review demonstrated a general lack of research studies using simulation in NP students and no studies were found that specifically measured clinical reasoning as an outcome measure using DML or the DTI. In the studies reviewed there were consistent limitations in using small convenience sampling, undetermined or absent theoretical models, and not using standards of simulation designs. Positive outcomes were reported in knowledge, satisfaction and increased confidence however most studies in medicine and nursing lacked structured debriefing or debriefing was not described (Haut, Fey, Akintade, & Klepper, 2014; Scherer, Bruce, & Runkawatt, 2007; Tiffen, Corbridge, Shen, & Robinson, 2011).

Summary of the Chapter

Synthesis of the data analyzed in this literature review showed limitations in the NP student, nursing and medical research related to reliable outcome measurements (instruments not provided or listed), valid instruments to measure diagnostic reasoning in NP student, use of simulation standards (most medical and NP student studies had no use of standards), use of theoretical models (most medical and NP student studies lacked stated theoretical models), clearly defined objectives, structured debriefing (nursing studies showed an increased use of structured debriefing but elements were not defined) and the amount of deliberate or repeated practice needed to attain and/or maintain skills. Studies using clinical or diagnostic reasoning as a dependent variable had various methods utilized to measure this outcome with most studies using pre-test and post-test knowledge data. Outcomes were related to implied diagnostic reasoning gains and not the process of increasing diagnostic reasoning. The studies in the medical and NP student populations failed to measure the use of simulation and structured reflective debriefing as an educational modality to advance diagnostic reasoning using an objective quantitative measure except in knowledge testing gains. NP student studies contained small convenience samples, which may be related to small class sizes and difficulty in accessing larger cohorts of NP student populations.

There were a number of studies that measured the impact of debriefing with simulation and recognized that this is the most important element utilized in simulation pedagogy but failed to define the structured debriefing technique. DML is a validated debriefing model that has been used in undergraduate nursing education and has shown improvement in clinical (diagnostic) reasoning through measurement of the C-SEI but this tool is not specific to nursing or diagnostics.

Medical studies showed the largest use of simulation with deliberate practice and repeated measures with reports of improvement in procedural skills, team resuscitation, and triage that were sustained over time. There were different studies that utilized simulation in NP students within various aspects of the curriculum. These studies placed simulation and deliberate (repetitive) practice within advanced health assessment courses prior to clinical rotation and others within the first clinical semester. There were general limitations related to outcomes specific to the process of diagnostic reasoning or debriefing in NP-s and a lack of validated instruments to measure diagnostic reasoning throughout most studies. A large number of the studies measured outcomes by checklists, OSCE or through pre and post-testing results on knowledge acquisition.

Overall simulation integration within the curriculum in NP-s is in the beginning stages of development and the error rates associated with patient harm related to diagnoses are an emerging area for study within patient safety and quality outcomes. Diagnostic reasoning utilizing DPT is an important skill for nurse practitioner students to develop to prevent errors in diagnoses resulting in erroneous treatment decisions however, research in the teaching and learning of diagnostic reasoning in NP programs is lacking. Exploring best practices in teaching this skill can lead to improved educational outcomes that will affect patient quality and safety. Currently in nurse practitioner courses, domain knowledge is taught separately in advanced pathophysiology, health assessment and pharmacology. Research was not found that specifically taught diagnostic reasoning context within the NP-s curriculum. Synthesis and application of this knowledge seems to occur within clinical practicum courses thus retrieval of the combined contexts in the advanced courses must be placed into a recognizable pattern or schema to accurately associate a diagnosis related to a patient condition during clinical practicums. Simulation with repeated practice and DML in NP-s to teach diagnostic reasoning through synthesis and application may be able to advance development of non-analytic and analytical processes in diagnostics by reflective practice strategies enhancing cognition and metacognition.

Therefore, the use of simulation, repeated practice and reflective debriefing as opposed to standard debriefing may show changes in NP students' diagnostic reasoning involving knowledge structure and flexibility in cognition. The use of DPT and DTI is supported in the medical literature as a cognitive reasoning process and as an objective measurement in diagnostic reasoning ability. The addition of metacognitive practices in both non-analytic and analytic reasoning through reflection may mitigate diagnostic error and show change in knowledge structure and/or flexibility in cognitive ability.

CHAPTER THREE: METHODOLOGY

Introduction

Nursing education research using simulation methodology applied to nurse practitioner students (NP-s) is in the early stages of development and research. Simulation approaches in teaching and learning of NP-s has not been explored fully (Giddens et al., 2014). Current studies involving NP-s and simulation have focused on broad outcomes related to the National Organization of Nurse Practitioner Faculties (NONPF) competencies, and satisfaction in student learning (Haut, Fey, Akintade, & Klepper, 2014; Kesten, Brown, & Meeker, 2015). There are limited studies exploring the development of diagnostic reasoning in NP-s. Current studies describe the use of specific learning tools to facilitate reasoning, case studies comparing diagnostic reasoning to physicians, and studies that evaluate online learning verses traditional educational practices (Appel, Wades, Talley, & Williams, 2013; Colella & Beery, 2014; Davis & Pruitt, 2014; Pirret, 2013).

Simulation has been suggested to increase knowledge acquisition, critical thinking, and identification of a deteriorating patient in undergraduate nursing education but specific quantitative tools to measure diagnostic reasoning in nursing education are lacking (Lapkin, Jones, Bellchambers, & Fernandez, 2010). The initiation of diagnostic reasoning starts in the context of critical thinking, and requires previous acquired knowledge, and past experiences to construct new knowledge within that domain (Lapkin et al., 2010). Healthcare professionals gather subjective and objective data, and information is combined with what is known and unknown to formulate diagnosis through the cognitive reasoning process to render a clinical decision. Metacognition (thinking about one’s thinking) has been suggested to improve diagnostic reasoning and decrease errors or bias (Croskerry, 2013). Clinical judgment or diagnostic decision-making occurs after critical thinking and diagnostic reasoning, and is based on an inference of the evidence based on patient presentation (Jacobs, Wilkes, Taylor, & Dixon, 2016)

Based on a comprehensive literature review, diagnostic reasoning development has not been measured in NP-s using a quantitative or qualitative research design. The purpose of this descriptive, exploratory pilot study was to explore, describe, and measure the effect of the *Debriefing for Meaningful Learning®* (DML) method on the development of diagnostic reasoning in family nurse practitioner students (FNP-s) during primary care simulated patient care scenarios. To achieve this goal the following research questions were proposed:

Research Questions

1. Does the educational practice of simulation with debriefing for meaningful learning (DML) method change the diagnostic reasoning ability in FNP-s as measured by the Diagnostic Thinking Inventory's (DTI) total score?
    c. Does the educational practice of simulation with the DML method change the diagnostic reasoning ability in FNP-s as measured by the DTI in the subscale of knowledge structure?
    d. Does the educational practice of simulation with the DML method change the diagnostic reasoning ability in FNP-s as measured by the DTI in the subscale of flexibility in thinking?
2. Does the use of the DML method after simulation cause a change in the response time from the pre-testing Diagnostic Thinking Inventory (DTI) to the post-testing DTI in the total score?
    c. Does the use of the DML method after simulation cause a change in the response time from the pre-testing Diagnostic Thinking Inventory (DTI) to the post-testing DTI in the subscale of knowledge structure?

   d. Does the use of the DML method after simulation cause a change in the response time from the pre-testing Diagnostic Thinking Inventory (DTI) to the post-testing DTI in the subscale flexibility in thinking?

3. How satisfied are FNP-s with the DML method in improving their performance during the simulation as measured by the Debriefing Assessment for Simulation in Healthcare student version (DASH-SV) survey?
4. Does registered nurse specialty practice area and years of practice as a registered nurse yield differences in the diagnostic reasoning ability of FNP-s as measured by the DTI total scores?
   c. Does registered nurse specialty practice area and years of practice as a registered nurse yield differences in the diagnostic reasoning ability of FNP-s as measured by the DTI scores in the knowledge structure subscale?
   d. Does registered nurse specialty practice area and years of practice as a registered nurse yield differences in the diagnostic reasoning ability of FNP-s as measured by the DTI scores in the flexibility subscales?

Chapter Three will describe the research design overview, target population, sampling method and setting, recruitment procedures, instrumentation and procedures, data collection, data analysis, limitations and ethical considerations.

Research Design Overview

The three common approaches used in educational research can include qualitative, quantitative and mixed-method research designs. Quantitative research is most associated with the biological or natural sciences and is usually a statistically analyzed measurement that involves an intervention using an experimental group (Polit & Beck, 2012). Qualitative research seeks to understand the human experience based on the participant's reality through techniques such as interviewing or observation and can explain themes or commonalities of an experience in a special population group (Polit & Beck, 2012). Mixed methods research involves elements of both qualitative and quantitative designs and seeks to offset any weaknesses in either design by combining designs in one study (Polit & Beck, 2012). Exploratory research is used when initial exploration of a phenomenon is needed because there is limited research in the focus of study (Polit & Beck, 2012). Quantitative descriptive exploratory design was used in this study due to the limited information on this topic. Pilot studies are used in small-scale feasibility research either randomized or nonrandomized to evaluate the practicality of carrying out a larger scale study at a later date, and may use all or parts of the interventions. A pilot study was used in this study to determine the feasibility of a larger scale study (Morris & Rosenbloom, 2017).

This study used a descriptive, exploratory research design with a convenience sample of FNP-s at a public university in the Northeast. The FNP-s sample consisted of five groups that participated in three moderately complex patient simulations that focused on patient diagnoses and differentials that have been shown to cause diagnostic errors. The debriefing method of DML was used after the completion of each of the three (3) simulations. Diagnostic thinking inventory total scores, subscale scores in knowledge structure, and sub-scale scores in flexibility in thinking, along with survey response times were assessed through pre-and post- DTI survey data measured before simulation and debriefings, and after the completion of the (3) simulations with the DML method. Assessment of the FNP-s satisfaction with the debriefing method was measured using the DASH-SV survey. Finally, demographic data related to registered nursing practice area, (one or more than one) and years of practice as a registered nurse (less than five years or greater than five years) was assessed to yield any changes in the DTI total, and subscale scores in knowledge structure, flexibility in thinking, and, response times.

Target Population

The target population consisted of a convenience sample of registered nurses who were currently enrolled in a FNP program at a state university in the Northeast, and who had completed their first role course/clinical rotation in their graduate coursework and were entering their second clinical rotation/role course. The FNP-s had completed the core NP courses of advanced health assessment, advanced pathophysiology, and advanced pharmacology. FNP-s at the study university had not participated in simulation and debriefing methods in their FNP graduate program, and were not excluded from this study if they had participated in simulation and debriefing methods at other universities.

Sampling Method and Setting

A convenience sample of FNP-s enrolled part-time or full-time in their second FNP role course were recruited to participate in (3) clinical simulations and the DML method of debriefing in groups of (2) to (3) students over a twelve-week period. The time and location of the study was October 2017 to December 2017 at a university in the Northeast. This was a pilot study that took place at the university simulation laboratory and debriefing room. Sample size of this universities FNP-s was estimated at 24 and all students were invited to participate. Final recruitment of FNP-s was randomized and assigned into groups based on the student's time availability.

Recruitment

IRB approval was obtained at both the researcher's university and the study university. The program director of the study university was contacted to obtain approval of recruitment of students and confirmation of didactic teaching involving the diagnostic simulation scenarios. The simulation lab coordinator was contacted to arrange study dates and times. Recruitment was from one cohort of FNP-s in their second semester clinical/role course. Students were recruited by the researcher at their first class in a face-to-face introduction, and an explanation of the research study. The course instructor was out of the room during this introduction and explanation to avoid coercion of the students to participate in this study. Explanation involved the purpose of the study, confidentiality, informed consent procedures, explanation of simulation and debriefing pedagogy, time frame commitment, and the dates and time-frame of the study. Human subject protection was explained with the information that they would be allowed to withdraw at any time during the study. Students were offered a stipend of a $10.00 gift card to participate in the study. Informed consent to participate and confidentiality agreement regarding the simulation and debriefing scenarios were signed at that time and email addresses were collected along with demographic data (see Appendix A and B).

A total of eighteen FNP-s agreed to participate in this study, three FNP-s withdrew before the start of the study. Two withdrew after the initial pre-testing of the DTI and the final number of FNP-s participants who completed this study was thirteen. Students were placed into randomly assigned groups based on time availability that remained consistent throughout the study period. One student missed simulation two and this simulation continued with the minimum of two students. This student was placed into the next groups simulation two which occurred in the following week. A spreadsheet was designed and color coded identifying the randomly assigned groups and participants. A schedule was developed with participant groups that randomly assigned rotation of the roles involved in the simulations.

Instrumentation and Procedures

Simulation scenarios. The simulated primary care environment was based in an urgent care office setting and involved three medically complex patient situations in the order of simulation one (S1), simulation two (S2), and simulation three (S3), with rotation of FNP-s through each of the three different roles during the three simulations (see Appendix C, D, E). The roles were FNP-s leader, registered nurse and observer. Participants received role descriptions and instruction during the pre-debriefing prior to the start of each simulation. The FNP-s leader was instructed to collect subjective and objective data from the simulated patient that included instructions to collect data not given in the pre-debriefing related to the history of present illness (HPI), review of systems (ROS), and the need to perform a focused physical assessment and exam on the high-fidelity patient simulation mannequin depending on the chief complaint. The registered nurse was instructed to complete needed tasks within the simulation as directed by the FNP-s leader including administration of medications, respiratory treatments, administering oxygen or performing a blood sugar test. The observer was instructed to collect data that occurred within the simulation and record observations through note taking. In a recent study by Zulkosky, White, Price and Pretz (2016), in undergraduate nursing students participating in simulation, role assignment did not impact accuracy in clinical decision making related to familiar situations, however, in unfamiliar situations observers outperformed other roles within the simulation. This may be due to the ability of an observer to assimilate information objectively and under less stressful conditions. This study recommended the importance of rotation through roles within the simulations to allow for both active and passive learning (Zulkosky, White, Price, & Pretz, 2016).

The three medically complex simulation scenarios were based on adult practice and developed by the researcher. All three simulation scenarios went through a content review from expert adult and family nurse practitioners using a *Delphi* technique to form consensus on the validity of the simulated scenarios. Content review was completed by one adult and two family nurse practitioners with levels of experience from under five years to over five years to create a range of experience (Hsu & Sandford, 2007; Wilkes, 2014). Delphi review was used to explore or expose differing diagnostic assumptions based on the information presented within the scenarios to generate a consensus on the validity or changes needed to the simulation scenarios. Appropriate references to the medical diagnoses were listed and available in the simulation scenario templates to the Delphi reviewers. The National League of Nursing (NLN) template was used for the simulation design and is free to use without specific permission (National League of Nursing [NLN], 2009). The Delphi technique used a confidential collection of responses by the three participants and revisions were undertaken until consensus was reached (Wilkes, 2014). A pre-addressed stamped envelope with the researcher's address was given to the three reviewers with instructions on the review procedure and directions for completion and return (see Appendix F). The final review of all three scenarios based on consensus was completed and mailed to all reviewers for a final review which was approved (Wilkes, 2014). No changes were needed in the simulation scenarios however clarification was required of the reason for missing data in the initial patient vignettes that was to be given to the FNP-s. Clarification by this researcher to one reviewer involved the need for the FNP-s to recognize vital questions that needed to be asked of the simulator to elicit important diagnostic information.

The simulations proceeded and ranged in time from twelve to fifteen minutes. Simulation scenarios were appropriate to the level of the FNP-s and didactic education on the diagnosis used in the scenario was verified prior to the simulations by the FNP faculty program director. Pilot testing of the simulations was completed prior to the start of the research study by the researcher with a separate cohort of adult nurse practitioner students and minor refinements were made in timing and pre-debriefing information. A lab assistant was hired to assist with this study and training and practice of the simulations occurred at the study university's simulation lab prior to the start of the study.

The simulation scenarios were developed based on diagnoses that are documented in medical and NP research as causes of medical diagnostic error (Leigh & Flynn, 2013; Miller, 2011; Miller, 2013; Tehrani et al., 2013). Prior contextual didactic instruction of the FNP-s was verified with the program director on these diagnoses prior to the development of the simulation scenarios.

The scenarios involved contextual clues and scripting that are relevant to the diagnosis (forceful features related to the DTI knowledge structure in memory) and the ability to follow up on new information, obtained by the FNP-s, provided by the simulator during the HPI, ROS, and focused physical exam. This follow-up questioning involves flexibility shifts in thinking by the FNP-s to elicit causal and situational cognitive modes shown to correlate to the DTI flexibility in thinking (Bordage, Grant, & Marsden, 1990). The three scenarios included diagnoses of myocardial infarction, pulmonary emboli and stroke. The pre-debriefing included a description of roles, orientation to the room and simulator, and a brief history of the patient with atypical presentations of disease related to the chief complaint, age, sex, and past medical and family history. This was used to activate non-analytic and analytic diagnostic reasoning processes tailored to the simulation scenario. These diagnoses and atypical presentations are well documented in the primary, internal, and family medicine literature as causes of diagnostic error (Balla, Heneghan, Goyder, & Thompson, 2012; Ely, Kaldjian, & D'Alessandro, 2012; Graber, Franklin, & Gordon, 2005; Schiff et al., 2009).

Actions that occurred in the simulations, and proposed diagnosis and differentials were discussed within the DML method to explain, reveal, and explore any errors in cognitive thinking generated in the scenarios using concept mapping on a white board, and focused on atypical presentations, and information that can lead to diagnostic errors. These diagnostic errors included initial framing of the case that may be incorrect based on the pre-debriefing information (leads to premature closure) or bias (stroke symptoms in a cocaine user), failure to consider an alternative diagnosis when a patient presents with atypical symptoms (myocardial infarction in a younger women presenting with back pain and multiple cardiac risk factors), and the failure to considering alternate diagnosis that may not be related to a chronic illness (pulmonary emboli in an asthmatic patient).

Timing occurred within each of the simulations and debriefings as outlined in the proposed research plan (see Table 2) and FNP-s received active cueing to complete the simulation within the allocated time. Procedures outlined in the simulation scenario templates, were consistent, and the simulations occurred in a consistent order; S1 completed by all groups over three weeks, followed by S2 over three weeks, then S3 over three weeks with consistent standardized scripted simulated patient responses within the scenario based on anticipated questioning by the FNP-s leader. Focused physical exam findings were programmed into the simulator and outlined in the scripted scenarios. Redirection and contextual cues were delivered to the students in response to unanticipated FNP-s questioning, responses, or actions at the discretion of the researcher. Debriefing then occurred with the DML method after each simulation. At the completion of the study, FNP-s completed the DASH-SV assessing their satisfaction with the DML method and the DTI post-survey.

Table 2

Proposed Research Plan

Spring 2017	Summer 2017	September 2017	September-December 2017	December to May 2018
Research proposal submittal to committee IRB approvals Obtain formal training in DML Simulation case development, objectives Delphi Technique Pilot testing of simulation scenarios	Hire & train lab assistant in Simulation and practice simulations and DML	**Recruiting** Study explained, recruitment and consent one week prior to the start of the study Consent and confidentiality agreements Administer demographics & DTI in Qualtrics Statistical Server Delineate groups into spreadsheet and code Schedule simulations	**Data Collection** Pre-debriefing: Orientation to student objectives, patient case and simulation room Simulation (proposed 15 minutes) and debriefing (proposed 30 minutes) 3 simulations with 3 or 4 students in each group over a 12-week period DASH-SV survey Post DTI testing	**Data Analysis** Statistical analysis of the DTI pre-and post- total scoring, and subscales, response times and demographic data DASH-SV satisfaction survey Chapter 4 and 5 write-ups

International Nursing Association for Clinical Simulation and Learning (INACSL) standards of simulation. The standards developed by INACSL address and clarify elements required in simulation education related to learner objectives, fidelity, pilot testing, assessment, pre-debriefing, contextual learning prior to the simulation, maintaining the professional integrity of participants, guidance and cueing within the simulation, debriefing after the simulation, behaviors of the facilitator and evaluation ("Standards of best practice: Simulation," 2016).

These standards were used in this research study to maintain fidelity and consistency required in simulation education specifically directed toward enhancing and guiding learners through simulation pedagogy. Table 3 references criteria that were met in this study:

Table 3

Study Criteria

INACSL Standards	Required criteria per INACSL	Criteria met and defined within this study
Simulation design overview	Needs assessment Measurable objectives Structured format, contextual case & variable fidelity	Literature review FNPs objectives Standardized simulations with simulated scripting, maintaining fidelity
Outcomes and objectives	Preparation materials Pre-debriefing Debriefing Evaluation	Yes, prior contextual teaching verified
Simulation facilitation	Theoretical frameworks	Jeffries Simulation theory Dual process theory with metacognition
	Pilot testing/design templates	Yes/Delphi technique/simulation design template (NLN)
	FNPs centered objectives based on specific, measurable, assignable, realistic, and time related framework Pre-debriefing, preparation and scripted cues Realistic objectives consistent with FNP program outcomes	See appendix student objectives & simulation designs Align with study university, NONPF and AACN scientific/core competencies
Debriefing	Facilitator has specific skills and knowledge in simulation pedagogy and debriefing Debriefing by person competent in debriefing and a private environment Feedback during the debriefing Objectives of the debriefing relate to diagnostic reasoning	Researcher has formal training in simulation and formal training in DML method Separate debriefing room Debriefing planned for twice the simulation time Concept mapping with DML See appendix simulation design DASH-SV evaluation of the debriefing method and facilitator
Participant evaluation	Evaluation of simulation	DASH-SV DTI pre-and post-survey

Debriefing for meaningful learning method (DML). Debriefing fosters the development of reasoning and examines clinical judgment skills through a reflective learning process (Neill & Wotton, 2011). Reflective learning is based on Schon's (1983) concepts of reflective practice in professional knowledge. Professionals use the action of reflecting on a situation and exploring how this action may have contributed to an expected or unexpected outcome (Schon, 1983). Educational practices that cultivate a reflective environment of openness, shared control, information, and encouragement through feedback using a group exchange can provide coaching and teachable moments that are transformational to students (Schon, 1983).

Objectives incorporated into debriefing practices involve the identification of different perspectives, attitudes, contexts, theory, or skill building techniques (Dreifuerst, 2012). However, most debriefing focuses on discussions about learning outcomes and intended objectives of the experience not on how the simulation experience advances reasoning skills or what type of reasoning occurred. Debriefing for Meaningful Learning© is a theory-based structured debriefing method that is used to uncover thinking used in simulation. This reflective learning may facilitate the development of diagnostic reasoning in FNP-s through the integration of new knowledge into existing knowledge which is based on Piaget's (1953) Assimilation and Accommodation Theory (Dreifuerst, 2009). *Meaningful learning* differs from knowledge assimilated unchanged into cognitive structures (rote learning) by emphasizing metacognition and identifying gaps in the assumptions of students as they begin to apply new knowledge (Dreifuerst, 2009; Bonnevier, 2015). The DML method uses *Socratic* questioning and concept mapping to make visible the relationships involved in the patient case and connects the assessment, actions and decisions to stimulate reflection, dialogue, and metacognitive practice to guide reflection-in-action, reflection-on-action, and reflection-beyond-action (Dreifuerst, 2012).

Socratic type questions are used in the engage, explore, explain, elaborate, evaluate, and extend phase in the DML method to assess the students reasoning processes and identifies themes. Questions are open-ended and explore student's underlying beliefs, opposing thoughts, the origin or source of information, the implications, or consequences, and the reasoning that provides evidence of the assumptions in the thought processes involved in the decision (Dreifuerst, 2015). Modern Socratic questioning is consistent with three common components: collaboration in groups, exploring interpretive questions that lack a certain answer but activate prior knowledge, and reflecting on the experience. Emphasis is placed on reasoning skills and reflection (Kost & Chen, 2015) through questioning involving "who, what, where, when, how and why" (Dreifuerst, 2015, p. 268). The literature currently contains gaps in best practices related to the process of debriefing, allocated time needed, and specific learning outcomes associated with debriefing (Neill & Wotton, 2011). The DML method uses six phases listed in Table 4 and the use of a student worksheet (see Appendix G). Permission to use the DML student worksheet was obtained after completion of formal training by the author (see Appendix J).

Table 4

Debriefing for Meaningful Learning Phases

Engage	Explore	Explain	Elaborate	Evaluate	Extend
Starts at the conclusion of the simulation Begins with a welcome to debriefing and an introduction to the worksheet The worksheet begins with the concepts of emotion and self-reflection that allows the student to park their emotions Engagement of the students occurs through all of the debriefing experience	Starts with the patients story as a group with questioning on who the patient was through a perspective of the students role and continues into the reflection-on-action and in-action phase that describes actions, interventions and responses The student tool is used continuously to guide students through reflection on and in action Socratic open-ended questions are used in this phase and explores reasons on why specific actions were taken This expands on decisions by uncovering thinking and exploring different actions that could be done differently to prompt reflection on actions	Priorities are discussed and students are engaged through the use of questions that start with phrases of I saw, I noticed, and I wonder by the instructor to engage reflective practice of the students A white board conceptually maps out care involving central issues, problems, diagnosis, differentials, areas of concern and, decision making points Deduction, induction, analysis, and inference develops reasoning skills Errors are corrected and explained during this phase through Socratic questioning	Facilitation in this phase emphasizes links to knowledge, application, and conceptual reasoning Clarification through justification is discussed and the instructor challenges any taken for granted assumptions	Framing of the case is used to describe the clinical simulation differently to expand on learning and determine identification of errors by students, peers or the instructor Students explain their thinking by reflecting on their actions Identification of errors is discussed in this phase and concludes with a discussion on what went well, what did not and areas explores areas for correction to frame the experience in a meaningful way with application to similar situations	This is the thinking – beyond-action phase that explores how things would be different if some of the clinical situation changed Assimilation and accommodation is active in this phase and facilitates student learning of an anticipated situation to develop higher order thinking based on metacognition to separate the novice from expert

Note. Debriefing for meaningful learning phases (Dreifuerst, 2015).

Diagnostic thinking inventory (DTI). Diagnostic reasoning has been described in theoretical studies over the past 30-plus years involving different perspectives in psychology, clinical education, and clinical practice in medicine and nursing (Round, 2001). Diagnostic reasoning starts in the context of critical thinking that requires previous contextual knowledge and past experiences to construct new knowledge commonly referred to as assimilation and accommodation (Lapkin et al., 2010). Critical thinking is domain specific and requires knowledge specific to that domain. Healthcare professionals gather subjective and objective data and information is combined with what is known and unknown to formulate diagnoses which involve building of knowledge structures in memory (Simmons, 2010). The practice of diagnosis is complex and involves active data gathering, data integration, perception of data and the experience of the clinician. This integration of thinking describes and demonstrates flexibility in thinking. Knowledge structure and flexibility in thinking produces meaning specific to that practitioner through use of inductive and deductive logic and implicit and explicit knowledge. This assists to identify, classify and formulate a diagnosis of disease (Evans, 2008; Marcum, 2012).

The DTI designed by Bordage, Grant and Marsden (1990), is a survey used to measure the participant's self-reported competence in using cognitive skills involving knowledge structure and flexibility in thinking applied to the diagnostic process and has been used in medicine and other healthcare disciplines (Bordage, Grant, & Marsden, 1990; Gehlhar, Klimke-Jung, Stosch, & Fischer, 2014; Goss, Reid, Dodds, & McColl, 2011). Development of this survey was based on previous research by the authors and others related to knowledge-based models of clinical reasoning that identified variables necessary to the cognitive process of diagnoses (Gale & Marsden, 1982; Grant & Marsden, 1987; Grant & Marsden, 1988). Variables include recognition of relevant information, clinical data definitions, and access to knowledge structure in memory. Forceful features presented within the clinical data gathering represent keys to unlock memory structure in knowledge that influence interpretation or meaning that is confirmed or excluded based on the person's knowledge structure in memory. Flexibility in thinking involves a variety of cognitive processes such as clinical data gathering, and advancement through both deterministic (causal) and responsive (appropriate to the situation) modes of inquiry to focus memorized knowledge, data integration, and further new information on inquiry of the patient (Bordage et al., 1990). Shifts in thinking from additional forceful features can occur throughout data gathering and are not static.

The DTI describes participant's self-reported preferences in diagnostic thinking when developing a diagnosis using a six-point scale that instructs participants to not use the middle (assigned a value of three) scale but choose which one of the two statements best describes the position on the continuum that is used most often. Scoring of the inventory depends on the inventory item designated as either a knowledge structure or flexibility in thinking response and the rating of a negative or positive position on the continuum scale. Total scores of the DTI range from a low of 41 to a high of 246, subscales range from a low in knowledge structure of 20 to a high of 120, and flexibility of thinking range from a low of 21 to a high of 126 (see Appendix H) (Bordage et al., 1990).

The DTI was tested on thirty subjects from nine subject groups involving a total number of 270 participants. The nine subject groups were comprised of first-year medical students, third-year medical students, house officers, senior house officers, registers, senior registers, consultants, trainees in general medicine and general medicine practitioners. The original inventory was comprised of 56 items with each item containing a stem followed by a six-point, semantic-differential type scale with items grouped into two main categories indicating flexibility in thinking and knowledge structure in memory (Bordage et al., 1990). Data analysis was comprised of item discrimination and one-way analysis of variance. Content validity of item analysis was established from six of the nine groups and showed an overall reliability of 0.84, with 0.73 for flexibility in thinking and 0.75 for knowledge structure. Discriminate values were lower on five items and these items were discarded and an additional ten items were removed due to similar constructs. This left a total inventory of 41 items, 20 in knowledge structure and 21 in flexibility in thinking which comprised the final DTI. The instructions on the inventory were found to be ambiguous and were clarified by instructing the participants to complete the inventory based on how one makes a diagnosis not on how a diagnosis should be made and to complete the inventory in the context of general medical diagnosis.

The DTI underwent a second analysis with the same participants for an overall score of 0.83 for reliability, 0.72 for flexibility and 0.74 for knowledge structure with mean scores in reliability consistent with the level of experience of the participants. These scores ranged from117 to 215 (40% of the width of the scale) with a median score of 170.3 (17.9) out of a possible maximum score of 246 (69%). The higher the scores the more developed diagnostic thinking is expressed in the total and subscale categories. The final DTI contains 21 items relating to flexibility in thinking, and 20 items relating to knowledge structure with a mean discrimination index of 0.363 and a total score reliability coefficient of 0.83 (Bordage et al., 1990). The DTI is not content specific and identifies the reasoning abilities used by healthcare professionals, or students to come to a diagnosis (Round, 1999). Bordage et al. (1990) has recommended the use of this inventory to measure strengths and weaknesses in individual participants related to diagnostic thinking to tailor educational activities to improve scores. Permission to use the DTI was obtained by the author and is attached (see Appendix K). One sample item from each subscale of the DTI is presented in Table 5 and each question relates to knowledge structure or flexibility in thinking with a position on the continuum of positive to the right or left depending on subscale rating and question:

Table 5

Diagnostic Thinking Inventory Examples

Knowledge Structure		
1. Once the patient has clearly presented his symptoms and signs: (Response scale is negative to the left; 1-3 points, positive to the right; 4-6 points)		
(Left) I think about them in the patients' own words.	☐☐☐☐☐☐	(Right) I translate them in my mind into medical terms (numbness becomes paresthesia).
Flexibility in thinking		
2. In considering each diagnosis: (Response scale is negative to left;1-3points, positive to the right; 4-6 points)		
(Left) I try to evaluate their relative importance	☐☐☐☐☐☐	(Right) I try to give them equal importance or weighing

Note. Bordage et al., 1990

The measures that were assessed in this study involved the DTI total scores, subscale scores and survey response times of the pre-intervention scores with comparison to post-intervention scores. In a study by De Neys (2006), significantly longer response times to item testing that included a reasoning problem were found in participants that used analytic reasoning, with shorter responses times of participants being found with the use of non-analytic reasoning (De Neys, 2006). Charness, Karni and Levin (2009) found that incentives and group work decreased the risk of violating the conjunction fallacy in probability (use of non-analytic reasoning) that could affect diagnostic error (Charness, Karni, & Levin, 2009).

Reliability refers to how consistent and dependable the tool is in what it measures. Validity refers to the degree that the tool measures what it is intended to measure. The DTI was assessed for reliability and validity in physiotherapists (diagnostic pathways are comparable to medical physicians) and physiotherapist students using internal consistency by Cronbach's alpha (Jones, 1997). The diagnostic thinking inventory was administered to 22 qualified physiotherapists and 26 students in physiotherapy allowing 48 inventories to be evaluated. The inventory was then repeated within three-weeks and was assessed in the qualified physiotherapists. Mean total scores, and the two subsections regarding knowledge structure and flexibility in thinking of the qualified physiotherapists were analyzed using Pearson correlation coefficient with findings showing scores were reliable in repeated administration of the DTI ($p < 0.002$) and the entire DTI inventory Cronbach's alpha = 0.8464. Jones (1997) evaluated content validity using experts in the field of physiotherapy who looked at differences in the responses between student and qualified physiotherapists working in an outpatient department. All agreed that that the DTI measured differences in diagnostic thinking between these groups which showed a t value of -3.79 ($p<0.001$) in total score of the DTI, flexibility in thinking subsections t value of -3.25, ($p<0.002$) and knowledge structure subsections t value of -3.53, ($p< 0.001$) indicating construct validity in differences between qualified physiotherapists and students showing the DTI did measure diagnostic thinking (Jones, 1997).

The intervention of Diagnostic Grand Rounds (DGRs) was used to evaluate pre-survey and post-survey DTI scores in fifth-year medical students with a time span between pre-and post-survey repeated administration of sixteen weeks. The fifth-year students participated in eight DGRs, containing 23 clinical cases with the objectives to improve student's knowledge in testing methods, selection, and interpretation of test results to improve diagnostic reasoning (Stieger, Praschinger, Kletter, & Kainberger, 2009). Internal consistency of the DTI in the pre-survey showed a Cronbach's alpha of 0.72 for the flexibility subscale and 0.85 for the knowledge subscale for a total DTI score of 0.88. Mean scores using a dependent t-test and Cohen's D effect size showed significantly higher post- survey DTI scores ($p < 0.001$) (Stieger et al., 2009).

Debriefing Assessment for Simulation in Healthcare Student Version (DASH-SV). DASH-SV assesses the facilitator and the debriefing experience by rating six instructor debriefing behaviors using a seven-point behaviorally anchored rating scale describing the debriefing experience (Brett-Fleegler et al., 2012). The DASH -SV has been used in a wide variety of simulation environments in the healthcare field and has shown good reliability and evidence of validity (Brett-Fleegler et al., 2012). Table 6 describes an element of the DASH-SV.

Table 6

DASH-SV Behaviorally Anchored Rating Scale

Rating	1	2	3	4	5	6	7
Descriptor	Extremely Ineffective/ Detrimental	Consistently Ineffective/ Detrimental	Mostly Ineffective/ Poor	Somewhat Effective/ Average	Mostly Effective/ Good	Consistently Effective/ Very Good	Extremely Effective/ Outstanding

The students completed a rating sheet that scores six elements based on the rating scale using seven descriptions with ranges from extremely ineffective/detrimental to extremely effective/outstanding (see Appendix I). The Behaviorally Anchored Rating Scale contains descriptions of an engaging learning environment, maintenance of the learning environment, an organized structured debriefing protocol, engagement of students in provocative discussions, identification of performance gaps, and assisting students to achieve future performance goals (Simon, Raemer, & Rudolph, 2012). The reliability and validity of the DASH-SV instrument was first reviewed for content and usability by eight simulation experts from five tertiary care medical centers. The psychometric properties were assessed by 151 healthcare educators from various healthcare professions that use simulation and debriefing practices. They participated first in a rater training session, and then rated three scripted videos that exemplified superior, average and poor debriefings. The results found the interclass correlation coefficient for the individual items were greater than 0.60, with the overall interclass correlation coefficient in the combined elements of 0.74 with significant differences (p <0.001) seen among the three standard debriefing groups (Brett-Fleegler et al., 2012). Conclusions were that the DASH-SV scores showed good reliability and preliminary evidence for validity (Brett-Fleegler et al., 2012). Permission to use the DASH-SV is available on their website and requires that the Center for Medical Simulation (CMS) receives copies of any manuscripts, articles, or studies published using the DASH-SV survey (Center for Medical Simulation [CMS], 2010).

Data Collection

The numbered list below describes the steps in the specific order that were used in this study to collect data in an organized manner that assured fidelity and integrity of this research study:

1. Participant informed consent and confidentiality agreement was obtained at the time of the face-to-face meeting with students at their first class (see Appendix A).
2. Pre-survey administration of the demographics and DTI was completed by all consented study participants via an email link one week prior to the first scheduled simulation using Qualtrics data platform (see Appendix B and H). Baseline measurements of student's diagnostic thinking ability total scores, subscales in knowledge structure and flexibility, and reaction time was entered through Qualtrics data platform. Results of the pre-survey DTI and post-survey DTI were coded by student and group color by the researcher to protect the identity of students. Simulation times and dates were scheduled to coordinate with the students before class times to avoid scheduling constraints or disruptions.

3. Student groups were randomized for the first simulation using two to three students and assignments of roles were determined. These were further randomized within the consistent groups, and roles were assigned and rotated randomly so each student functioned at least once in the role of FNP-s leader, registered nurse, and observer during each of the three simulations as they progressed through S2 and S3 (see Appendix C, D, and E).
4. INACLS standards were used consistently throughout this study to maintain fidelity of the simulation and debriefing practices ("Standards of best practice: Simulation," 2016).
5. Pre-debriefing occurred with each FNP-s group prior to each simulation scenario consisting of the student learning objectives, orientation to the simulation room, simulator, available supplies, treatments and medications available, procedures for obtaining additional information, equipment functions, and role definitions and responsibilities. Patient data was given to the students prior to the simulation that included the chief complaint, pertinent diagnostic data; past medical, surgical, family, and social history as described in the simulation scenarios (see Appendix C, D and E).
6. Five groups of students participated in the three scenarios in two groups of (2) students, and three groups of (3) students and video-taping was used to maintain a record of fidelity. The FNP-s completed S1 over three weeks, then S2 over three weeks then S3 over three weeks. The FNP-s did not move to S2 or S3 until all five groups had completed the simulations in order. Absence did occur with one student during S2 within their assigned group, but the participant was able to join a later group for S2 after permission was obtained from the researcher’s chair.
7. FNP-s participated in DML for 20 to 30 minutes after each simulation. The debriefing occurred in a separate area from the simulation room with each consecutive group of

students after each of the three simulations. The debriefings were videotaped to provide a record of data and to monitor fidelity of the debriefing practice. Fidelity was monitored by a lab assistant. A white board to link concept mapping, per the DML method, was utilized along with the DML student worksheets (see Appendix G). The researcher conducted the DML debriefings.

8. A sample interviewing guide that outlined the DML method of debriefing was developed by the researcher that assisted in the facilitation of the DML method based on each simulation scenario (Creswell, 2013).
9. Observational field notes were recorded on paper by the researcher of the simulation and debriefing intervention, and the videotaping was downloaded on two encrypted flash drives (one for back-up). All research materials involving data collection are being kept in a locked file cabinet that is accessible to the researcher only and will be destroyed after three years (Creswell, 2015).
10. The FNP-s completed the DTI post-survey and DASH-SV (see Appendix I) at the completion of the study through an emailed link to Qualtrics and gift cards were distributed to all study participants.

Demographics

Demographic data was collected recording years of experience as a registered nurse, any previous degrees outside of nursing, undergraduate nursing program (traditional verses accelerated) and practice areas as a registered nurse. Registered nursing practice areas were collected and coded into two broad categories labeled inpatient and outpatient. Outpatient included community health, school, and physician’s office, and inpatient included medical-surgical, critical care, post- anesthesia care, and the emergency department. These were further coded into one or more than one specialty area. Nurses that have critical care based registered nursing experience, have been shown to have increased critical thinking skills (Gorton, 2010). Years of practice as a registered nurse were coded into less than five years or greater than five years as nurses with more than five years' experience have been found to have increased development of critical thinking skills (see Appendix B) (Becker, 2007; Sands, 2001).

Data Analysis Procedures

Prior to addressing the research questions, the data from the two questionnaires (DTI and DASH-SV) were inspected for (1) missing values, (2) outliers, and (3) violations of the assumptions of the proposed statistical analyses. The presence of any one of these three issues can result in biased data and jeopardize the conclusions from this study. The quality of the evidence can be seriously compromised when there are values missing for some study participants or when one or more of the subscales are not completely answered by all the participants. Although there are several strategies for dealing with missing values, the DTI and DASH-SV data were first examined for the extent of missing responses (e.g., what percentage of the responses are missing), the pattern of missing data (haphazard, random, or systematic), and the nature of the missing data (e.g., if values are missing for single items in a multi-item measure). These indices determined which method of missing value strategies would be implemented (Polit & Beck, 2012).

Outliers on the total and subscale scores from the DTI and DASH-SV inventories were determined using graphical techniques (e.g., boxplots) as the presence of outliers can bias a parameter estimate, especially the mean. Next, the assumptions of the parametric analyses were verified as violations of these assumptions can also bias the conclusions from the data, given the anticipated sample size of less than 30 participants (Field, 2009). Specifically, two assumptions were verified: Normality and Homogeneity of Variance. The Normality of the total and subscale scores from each measure was determined by two statistical procedures, the Kolmogorov-Smirnov and the Shapiro-Wilk Test, which are both non-parametric tests that allow you to check the shape of a sample against a variety of known, popular shapes, including the normal distribution. If the resulting *p*-value is .05 or under, there is significant evidence that the sample is not normal, and adjustment of the analysis would be needed to address the research questions. Support for the assumption of Equality of Variances was determined using the Levene's Test (Polit & Beck, 2012).

Once it was determined that the assumptions of Normality and Equality of Variance were supported by the data, the next step in the analysis of the data were to determine the reliability of the two instruments (DTI and DASH-SV) for this sample of graduate FNP-s. This is necessary as reliability coefficients are important indicators of an instrument's quality. Unreliable measures affect statistical conclusion validity (Polit & Beck, 2012). Further, and perhaps more importantly, an instrument's reliability is not a fixed entity. As Polit and Beck (2012) acknowledge, "The reliability of an instrument is a property not of the instrument but rather of the instrument when administered to certain people under certain conditions" (Polit & Beck, p. 335). However, just because an instrument is reliable when it was developed, does not mean it is reliable when another group of participants responds to the questions.

Scales and tests that involve summing item scores (as both the DTI and the DASH-SV) are typically evaluated for reliability by using a technique referred to as internal consistency. The most widely used method for evaluating internal consistency is Coefficient Alpha or Cronbach's Alpha.   The normal range of values of Coefficient Alpha is between 0 and 1.00, with higher values reflective of greater internal consistency. The target reliability was .70 for this study (Polit & Beck, 2012).

Finally, the data from the study participants was summarized using descriptive statistical procedures, including the mean and standard deviation. As the research design of this study was exploratory, and involved only thirteen participants, the research questions were addressed using mean comparisons in repeated measures analyses only to determine whether there was a significant change in the scores of each of the measures from pre-to post-test. For example, the participants' total pre-and post- test DTI scores will be graphed and subsequently correlated to determine whether the relationship between the pre-and post-DTI measure is positive, negative or has no relationship. Additionally, the average pre-and post-test scores on the DTI will be compared using either a parametric or non-parametric inferential test for a within-subjects or paired measures treatment to determine whether there was an increase, decrease or no change in the total DTI scores after participating in the simulation using the DML. These analyses were systematically implemented for all four research questions addressed by this exploratory descriptive research study. Because the sample size was small, each analysis used a .01 level of alpha, given that there are repeated significance tests that will automatically inflate the probability of making a Type I error, claiming that the DML debriefing used in a simulation, raises FNP-s diagnostic thinking scores, when it may not. MANOVAs, which control the probability of a Type I error over the course of repeated analyses, are not possible for use in this situation due to the small sample size.

Limitations

This was a pilot study of a small number of FNP-s so results may not be applicable to other NP students in different specialty practices at other schools of nursing. Results may not show changes in the DTI due to the limited number of simulations and debriefings. Students may not complete all the survey items in the DTI post-survey or may not answer the pre-and post-survey honestly. Timing of data collection and cohort placement may be a factor in the results obtained and not generalize across curriculums. Measurement of progression in diagnostic reasoning development may not be related to the intervention but through clinical rotations, other educational interventions and/or program continuance.

Ethical Considerations

The researcher obtained IRB approval from the researcher's University and the University involved in this research. A cover letter was sent outlining the purpose of the study, participant consent, confidentiality agreement, the right to withdraw at any time, simulation dates and times, human protection procedures and quantitative testing measures. The researchers contact information was listed for participants to withdraw during any portion of the study. Demographic data, the DTI survey (both pre-and post), and the DASH-SV survey of each participant was assigned an identification number that protected the confidentiality of each participant and was electronically de-identified by the password protected server used by Qualtrics. All related study data was downloaded and stored on a separate password protected encrypted USB drive and is stored in a locked filing cabinet in the researcher's office. This will be kept for a period of three years, and then the data will be destroyed.

Measures were taken by the researcher to minimize any anxiety exhibited by the participants by providing pre-debriefing prior to the start of the simulations, supportive behaviors during the simulation and the debriefing method of DML after the completion of the simulation to allow student expression of emotions per INACSL standards. The risk of coercion in the study participants was minimized because no relationship existed between the researcher and the study participants. Participants were treated in a supportive and respectful environment that encouraged reflective thinking and to minimize any feelings of anxiety. The researcher provided support and non-judgmental debriefing practices as outlined in the INACSL standards of simulation to avoid any cause for psychological distress (INACSL, 2016). Participants were asked to sign a promise of confidentiality to not discuss the simulation designs or debriefing experiences involving themselves or other participants to protect the integrity of the research data collected and maintain participant privacy (Polit & Beck, 2012).

Summary of the Chapter

In summary, this research study was a pilot exploratory descriptive study in FNP-s examining the use of the educational pedagogy of three simulations followed by the DML method of debriefing after each simulation event to examine changes in diagnostic reasoning in the pre and post survey and response times using the DTI survey instrument. Demographics data was collected and years of experience as a registered nurse and registered nurse practice areas will be correlated to examine positive, negative or no relationship to the pre-and post-survey data of the DTI. The DASH-SV survey was used to assess FNP-s satisfaction with the DML method of debriefing.

CHAPTER FOUR: DATA ANALYSIS AND RESULTS

Introduction

This chapter describes the quantitative results of diagnostic reasoning development in family nurse practitioner students (FNP-s) using a descriptive, exploratory pilot study design. This method was used to explore, describe, and measure the effect of *Debriefing for Meaningful Learning*® (DML) on the development of diagnostic reasoning in FNP-s using primary care simulated patient care scenarios. Developing diagnostic reasoning skills in advanced practice nursing students is a challenging goal as FNP-s need to change their thinking from nursing diagnosis to medical diagnosis. The healthcare environment has become increasingly complex with clinical situations that are complicated by high levels of uncertainty in diagnosis and unpredictability in the management of patient care problems. Nurse practitioners need to develop highly skilled knowledge structures and flexibility in thinking to generate diagnosis and prevent error. Diagnostic errors are a patient safety initiative recommended by the Institute of Medicine (IOM) as diagnostic errors affect the quality of patient care. Recommendations from the IOM include that healthcare professionals be taught the diagnostic process and include diagnostic competency assessment and feedback on performance (Institute of Medicine [IOM], 2015).

Diagnostic reasoning is the ability of the healthcare professional to think critically about the patient's problems and their own actions in response to those problems. Failures in these processes lead to diagnostic error and potential patient harm. Cognitive theorists believe that there are both non-analytic and analytic thinking modes that can occur singularly or in parallel when generating a diagnosis. The use of reflection as a metacognitive practice, may correct or mitigate errors in diagnoses and is the basis of the Dual Process Theory and Metacognition (Marcum, 2012). This study sought to affect both processes (non-analytic and analytic) by using simulation and DML, however changes only occurred in non- analytic thinking modes affecting knowledge structure. This finding is important as expert thinking involves how knowledge structure is arranged in memory and effects diagnostic reasoning accuracy (Eva, Hatala, LeBlanc, & Brooks, 2007).

Prior to the start of this study, permission was obtained from Southern Connecticut State University's Institutional Review Board. This chapter will report the changes in diagnostic reasoning skills found in this group of FNP-s, and evaluate the role of two learner characteristics (amount of prior specialty exposure and amount of nursing experience as an RN) on the development of diagnostic reasoning skills in this sample of FNP-s. This chapter will detail the procedures executed once the data collection was completed. Reports include data cleaning, summarizing the demographic characteristics of the sample, assessing the reliability of the quantitative measures, and finally evaluating the research questions that guided this exploratory pilot descriptive study. The research questions are as follows:

Research Questions

1. Does the educational practice of simulation with Debriefing for Meaningful Learning (DML) method change the diagnostic reasoning ability in FNP-s as measured by the Diagnostic Thinking Inventory's (DTI) total score?
    a. Does the educational practice of simulation with the DML method change the diagnostic reasoning ability in FNP-s as measured by the DTI in the subscale of knowledge structure?
    b. Does the educational practice of simulation with the DML method change the diagnostic reasoning ability in FNP-s as measured by the DTI in the subscale of flexibility in thinking?

2. Does the use of the DML method after simulation cause a change in the response time from the pre-testing Diagnostic Thinking Inventory (DTI) to the post-testing DTI in the total score?
    a. Does the use of the DML method after simulation cause a change in the response time from the pre-testing Diagnostic Thinking Inventory (DTI) to the post-testing DTI in the subscale of knowledge structure?
    b. Does the use of the DML method after simulation cause a change in the response time from the pre-testing Diagnostic Thinking Inventory (DTI) to the post-testing DTI in the subscale flexibility in thinking?
3. How satisfied are FNP-s with the DML method in improving their performance during the simulation as measured by the Debriefing Assessment for Simulation in Healthcare student version (DASH-SV) survey?
4. Does registered nurse specialty practice area and years of practice as a registered nurse yield differences in the diagnostic reasoning ability of FNP-s as measured by the DTI total scores?
    a. Does registered nurse specialty practice area and years of practice as a registered nurse yield differences in the diagnostic reasoning ability of FNP-s as measured by the DTI scores in the knowledge structure subscale?
    b. Does registered nurse specialty practice area and years of practice as a registered nurse yield differences in the diagnostic reasoning ability of FNP-s as measured by the DTI scores in the flexibility subscales?

Description of the Sample

A total of thirteen FNP-s participated in this exploratory, descriptive pilot study, designed to document the changes in diagnostic thinking skills after exposure to three simulations, each followed by a DML debriefing. All FNP-s completed questionnaires at two points in time: before exposure to the simulations and debriefings, and again after exposure to the simulations and debriefings. These FNP-s completed the DTI at both points in time (before and after the intervention) but they only responded to the DASH-SV once, after the intervention, on the post-survey. Based on this sample of 13 FNP-s, the reliability of these two quantitative questionnaires were above the .70 minimum criterion specified by Polit and Beck (Polit and Beck, 2012).

Once the survey questions in Qualtrix were closed, the data files were inspected and cleaned, removing participants who did not complete both the pre- and post-survey questionnaires. This process resulted in a loss of two of the fifteen participants, yielding an 87% response rate of those students who agreed to participate in the study. These two participants completed only one of the surveys, either the pre- or the post-test survey. The remaining thirteen participants responded to all the questions included in the pre- and post-surveys, and the DASH-SV making missing values a non-issue. Next, the demographic information was summarized, providing a profile of the FNP-s participants.

A limited profile of these FNP-s was constructed from the demographic questions. This data confirmed that all 13 graduate student nurses had a traditional (four-year baccalaureate undergraduate degree in nursing) experience. Three-fourths (10) of the FNP-s indicated that they had five or more years of experience as an RN at the time of this data collection, resulting in a second group of three participants who reported they had less than five years of RN experience. The FNP-s were nearly evenly split in terms of their reported inpatient specialty unit experience; six nurses indicated only one inpatient specialty unit experience and the remaining seven FNP-s reported that they had two or more inpatient specialty unit experiences. The demographics are presented in Table 7.

Table 7

Demographic Data

Question	Number of participants at each option	
Type of undergraduate education		
	Traditional	13
	Accelerated	0
Number of years working as an RN		
	Less than 5 years	3
	5 or more years	10
Type of inpatient specialty unit experience		
	1 unit	6
	2 or more units	7
Type of outpatient unit experience		
	One experience	2
	Blank	11

Reliability of the Quantitative Measures

Participants completed two survey questionnaires in this study: The Diagnostic Thinking Inventory (DTI) and the DASH-SV. The DTI was included in both the pre- and post-surveys and the DASH-SV was only administered as part of the post-survey. The reliability of each of these measures was evaluated for these thirteen respondents. As is customary for scales that involve the summing of item scores (as both the DTI and DASH-SV), reliability was determined by a technique referred to as internal consistency (Polit & Beck, 2012). The most widely used method for evaluating internal consistency is Cronbach's Alpha. The normal range of values for this measure of internal consistency is 0.00 to 1.00, with higher values indicative of greater internal consistency. Based on this sample of thirteen FNP-s, the reliability of these two quantitative questionnaires were above the .70 minimum criterion specified by Polit and Beck (Polit and Beck, 2012). The reliability coefficients of these measures are reported in Table 8.

Table 8

Measures of Internal Consistency

Survey	Cronbach's Alpha
DTI total	.83
DTI knowledge	.73
DTI flexibility	.55 / .74
DASH-SV	.94

As evidenced by these reliability values, the total DTI, the DTI knowledge subscale, and DASH-SV surveys met the .70 standard specified by Polit and Beck (2012). However, the flexibility subscale of the DTI was initially well below the .70 standard. To raise this value, three items (DTI 16, DTI 24 and DTI 34) were deleted from the flexibility subscale and not included in any subsequent analysis. All three items were negatively correlated with the remaining flexibility items. These items are identified in Table 9.

Table 9

Items Deleted from the DTI Flexibility Subscale

16. When I cannot make sense of the patient's symptoms and signs:	I move on to get new information and a new perspective	└┴┴┴┴┴┴┘	I look at them from a different perspective before moving on
24. When the patient uses imprecise or ambiguous expressions:	I let them go on to maintain the flow of the interview	└┴┴┴┴┴┴┘	I make them clarify precisely what he means before going on
34. Throughout the interview:	I managed to test my ideas even if I let the patient control the interview	└┴┴┴┴┴┴┘	I am only successful if I can control the direction of the interview

Once these items were deleted, the internal consistency of the Flexibility subscale increased to .74, a value about the minimum standard specified by Polit and Beck (Polit & Beck, 2012).

Assumptions of the Planned Analyses

Although it was initially planned to evaluate the research questions using both correlational and mean comparisons, the research questions were only addressed using mean comparisons in repeated measures analyses, given that only thirteen FNP-s completed both the pre- and post-surveys. This modification was based on the guidelines provided by Field (2009), that states correlations and regressions should be based on sample sizes greater than 30. Accordingly, the data from the DTI and DASH-SV surveys were evaluated for normality and outliers, the assumptions of repeated measures statistical analyses comparing means. The responses from both questionnaires supported these assumptions.

Summary of the Results

The changes observed in the diagnostic thinking skills of these FNP-s showed through statistical analyses that the total DTI scores were significantly higher after exposure to the simulation and DML method than before. Although this change in total DTI scores was significant, it is important to be cautious in ascribing this change to the intervention (simulation and DML method) given the fact that there was no control group in this exploratory pilot descriptive study. Given that the DTI includes both knowledge and flexibility components, it was necessary to determine whether the overall improvement in the total DTI scores resulted from changes in both knowledge and flexibility, or from only one of these subscales. Dependent groups *t* tests revealed significant gains on the knowledge subscale but not on the flexibility items, suggesting that the improvement in diagnostic thinking skills evidenced in this sample was principally due to the increase in knowledge gained from participation in the simulations and associated DML debriefings but not to any significant changes in the flexibility subscales.

The effect of the simulations followed by DML method was also evaluated on reaction time (RT) indices. Although the total DTI scores did not show evidence of a significant improvement in time related to the RT to the diagnostic questions, the knowledge subscale of the DTI showed evidence of a significant improvement in RT. The observation that these FNP-s responded to the knowledge subscale of the DTI significantly faster after the intervention than before, provides additional evidence that suggests that the diagnostic knowledge of these FNP-s was improved by this intervention. Knowledge (non-analytic reasoning) was improved by participation in the simulations followed by DML as evidenced by improvement in knowledge decision efficiency (shorter RTs) in this subscale, however, there was not a similar improvement in the RTs in the overall total DTI scores or in the flexibility subscale. In DeNeys (2006) study participants showed that non-analytic reasoning (knowledge structure) results in faster RTs and analytic reasoning (flexibility in thinking) has longer RTs. This lack of improvement both in the flexibility subscale and RTs may have been due to the small sample size and the limited exposures to simulations and DML.

These FNP-s also responded to the items comprising the DASH-SV. The mean student ratings for each of the six elements comprising the DASH-SV, were near their maximum value of seven, showing that these students rated the facilitator as “extremely effective or outstanding” on each element. These high scores on each of the elements may also suggest that the DASH-SV exhibits a ceiling effect. A ceiling effect describes the scores of a measure (DASH-SV) being at or near the highest value which may limit the variability of a variable (Polit & Beck, 2012).

Besides documenting the significant improvement in diagnostic knowledge and its related effect of improving the efficiency of these FNP-s in diagnostic skills, this group of FNP-s failed to identify the impact of two learner characteristics (amount of prior specialty exposure and amount of nursing experience as an RN) on the development of diagnostic thinking skills in this sample of FNP-s. This may have been due to the small sample size as other studies that supported these learner characteristics had larger sample sizes (Becker, 2007; Gorton, 2010; Sands, 2001).

Detailed Analysis

Total DTI scores were calculated separately for the pre- and post-measurements for each participant by summing the values assigned to each of the DTI questions. Descriptive statistics for the pre-DTI total scores and the post-DTI total scores are presented in Table 10.

1. *Does the educational practice of simulation with debriefing for meaningful learning (DML) method change the diagnostic reasoning ability in FNP-s as measured by the Diagnostic Thinking Inventory’s (DTI) total score?*

Table 10

Pre- and Post-total DTI Scores

	Minimum	Maximum	Mean	SD
Pre-total DTI scores	130.00	194.00	152.62	17.21
Post-total DTI scores	141.00	194.00	163.92	15.63

The total DTI scores were compared using a dependent groups *t* test, which identified a significant increase in the post-test total DTI scores as compared to the pre-test values, t (12) = 2.81, $p = .02$, $d = .78$, a medium difference. In other words, the total DTI scores were significantly higher after exposure to the simulation and debriefing than before. Although the change in total DTI scores was significant, it is important to be cautious in ascribing this change to the intervention (simulation and DML debriefing) given the fact that there was no control group in this exploratory, descriptive study.

Given that the DTI includes both knowledge and flexibility components, it is necessary to determine whether the overall change in total DTI scores resulted from changes in both knowledge and flexibility, or from only one of these subscales.

a. *Does the educational practice of simulation with the DML method change the diagnostic reasoning ability in FNP-s as measured by the DTI in the subscale of knowledge structure?*
b. *Does the educational practice of simulation with the DML method change the diagnostic reasoning ability in FNP-s as measured by the DTI in the subscale of flexibility in thinking?*

As presented in the top two rows of Table 11, the average post-test knowledge DTI score was significantly higher than the average pre-test score, *t* (12) = 3.02, *p* = .01, *d* = .84, a large difference. The significant change in this subscale of the DTI suggests that this intervention (simulation and DML method) addressed the knowledge structure in the FNP-s. However, the significant change in the knowledge subscale between the post and pre-test was not evidenced on the flexibility subscale. As shown in the bottom two rows of Table 11, the post-test score on the flexibility subscale was not significantly different from the pre-test flexibility subscale score, *t* (12) = 1.57, *p* = .14, *d* = .44, a small effect. The lack of a significant change in the flexibility subscale suggests that the documented improvement in the overall DTI scores was principally a function of the knowledge structure items.

Table 11

Change in DTI Knowledge and Flexibility Subscales

Subscale of DTI	Minimum	Maximum	Mean	SD
Pre-knowledge scores	61.00	95.00	78.31	8.94
Post-knowledge scores	72.00	98.00	86.00	7.42
Pre-flexibility scores	63.00	99.00	74.31	9.70
Post-flexibility scores	65.00	96.00	77.92	9.53

1. D*oes the use of the DML method after simulation cause a change in the response time from the pre-testing Diagnostic Thinking Inventory (DTI) to the post testing DTI in the total score?*

Qualtrics, the software package that hosted the pre- and post-surveys, recorded the response time of each participant to each question. The response times (RT) were averaged and compared for the pre- and post- DTI scores. As summarized in Table 12, response times on the post-survey DTI questions were faster than on the pre-survey. However, this striking reduction in RT after the intervention was not significantly faster, *t* (12) = -2.02, *p* = .07, *d* = .31.

Table 12

Response Times for Pre- and Post-total DTI Scores

	Mean	SD
Pre-total DTI RT	32.51	32.31
Post-total DTI RT	14.51	5.71

a. *Does the use of the DML method after simulation cause a change in the response time from the pre-testing Diagnostic Thinking Inventory (DTI) to the post-testing DTI in the subscale of knowledge structure?*

b. *Does the use of the DML method after simulation cause a change in the response time from the pre-testing Diagnostic Thinking Inventory (DTI) to the post-testing DTI in the subscale flexibility in thinking?*

Although the response times for the total DTI scores did not differ significantly between the pre- and post- measurements, the situation was different when the pre- and post-knowledge and flexibility RTs were compared. As presented in Table 13, the RTs for the knowledge subscale were significantly faster after the simulations and debriefings compared to the response times for the pre-test questions, *t* (12) = -2.33, *p* = .03, *d* = .65, a medium effect. This significant difference in RT supports the change in knowledge structure and suggests that once the FNP-s acquired relevant knowledge structure from the simulation and DML method, this allowed them to respond to the knowledge structure subscales faster which supports nonanalytic cognitive patterns. Despite the significant difference in RTs for the knowledge subscale, the response times for the flexibility questions did not differ significantly between the post and pre-test surveys, t (12) = -1.72, p = .11, d = .40, a small effect.

Table 13

Response Times for Pre- and Post-Knowledge and Flexibility DTI Subscales

	Mean	SD
Pre-knowledge DTI RT	26.51	17.12
Post-knowledge DTI RT	15.34	7.76
Pre-flexibility DTI RT	38.23	51.40
Post-flexibility DTI RT	13.73	5.41

2. *How satisfied are FNP-s with the DML method in improving their performance during the simulation as measured by the Debriefing Assessment for Simulation in Healthcare student version (DASH-SV) survey?*

The DASH student version (DASH-SV) was used to gather FNP-s feedback on the debriefing experience, specifically, to identify the extent to which students perceived that the facilitator demonstrated the six elements of effective debriefing following simulation sessions. Using the DASH-SV, FNP-s assessed the facilitator and how the debriefing impacted their own engagement and learning. The 23 items comprising the DASH-SV survey reflected six elements. Each item was evaluated on a 7-point scale, with higher scores indicative of better performance. Table 14 summarizes the FNP-s responses.

Table 14

DASH-SV Descriptive Statistics by Element

Element	# items	Min	Max	Mean	SD	Mean Rating
1	4	23	28	27.08	1.50	6.77
2	5	32	35	34.54	1.13	6.98
3	4	24	28	27.38	1.26	6.85
4	5	30	35	33.92	1.85	6.78
5	2	10	14	13.23	1.36	6.62
6	3	18	21	20.38	1.04	6.79

As shown in this table, the mean FNP-s ratings for each element were near their maximum value of 7 (Mean rating = mean for the element divided by the number of items evaluated by the element). In fact, as shown in the following table (Table 15), 61.5% (N = 8) or more of the student respondents rated the facilitator as “extremely effective or outstanding” on each element. These two tables suggest that the DASH-SV scores may reflect a ceiling effect for this group of FNP-s.

Table 15

DASH-SV

Element	Maximum Value	N respondents	% of respondents
1	28	8	61.5
2	35	11	84.6
3	28	10	76.9
4	35	8	61.5
5	14	9	69.2
6	21	9	69.2

3. *Does registered nurse specialty practice area and years of practice as a registered nurse yield differences in the diagnostic reasoning ability of FNP-s as measured by the DTI total scores?*

One of the demographic questions asked the FNP-s about their experience as a registered nurse. Ten of the FNP's reported five or more years of registered nurse experience and only three indicated that they had less than five years of nursing experience. This small sample size made statistical comparisons in total DTI, knowledge, and flexibility subscale scores inappropriate to execute using this demographic variable.

The FNP-s were also asked to check all the inpatient and outpatient specialty units related to their work experience. Some of the FNP-s indicated they had only experience working on one inpatient unit while a few FNP-s reported they had experience on multiple specialty units. Accordingly, the FNP-s were divided into two groups, based on the number of reported inpatient experiences: one, or greater than one. Six (46.2%) of the FNP-s reported only one inpatient unit experience and seven (53.8%) indicated having those with two or more inpatient unit experiences. These groups of FNP-s were then compared to the change in DTI between the post- and pre-measurements. As presented in Table 16, the average amount of change in the DTI scores (total, knowledge and flexibility) did not differ significantly when the FNP-s were grouped by amount of inpatient unit experience, all ts (11) > .05.

Table 16

DTI Change Score (Post-pre)

	Specialty Experience	Mean	SD
Total DTI	1 inpatient specialty unit	11.33	16.11
	2+ specialty units	11.29	14.36
Knowledge	1 inpatient specialty unit	7.50	9.59
	2+ specialty units	7.86	9.58
Flexibility	inpatient specialty unit	3.83	10.91
	2+ specialty units	3.43	6.19

Summary of the Chapter

In summary, a total of 13 FNP-s participated in this exploratory descriptive pilot study. All students participated in three simulations followed by the debriefing method of DML according to study protocols and procedures. All students completed both the pre-DTI survey prior to the start of the study, and the post DTI survey followed by the DASH-SV survey at the completion of this study. The reliability of the quantitative measures related to the DTI and DASH-SV were evaluated for internal consistency using Cronbach's Alpha. The reliability coefficients of the total DTI inventory, the knowledge subscale of the DTI and the DASH-SV met the .70 standard specified by Polit and Beck (2012). The flexibility subscale of the DTI was initially well below the .70 specified standard. Item analysis of three survey questions (DTI 16, DTI 24, and DTI 34) were found to be negatively correlated with the remaining flexibility items in the flexibility subscale. By deleting these items, the internal consistency of the flexibility subscale increased to greater than the .70 standard specified by Polit and Beck (2012). Both the DTI and DASH-SV surveys showed a normal distribution with no outliers.

The results of this study used mean comparisons by use of a repeated measure analysis given the small sample size (< 30) in this descriptive exploratory study (Field, 2009). Mean comparisons using a dependent group t-test showed significant statistical gains in post-total DTI scores from the pre-total DTI scores. Statistically significant gains were also shown in the post-total DTI knowledge structure sub scores following the intervention of simulation followed by DML. Given that the DTI contains both knowledge and flexibility subscales within the survey, the flexibility subscale was then measured. The post-test DTI scores when compared to the pre-test scores on the flexibility subscale did not show a significantly statistical change, thus showing that increases in the DTI's total score were due to increases in the knowledge structure subscale.

In addressing the research question related to changes in response time (RT) of the survey data from the pre-total DTI to the post-total DTI, results showed that the response times were not statistically faster on the post survey DTI and did not reach statistical significance after inspection of the standard deviations, and comparison of the variability. However, RT on the pre-survey DTI knowledge subscale was more than six times greater than RT on the post-survey DTI knowledge subscale. This showed that the RT for the knowledge subscale scores were significantly faster on the post- DTI knowledge subscale compared to the pretest knowledge subscale RT, showing a medium effect. This data correlates with the increases shown in the post-DTI knowledge structure scores. In assessing the RT for the flexibility subscale of the DTI, RT showed that the on the post-

DTI flexibility subscale times did not differ significantly from the pre-DTI RT flexibility subscale. Pretest flexibility RT was substantially ten times longer than on the posttest flexibility RT survey. The standard deviations showed increased areas of variability (dispersion of data) which would be consistent with some type of change taking place. The assessment of the DASH-SV survey showed that FNP-s were satisfied with the use of DML as a debriefing method after simulation.

In conclusion, simulation with the debriefing method of DML was found to significantly increase knowledge structure in this small sample of FNP-s, which is indicative of non-analytic diagnostic reasoning. Although flexibility subscales and RT did not show a change this may have been due to the very small sample size of FNP-s and the limited amount of simulation and debriefing practice. All FNP-s were satisfied with the debriefing method of DML.

CHAPTER FIVE: CONCLUSIONS AND DISCUSSION

Introduction

In this chapter the findings of this study will be discussed in relation to the current research involving diagnostic reasoning development in advanced practice nurses and other healthcare disciplines. The results of this research have important implications related to education of family nurse practitioner students (FNP-s) in advancing diagnostic reasoning development using simulation and Debriefing for Meaningful Learning ® (DML). Further, implications and applications of this research may be applied to general nurse practitioner education related to diagnostic reasoning development. How diagnostic reasoning is taught in nurse practitioner (NP) programs is inadequately studied and is a significant gap in entry level NP practice that may lead to diagnostic error (Sands, 2011). This chapter will cover a summary and discussion of the results, their relation to the current literature, the limitations of the current research, implications in graduate education of advanced family nurse practitioners, and suggestions for further research.

The purpose of this research was to explore, describe and measure, using a descriptive exploratory pilot study, the effect of the DML method on the development of diagnostic reasoning in FNP-s after participation in simulated patient care scenarios. This study sought to explore if the use of simulation pedagogy, followed by a reflective debriefing method (DML) increased knowledge structure, flexibility in thinking, or both as measured by the diagnostic thinking inventory (DTI). Response times (RT) were also recorded on the DTI survey and subscales in the pretest and the post test, to further define differences between the knowledge and flexibility subscale RT. This was measured to determine if any changes occurred in increased (faster) or decreased (slower) RT when responding to the subscale survey questions on the DTI.

This study also sought to describe if there were any changes in knowledge structure or flexibility in thinking related to scores on the DTI in relation to the amount of registered nurse experience (greater than or less than five years) and undergraduate specialty work practice experience (one specialty practice or more than one). Finally, FNP-s satisfaction with the debriefing method was measured using the Debriefing Assessment in Simulation Healthcare student version (DASH-SV) survey. Currently in nursing educational research, studies are lacking in appropriate methods to teach diagnostic ability to advanced practice nursing students. Current national focus on prevention of diagnostic errors in patients is paramount to increasing patient safety and improving healthcare outcomes. Best practices in teaching diagnostic reasoning and avoiding diagnostic error should be a focus in nurse practitioner education. Diagnostic ability is an essential function of the nurse practitioner role that requires transition from the registered nursing (RN) role to the advanced practice role (Barnes, 2015). Educational processes that focus on improving diagnostic ability may mitigate errors in diagnoses, improve patient safety, improve competency in practice, and ease transition into the advanced practice role.

Summary of the Results

As shown in chapter four, simulation as an educational teaching method for FNP-s with the use of DML was shown to increase overall scores on the DTI, specifically subscale scores in knowledge structure, but not in flexibility subscale scores. The DTI measures diagnostic reasoning cognitive processes in both experts and novices, however this does not include diagnostic decision making (Bordage, Grant, & Marsden, 1990). This study showed faster RT in the knowledge structure subscale responses, and thus correlates to the increased knowledge structure subscale scores found in this study on the DTI. Flexibility in thinking did not show increased subscale scores on the DTI, nor did the RT related to the flexibility subscale, this may be related to the small sample size, the number of simulation scenarios or the scenarios not being discordant. Although RT on the knowledge subscale scores were faster and correlated with the knowledge sub-scale scores, RT related to the flexibility sub-scale did not show a statistically significant change.

Further, internal consistency measured by Cronbach's alpha was problematic in this small sample of FNP-s related to the flexibility in thinking subscale and was initially low (.55) but increased to (.74) with the elimination of three survey questions. Registered nurse experience and specialty practice area showed no effect on the DTI which is a different outcome compared to previous studies (King, 2006; Sands, 2001). These results will be further explored in the following sections.

Discussion of the Results

Students were instructed when completing the post-survey DTI to score items in relation to the interventions of the (3) simulations and (3) DML method and the effects these interventions had on their diagnostic reasoning. This instruction was given to students specifically to relate the effect of these interventions (simulation and DML) to their survey responses on the DTI and to exclude the effect of other teaching in their FNP-s educational program. Overall post survey total scores on the DTI where significantly higher after exposure to the simulations and debriefings. The gains shown in the DTI knowledge structure are consistent with characteristics of dual process theory and demonstrate non-analytic (pattern recognition) or type I processes of cognitive reasoning in these FNP-s. This is expected considering this cohort of FNP-s had background experience as RN's and bring clinical experience and one clinical rotation caring for patients in an FNP-s role. This experience would assist development in pattern recognition related to specific diseases (Pirret, 2013). However, this increase in DTI scores and specifically the knowledge subscale does not mean that the FNP-s were better able to diagnose from this intervention, but instead their perceived knowledge structure in the diagnostic process improved from these interventions. This is consistent with the development of expert reasoning (Groves, 2007). The challenge with using only non-analytic (type 1) processes in cognition is that failure to monitor thinking and adjust cognitive reasoning through analytical measures may lead to diagnostic reasoning errors in availability, context, bias, and premature closure (Miller, 2013). A combination of cognitive approaches, compared to only one, leads to improved diagnostic outcomes (Ark, Brooks, & Eva, 2007; Norman & Eva, 2010).

Both non-analytic and analytic process are not linear processes but are thought to occur simultaneously. The inclination to use one over the other may be related to the FNP-s knowledge, skill, prior training, previous clinical encounters, cohort level, diagnostic teaching and self-confidence in transitioning from the RN role to an advanced practice role. Use of one mode of thinking over another may suggest difficulties shifting from a nursing diagnosis model to a medical diagnosis model and require change or adaption of "habits of mind" in nursing to include analytic and reflective practice specifically applied to medical diagnoses (Scheffer & Reubenfeld, 2000). Errors in diagnoses are thought to occur in both dual processes (type I and type II), and reflective practices are thought to mitigate these errors (Ark et al., 2007).

Bordage et al. (1990) stated that excellent diagnosticians rely on both organization of knowledge structure and flexibility in thinking to arrive at diagnosis. Knowledge structure is proposed as the primary factor in diagnostic thinking by use of memory structure, recognition, and definitions of diagnostic data. Flexibility in thinking is proposed to be important because it shifts cognition through the recognition of forceful features in patient presentation and encourages follow-up either by deterministic or responsive inquiry (Bordage et al., 1990). It is postulated that the utilization of both type I and type II, or a combination of both with the use of reflective practices (metacognition) may decrease occurrences of diagnostic errors (Norman & Eva, 2010).

In discussion of the following research question*: Does the educational practice of simulation with the DML method change the diagnostic reasoning ability in FNP-s as measured by the DTI in the subscale of knowledge structure?* Results of Bland and Tobbell's (2016) study on why simulation is effective with students showed a connection supporting brain-based learning involving neuroeducation through cognitive imprinting allowing an orchestrated immersion in complex environments (testing of simulations, simulation activity), active cognitive processing (participation in or observing the simulation), and relaxed alertness (adequate pre-debriefing, safe learning environment, trained facilitator, and reflective debriefing practices) (Rogers, 2015). The International Association of Clinical and Simulation Learning (INACSL) standards were used as a design for the stages and planning in this study and these standards are synergistic to brain-based learning in simulation practice. Simulation learning must be developed, organized and planned based on standards that follow specific theory to affect learning and show measurable gains in outcomes ("Standards of best practice: Simulation," 2016).

Cognitive imprinting relates to the contextual meaning and the stimulus, as applied, within the learning context. While cognitive imprinting usually relates to short-term memory, it influences long-term knowledge if used correctly it can be more readily accessed by the student (Afzal & Babar, 2016). Emotional arousal enhances long-term memory through immersion in simulation activities and links to established educational and student outcomes and objectives. Reflection provides the metacognitive link to long-term memory and knowledge structure (Rogers, 2015). This study showed that simulation learning activities, with reflective debriefing, can change knowledge structure in diagnostic ability in this small group of FNP-s. Educational practices in teaching diagnostic reasoning ability is not known in nurse practitioner education. This study shows the effectiveness of simulation with reflective debriefing in advancing knowledge structure in FNP-s. Although flexibility in thinking was not changed in this small sample, larger studies are warranted.

In discussion of the following research question*: Does the educational practice of simulation with the DML method change the diagnostic reasoning ability in FNP-s as measured by the DTI in the subscale of flexibility in thinking?* In a study by Blondon et al. (2017) involving interprofessional (collaborative) reasoning between nurses and residents using simulation case studies, communication and reasoning was found to differ between these two groups. Using a mixed method analysis, fourteen residents and fourteen RN's participated in four simulation scenarios based on acute patient cases in a hospital setting. Interviews were held individually and with the team residents and RN's while watching the videotaped simulations. Transcripts were coded to explore collaborative reasoning and graded on a five-point Likert scale to describe how each theme in collaborative reasoning influenced the encounter. A global assessment score was given on how effective the team was in the work-up and management of the patient situation. Common themes in collaborative reasoning were identified as diagnostic reasoning, patient management, patient monitoring, communication, and explanations given to the patient. Quantitative results showed the lowest scores in residents for team communication and in nursing for explanations to the patients. There were no significant differences in resident or nurse individual performance for any theme ($p = 0.57$), however the global assessment score differed significantly from the mean of the individual resident and the mean of the individual nurse ($p = 0.03$) in team performance.

Diagnostic reasoning findings showed that nurses contribute to the collaborative process by communicating their initial assessment however, were not explicit in a cause or diagnosis for the change in the patient's condition. On qualitative interviewing, nurses considered their role as presenting findings or concerns to the resident, not diagnosing or discussing patient management. This is consistent with RN thinking and the nursing process. The authors concluded that residents used hypothetical reasoning in understanding signs and symptoms, in contrast to nurses who use clinical diagnosis to address psychological concepts that focus on symptom management. (Blondon et al., 2017). This study may suggest that the transition from nursing diagnosis to medical diagnosis requires further exploration and the lack of change in scores on the flexibility in thinking subscale may be related to uncertainty transitioning to a medical diagnosis. Specific education in the diagnostic process in nurse practitioner education needs to include non-analytic, analytic, and reflective practices to assist students with the process of transitioning to a NP role that includes medical diagnoses for diagnostic clarity with other disciplines. Simulation with the DML model may assist FNP-s to develop diagnostic reasoning.

Sobral (2000) examined 362 medical students over six years to evaluate curriculum changes that were implemented into a medical curriculum. The DTI was administered before changes were made to obtain baseline measurements on program entry. Introduction to case-based learning (CBL) and evidence-based practice was introduced during the clinical apprenticeship phases (year two and three), with retesting of the DTI during clinical advancement. Each cohort level scores (year one, two, and three) were correlated with learning achievement (test scores based on CBL) and self-confidence as a learner. Significant findings included three predicting factors associated with increased scores in the DTI. These included self-confidences of the learner, problem-solving ability and progression of the cohorts, with the final cohort having increased scoring on the DTI both in knowledge and flexibility (Sobral, 2000). Family nurse practitioner students may have decreased self-confidence in their diagnostic ability at this level (second semester students), and this may have affected the flexibility subscale sores on the DTI. The implementation of additional simulation with debriefings throughout the FNP-s curriculum may increase flexibility scores.

Use of metacognitive strategies through reflective debriefing practices may trigger type II analytic reasoning forcing retrieval of implicit thinking, and reanalyzing a problem because of cognitive dissonance (Marcum, 2012). In a study by Mamede et al. (2007) sixteen internal medicine residents diagnosed 20 cases and were asked to recall the case information. The authors used two versions of each case divided into straightforward cases (non-ambiguous) or unclear cases (ambiguous), and assessed diagnostic accuracy, time to process, and case information recalled. The participants were given the case in a booklet, instructed to read the case, provide a diagnosis, then turn the page and write down their recall of the case. Diagnoses were rated on a scale from completely inaccurate to correct diagnosis. The case recall was scored by means of a propositional analysis linked by a qualifier such as causation, acute or chronic, historical information or location. Results showed that mean diagnostic accuracy was higher for straightforward cases than unclear or complex cases and time to process case information was also faster in the straightforward cases. The details recalled in straightforward cases were higher than in the ambiguous cases, however recall in the ambiguous cases contained more literal clues than in the straightforward cases. This suggests that difficult cases may activate reflexive reasoning and take longer to diagnose (Mamede, Schmidt, Rikers, Penaforte, & Cuelho-Filho, 2007).

Debriefing for meaningful learning in this study sought to affect both knowledge structure (type I) and flexibility practices (type II) in these FNP-s, however failed to show significant changes in flexibility in thinking. This may have been due to the limited exposure to DML (three simulations, and three DML debriefings), the simulations not being ambiguous enough, and/or the small sample size. Additional research with larger samples, using complex and ambiguous cases are needed to explore this possibility with increased use of reflective reasoning strategies.

The current study measured the flexibility scale of the DTI using Cronbach's alpha and had an initial internal consistency of .55 that increased to .74 once three of the inventory questions were omitted due to negative correlations with the remaining flexibility items. In King's (2006) study on experienced NP's and NP-s, the DTI was shown to be a reliable tool using a larger sample size in NP-s. King (2006) studied NP and NP-s diagnostic reasoning and the use of intuition using a sample of NP-s and experienced NP at a large national conference. No intervention was used prior to administering the DTI except to have the participants answer the survey based on how they diagnose. Sixty-five NP-s and 164 experienced NP were recruited and took the DTI once as a baseline measurement. Internal consistency using Cronbach's alpha showed a reliability coefficient of .82 in total DTI score with subscale scores in flexibility of .65 and knowledge of .76, showing this was a reliable tool in NP and NP-s. King's (2006) scores were consistent with Jones (1997) study in physiotherapists (King, 2006; Jones, 1997). King's study also showed overall lower scores in the NP-s flexibility subscale that was unrelated to cohort level and increased flexibility subscales scores in practicing NP who had greater levels of practice experience. The DTI in the current study of FNP-s showed a total internal consistency of .83, and DTI knowledge .73 which was comparable to King's (2006) study but the flexibility of .55 was far below. This may have been due to the small sample size and not the FNP-s being studied. Use of the DTI should be used in future studies involving nurse practitioner students.

Beullens et al. (2006) tested diagnostic ability in three different groups of Dutch medical students using three series of 70 problem-solving clinical seminars administered over eight weeks. The total number of students who participated in the first series who took the pre-test DTI was 109 and out of those students 104 completed the post-test DTI. The second series involved 114 students who took the pretest DTI and out of those students 116 completed the post-test. In the third series 35 students took the pretest DTI and 36 completed the post-test DTI. The hypothesis stated that DTI scores would be higher after the problem-solving seminars. The internal consistency of the DTI in this large sample of medical students by Cronbach's alpha showed 0.64 for flexibility, 0.71 for knowledge and .80 for the total scale. The author noted that after the seminars the total DTI scores increased, but if each series is considered separately, the increases were seen only in knowledge structure not flexibility, which is consistent with the current study. They concluded this was probably due to the low reliability in the flexibility scale (Beullens, Struyf, & Damme, 2006). Both Beullens et al. (2006) and King (2006) showed lower internal consistency in the flexibility scales of the DTI, and this may relate to the placement of students within the curriculum and their experience with diagnoses, their overall level of medical and nursing experience, or inherent issues with the flexibility scales in these groups (students). The current study used reflection (DML) on simulation cases in these FNP-s which is not mentioned in either Beullens et al. (2006) nor King (2006) studies and had a much smaller sample size which may have impacted the reliability of the flexibility subscale.

In a study by Findyartini et al. (2016), examined medical students in the Asian and Pacific regions to determine if cultural differences effected diagnostic reasoning. This study involved two medical schools, one in Melbourne, Australia and one in Indonesia using the DTI scoring across both schools using a comparative case study to determine cultural differences in diagnostic reasoning between Asian/Pacific and Western cultures. Two cohorts at each school enrolled in semester six and semester twelve. The Melbourne cohort recruited a total of 166 students, and Indonesia recruited a total of 203 students. Internal consistency showed DTI total scoring and knowledge at both universities between 0.70-0.80, however internal consistency on the DTI flexibility subscale was much lower (0.55) in the Indonesia students compared to the Melbourne student's (0.79). Item analysis of the flexibility subscale in the Indonesia students showed survey item issues with thinking about early diagnostic possibilities, asking patients to define symptoms more clearly, arriving at a decision on diagnosis, and changing their decision on diagnosis.

In the current study of FNP-s the item issues with the flexibility subscale's internal consistency involved different subscale items and showed that FNP-s may have difficulty changing their perspective in relation to a patient's signs and symptoms, the need to direct the flow of the interview, and the need to control the direction of the interview to be successful. The possible common areas in this study of FNP-s and the Indonesia students may be cultural as FNP-s and Indonesia medical students may have difficulties adjusting their cognitive processes related to power and the ability to diagnose. The Indonesia medical students have cultural differences in power (students rely on authority figures for clear guidance), and experience a more authoritarian culture (Findyartini, Hawthorne, McColl, & Chiavaroli, 2016). Family nurse practitioner students are novices in generating and thinking about medical diagnosis and may be accustomed to deferring to authority figures (physicians) in their RN practice related to diagnoses. This may account for the lack of change in the flexibility subscales. Further education in the diagnostic process or the use of increased reflective practice within the nurse practitioner curriculum related to diagnoses may develop cognitive skills related to increased flexibility in thinking and move beyond routine memorization of knowledge content or tasks. This may improve cognitive patterns in thinking that could mitigate diagnostic error in arriving at a diagnostic conclusion. Repeated exposures to simulation and DML may decrease diagnostic errors when transitioning to the nurse practitioner role. Clinical experiences vary with FNP-s during clinical rotations, simulation with DML can be tailored to allow exposure to diagnoses that students may not see.

In discussion of the following research questions: *Does the use of the DML method after simulation cause a change in the response time from the pre-testing Diagnostic Thinking Inventory (DTI) to the post-testing DTI in the subscale of knowledge structure?*

Does the use of the DML method after simulation cause a change in the response time from the pre-testing Diagnostic Thinking Inventory (DTI) to the post-testing DTI in the subscale flexibility in thinking? Faster knowledge structure RT was also associated with increased knowledge structure scores on the DTI in FNP-s and is consistent with non-analytic thinking patterns. Flexibility RT did not show longer levels of response times which could be consistent with analytic thinking patterns. Comparable studies in NP-s are not available, however one study by De Neys and Glumicic (2008) on RT data showed that when problems were in conflict, RT data took longer in type II processing than congruent, non-conflicting problems in type I processing (De

Neys & Glumicic, 2008). For example, De Neys (2014) explains conflict and non-conflict reasoning using a short question as an example of a conflict:

"A psychologist wrote a brief description of persons involved in a study. There were 995 males and five females. A description was drawn from this 1000-person sample and states: Sam is a 25-year-old writer who lives in Toronto and likes to shop and buy clothes. What is most likely"? (De Neys, 2014, p. 4)

If the student chooses that Sam is a man instead of a woman, this is representative of type II analytic reasoning showing a slower response time (thinking that there are 995 males in the study) because it is based on probability. If Sam is a woman is chosen, this is representative of type I non-analytical reasoning with a faster response time (shopping and clothes relate to the female gender more) based on bias. For a non-conflict version, the question would be switched to 995 women and five men. This would trigger a non-conflict response and Sam is a woman would be chosen (De Neys, 2014). FNP-s may not have had sufficient conflict verses non-conflict in the three developed simulations (see Appendix C, D, E) or changes in flexibility RT may have occurred with increased practice cases using simulation and DML, larger sample sizes, increased conflict cases or reflective practice integrated in diagnoses across the NP curriculum to increase metacognitive skill.

In discussion of the following research question*: How satisfied are FNP-s with the DML method in improving their performance during the simulation as measured by the Debriefing Assessment for Simulation in Healthcare (DASH) student survey?* Bland and Tobbell (2016) used grounded theory methodology and sought to understand the attributes of simulation and their effect on learning in undergraduate nursing students (Bland & Tobbell, 2016). The findings showed that simulation allowed students to participate through emerging and engaging them in an active learning process that facilitated connections within their contextual domain. Simulation made them curious, stimulated their intellect through doing, interacting, and constructing an engaging collaborative environment. Because FNP-s are nurses, this study may associate with nursing perceptions of simulation-based learning and may be reflected by the ceiling effect scores on the Debriefing Assessment for Simulation in Healthcare (DASH-SV). Scores on the DML method using the DASH-SV were consistently high (ceiling effect), which may show that the tool was not valid in this group of FNP-s, the use of a small sample or may reflect the researcher's training in this debriefing method indicating that the students found DML reflection useful.

In discussion of the following research question: *Does registered nurse specialty practice area and years of practice as a registered nurse yield differences in the diagnostic reasoning ability of FNP-s as measured by the DTI total scores?* The research questions in this study examined length of registered nursing experience (greater than five years or less than 5 years), and practice areas (one or more than one) and found no differences in relation to the DTI scoring among participants. This may be attributed to the small sample size. Correlations between these two areas with the addition of grade point average (GPA), cohort level, age and sex using larger sample sizes should be explored. Sands (2011) and King (2006) both found correlations in practice area, age, and length of RN practice with increased scores in diagnostic testing and clinical reasoning (Sands) and the DTI flexibility subscale as a baseline measurement (King). In medical studies, advanced cohort levels, female sex and GPA correlated with increased total scores on the DTI and flexibility subscales (Groves, 2003).

Discussion of the Results in Relation to the Literature

In relation to studies focusing on diagnostic reasoning development or how diagnostic reasoning is taught in nurse practitioner students, there were no studies found. Ritter (2003) found through a qualitative content analysis that expert nurse practitioners learn through a combination of intuitive and analytic reasoning which may be consistent with what is now defined as Dual Process

Theory (DPT). Simulation research in NP-s is in the beginning stages of development and most studies reviewed in the literature that measured simulation and debriefing in NP-s focused on satisfaction with this educational strategy, completion of objective structured clinical exams using checklists, or competencies based on national standards of practice (Kesten, Brown, & Meeker, 2015; Morse, 2015; Miller & Carr, 2016). In fact, in a recent systemic review by Rutherford-Hemming et al. (2015) analysis of simulation studies in NP-s included only fifteen studies out of 198 citations based on the author's inclusion criteria and those studies failed to identify any evidence to replace NP-s traditional clinical hours with simulation. More than half of the studies reviewed used standardized patients, did not use theory-based learning, did not use the INACSL standards and did not focus on reflective debriefing strategies. Their findings show that research is needed to support learning outcomes using rigorous scientific studies in simulation and debriefing in NP-s. (Hemming, Nye, & Coram, 2015).

In a recent review of diagnostic reasoning and cognitive bias in nurse practitioners, Lawson (2018) found a significant gap in the nursing literature related to a definition for diagnostic reasoning and on how nurse practitioners diagnose patients. Diagnostic reasoning concepts found in other healthcare disciplines included Dual Process Theory, diagnostic error, patient harm, cognitive bias and debiasing strategies. Cognitive interventions that target debasing strategies to reduce error included training in reasoning theories, simulation, metacognitive strategies and forcing strategies that foster diagnostic reasoning into a more analytical mode. (Lawson, 2018). This current study in FNP-s shows preliminary evidence to support the use of simulation with DML as an educational strategy to advance diagnostic reasoning.

In a recent study assessing diagnostic reasoning in Doctor of Physical Therapy (DPT) students, Trommelen et al. (2017) examined the intervention of ten case-based learning (CBL) activities, divided into seven case discussions and three case demonstrations in groups of five to seven students. Twenty-seven DPT students participated in the study and used an external written reflective articulation using a physical therapy clinical reflective tool (PT-CRT) with specific questions related to the CBL as the intervention. This tool was used to encourage clinical reflection on CBL outcomes. The study also used both the DTI and the Self -Assessment of Clinical Reasoning and Reflection (SACRR) at time one (before the start of the CBL), time two (after five CBL) and time three after the written reflective articulation and the remaining five CBL. The Self - Assessment of Clinical Reasoning and Reflection is a reflective tool that was developed to evaluate reflective practices in occupational therapists and was not validated in DPT students prior to this study. It consists of 26 items using a Likert scales from 1 to 5 and measures different aspects of clinical reasoning related to occupational therapists. This reflective tool had high internal consistency using Cronbach's alpha of .87 and .92. The DTI was also applied to measure diagnostic reasoning in the DPT students and a test-retest of the internal reliability using a three-week time gap between administration of both survey items on the DTI showed total scores of .77, with knowledge subscale of .77 and flexibility of .76 respectively.

This study examined both explicit (three CBL using demonstrations) and implicit reasoning (the remaining seven CBT) that focused on discussions for a total of ten cases. The addition of a reflection strategy that used a written external review (PT-CRT) of the CBL was completed from time two to time three. Results showed no main difference in the scores of the SACRR or the DTI after time one or time two, (after 3 weeks) however, scores on the SACRR and DTI increased significantly after the PT-CRT tool (P=.001) was completed from time two to time three. The authors attributed the recognition of patterns to the increase in knowledge scores and the use of the PT-CRT in providing a formal structure for the reflective process. The tool encouraged the students to compare (reflection on action and in action) and contrast patient outcomes and goals related to the diagnosis and to explore other options (reflection beyond action). Additionally, students reflected on their action (reflection in action) and performed a self-assessment (self-reflection on ability). The PT-CRT tool was developed using the framework of the International Classification of Functioning Disability and Health and the patient management model in physical therapy practice. The results of this study showed significant statistical gains (*P*=.001) in total DTI scores in both knowledge and flexibility subscales (Trommelen, Karpinski, & Chauvin, 2017).

The results of Trommelen et al. (2017), may indicate the use of written guided reflection on CBL outcomes in both individual and group work can affect diagnostic reasoning. Increased reflection (written) and CST in groups may affect both subscales of the DTI and may translate to NP-s to support different models of reflective practice (written external, individual and in groups) that have been used in other healthcare disciplines. Changes may have occurred in the current study if increased amounts of simulation and debriefing were used with the addition of a written format being completed after the debriefing. Guided reflection that is written may show a benefit if used throughout the NP curriculum with incorporation into CBL, discussion questions, and seminars. Debriefing for Meaningful Learning uses a written component as a part of the method however, this is completed directly after the simulation and prior to the debriefing by the facilitator. This may be beneficial if students complete this after the debriefing has occurred to allow for reflective processing of the simulation and debriefing event. Feedback is not given by the facilitator on the student sheets, however it may be beneficial to explore this possibility.

Johns and Christensen (2018) assessed clinical reasoning in first-year medical students after an experiential course in rural family medicine. This was a longitudinal study that occurred over one year and included the course objectives of history and physical examination skills, understanding the principals of longitudinal care in the community, reflective practice and feedback, interprofessional care in the community, demonstrating professionalism and patient-centered care. Students were required to complete a portfolio that included reflection essays based on those course objectives. Results showed that total DTI scores increased in the 63 first year medical students after participating in experiential learning with the reflective essays compared to a previous cohorts control group in the previous year who had not. The control group had participated in only nine half day sessions with rural preceptors (less contact time with patients) as opposed to five weeks of training in the experiential learning group (more contact time with patients) and had not used the reflective essays. The experiential group had increased use of knowledge, practice, and use of a reflective process which the authors attribute to the increased scores on the total DTI survey (Johns & Christensen, 2018). The current study in FNP-s had a limited number of simulations and reflective practice, results may have improved in the DTI flexibility subscale if more practice in simulation and debriefings, including written reflections were incorporated.

Formal instruction in the diagnostic reasoning processes may be beneficial to NP-s. Yousefichaijan et al. (2015) showed that didactic instruction in the process of clinical reasoning indicated statistical increases in the total DTI scoring of the intervention group in medical students. This study used a semi-experimental design with a control group (23 students, no clinical reasoning instruction) and intervention group (19 students, clinical reasoning instruction) using a test-retest design in the intervention group over a span of fifteen days. The control group took the DTI survey after completion of case-based testing (CBT), which were divided into key features (KF) involving ten clinical cases and clinical reasoning problems (CRP) involving ten clinical cases. The intervention group took the DTI pre-test, attended a workshop over two days (six hours of instruction each day) that was related to the clinical reasoning processes in communication skills, data gathering, hypothesis generation, analytical reasoning approach, non-analytical reasoning approach, and changing the approach based on problem-solving. They then completed the CBT (KF and CRP), and the DTI post-test.

Results showed statistically significant gains from the pre-post testing of the intervention group DTI survey ($P < 0.001$) and increased scores on the CRP ($P>0.05$) but not the KF cases. There were no significant statistical differences in the DTI scoring of the control group compared to the intervention groups pre-DTI scores, however overall scoring in the intervention group after the clinical reasoning workshop compared to the control group was statistically significant ($P<0.05$). This study did not look at the separate subscales in knowledge or flexibility but showed an overall increase in clinical reasoning (CRP and DTI) scores (Yousefichaijan, Jafari, Kahbazi, Rafieri, & Pakniyat, 2016). The current study did not instruct FNP-s on diagnostic reasoning processes in analytic and nonanalytic thinking or how to change approaches in reasoning to mitigate and avoid diagnostic errors. The educational implications of instruction in clinical and diagnostic reasoning processes to avoid error may be beneficial in NP-s education to provide theory and structure in this difficult cognitive process.

In Groves et al. (2003) three successive cohorts (total of 290 students over three years) were voluntarily recruited to measure gains in clinical (diagnostic) reasoning in relation to cohort year (year one, two and three). Demographic data collected included gender, age, undergraduate degree (biological and non-biological), interview (communication ability and cognitive style) and mean Graduate Australian Medical School Admissions Test (GAMSAT) scores. Demographic data was correlated to ten sets of clinical reasoning problems (CRP) and DTI scores using univariate and multivariate analysis. Significant associations were shown in univariate analysis of CRP scores, between cohort level, gender (female) and primary degree (biological), with a small significance in interview scores and the total DTI and flexibility sub-scores (total DTI scores $p = 0.04$ and $p = 0.03$ respectively) but not knowledge scores ($p = 0.10$). However, increases in DTI scoring was not associated with only female gender. Stage of progression (year one to three), was also an indicator of increased DTI scores. Multivariate analysis showed female gender as a positive predictor in CRP scores (but not total DTI scores) that was independent of the stage of progression or primary degree. However, progression in the program by year three resolved this factor in CRP scores (primary degree). The GAMSAT scores had no effect on the DTI or CRP scoring and the authors concluded that increased scoring on the DTI and CRP was related to female gender, progression in the program and interview score (Groves, O'Rourke, & Alexander, 2003). In the current study on FNP-s one cohort was used (second semester students) and DTI scoring was not assessed throughout progression of student cohorts to see if increases occurred over time or if increases occur after transition into practice. This may be areas to explore in future studies in FNP-s and other specialty NP-s.

Sands (2001) recruited 70 entry-level NP's and examined diagnostic reasoning performance using a computer-based software system (DxR), an analytical decision style analysis, and critical thinking disposition scores (CCTDI). These three measures were correlated with demographic data of associate degree verses baccalaureate, age, years of practice, and specialty areas. Sands (2001) found that entry- level NP's who had greater than five-years' experience as an RN had better scores on the DxR and showed analytical decision styles, however there were only four nurses who had less than five years-experience as a RN in this sample, but they showed considerable lower scores on the DxR. Sands (2001) also examined the relationship between DxR and specialty areas (critical care based, and non-critical care based), and found no difference in DxR scores however, higher CCTDI scores and analytical mean scores were found with critical care based experience and greater than five years as a RN. The findings of increased experience were similar to King's (2006) study cited in chapter two, showing a statistically significant relationship between increased diagnostic skill performance $r\ (223) = .17$, ($p < .01$) and increased experience. The DTI was also positively and statistically significant $r\ (215) = .26$ ($p < .01$) with NP's job experience of greater than five years (King, 2006; Sands, 2001). For the purpose of statistical analysis, the research questions on demographics in this study examined length of registered nursing experience (greater than five years or less than five years), and specialty practice areas (one or more than one) and found no differences in DTI scoring among participants. Results of greater flexibility used in cognition may relate to greater experience thus corresponding to greater practice, however because the sample size in the current study was small no conclusions can be reached.

Limitations

This study used an exploratory descriptive pilot design in a small group of FNP-s at one university, results cannot be generalized to other NP-s in different specialty practices or across other curriculum designs. This study also lacked a control group. The DTI is a self-reported quantitative survey of student's diagnostic thinking ability and the survey may be subject to inherent bias by the participants, accordingly the survey questions may not be answered honestly. The DASH-SV survey showed a ceiling effect in these participants that may have been due to the small sample size, knowledge that the debriefer was the primary investigator for the study or their enjoyment of simulation and debriefing as this had not been used as a teaching modality before in this group of FNP-s. The position of the cohort (second semester FNP-s) may have been a factor in the results of this study along with the (3) simulation and (3) DML debriefings. This specific FNP-s cohort at this university may have been a factor and these results may not generalize across different curriculums and programs. The progression of diagnostic reasoning and the gains in knowledge structure may not be related to the intervention but through clinical rotations, and program continuance.

Implications of the Results for Nursing Education

This study shows important implications in teaching and learning practices related to diagnostic reasoning in FNP-s and validates simulation and the reflective debriefing method (DML). The FNP-s indicated perceived gains in knowledge structure in this small pilot study. This study was a descriptive exploratory pilot design with a limited number of participants of FNP-s, therefore data cannot be extrapolated or inferred to be accurate to other populations of nurse practitioner students. Gains in knowledge structure can enable FNP-s to achieve a higher rate of diagnostic accuracy by facilitating how knowledge is arranged and accessed in long-term memory. Simulation with DML showed knowledge structure gains in these FNP-s however, the lack of perceived gains in flexibility in thinking may be problematic. This may be related to the small sample size in this study, the limited number of simulation and debriefing practice, and difficulties with generating medical diagnosis in the face of uncertainty. This may also be related to difficulties in transitioning into an advanced practice nursing role and the expectation to perform medical diagnosis.

There may be a general need in NP programs to move away from routine learning and memorization, and include brain-based teaching that can be applied and practiced, encouraging reflection as a metacognitive habit to affect long-term memory. The use of written guided reflection involving diagnosis with faculty feedback should be explored. Curriculum change is needed in NP education that supports all forms of simulation and the use of a structured reflection can assist to develop cognitive structure in diagnostics and mitigate causes of diagnostic errors related to cognition. Instruction in diagnostic reasoning should include theory-based education on cognitive processes needed to generate diagnosis, identify cognitive errors that can affect diagnosis and instruction on theory-based reflective practices that are applied across the NP curriculum. Assessment practices should indicate development in knowledge structure and flexibility in thinking to cultivate expert reasoning that is reflective. Reflective practices that increase metacognitive skill can be applied across clinical didactic courses taught in NP-s to involve every patient encounter with the formative outcome to influence and cultivate diagnostic thinking processes.

Currently there is no evidence to support the use of simulation pedagogy to replace clinical hours in graduate nursing students unlike the National Council of State Boards of Nursing (NCSBN) study in undergraduate nursing students that indicated up to 50% of clinical practice can be substituted with simulation (Hayden, Smiley, Alexander, Kardong-Edgren, & Jeffries, 2014). The NCSBN study has important implications in advancing NP education due to the American Association of Colleges of Nursing (AACN) and the National Organization of Nurse Practitioner Faculties (NONPF) recent position statement on the Doctorate of Nursing Practice (DNP) being the entry level degree for advanced practice nurses by 2025 (The National Organization of Nurse Practitioner Faculties [NONPF], 2018).

Implications of the Results for Nursing Practice

In this study, the failure to show perceived gains in flexibility or analytical thinking may be related to limited reflective processes taught to FNP-s or the lack of development in analytical cognitive processes that do not rely on pattern recognition (signs and symptoms that are familiar based on the NP-s background and experience in nursing). Diagnostic reasoning that uses only patterns or nonanalytic processes may lead to diagnostic errors that can translate into practice beyond the RN role into the NP role. Simulation and debriefing can make visible errors in diagnosis through reflection in a safe environment that avoids patient harm and develops knowledge structure in cognitive structure.

Cognitive issues related to diagnoses are involved in up to 75% of patient errors that involve data collection, integration, verification and follow-up (Nendaz & Perrier, 2012). Nurse practitioners gain knowledge and pattern recognition through experience and progression in this discipline. Entry into practice should show foundational knowledge in cognitive strategies to reduce patient error in diagnostics. Using one primary mode of cognition (pattern recognition) more than another (analytic) may cause diagnostic errors that affect patient care in availability, anchoring, framing, and confirmation bias. Role transition from an RN role to an NP role in relation to medical diagnoses may be difficult and may result in diagnostic error.

Suggestions for Further Research

Further research should include replication of this study using larger NP-s cohorts across different NP specialty curriculums with increased amounts of simulation and a theory based reflective debriefing practice that is verbal and written. Further, learning strategies that are ambiguous and uncertain can assist students to develop analytic reasoning that can translate to the bedside and encourage the student to think about what if, why, how and what else questioning when applying diagnosis to patients. Formal training in cognitive structure and diagnostic theory should be introduced, practiced, and applied in NP programs to evaluate the effect on cognitive development. Assessment of transition related to diagnostic ability and the NP role should be evaluated along with assessment of how diagnostics is currently taught in NP programs.

Reflective structured debriefing can be incorporated across NP curriculum through written applications that provide feedback to the student using case studies, peer review seminars, discussion question assignments, standardized patient's feedback, virtual and high-fidelity simulations with debriefing, and reflective journals that evaluate one's own practice to develop insight. Reflective debriefing can be utilized verbally in groups, or individually using written structured reflective questions that explore, expose and encourage cognitive debiasing strategies. Debiasing strategies can include reflection on cognitive bias and relationships to the thinking process, alternative diagnosis and outcomes, use of cognitive aids, and deliberate cognitive discord with construction of forcing strategies to avoid errors (Croskerry, 2001). Further research can be explored related to the assessment of NP program outcomes involving teaching strategies fostering cognitive reasoning, and progression can be assessed by the DTI.

The AACN and NONPF with the support of other NP stakeholders are proposing the DNP be the entry level degree for NP's by 2025 (NONPF, 2018). This will result in double the current clinical hours needed for an advanced practice degree. Nurse practitioner programs face the same difficulty with obtaining clinical sites to obtain clinical hours as the undergraduate nursing programs. Future studies should look at how nurse practitioner students learn to diagnose in their clinical training and if simulation with DML compares to traditional clinical practice hour rotations.

Funding should be provided to explore if a percentage of the 500 clinical hours and soon to be 1000 clinical hours required for the NP and Doctorate of Nursing Practice (DNP) respectively could be replaced with simulation and reflective debriefing practices. The Institute of Medicine has placed a national focus on diagnostic errors and their relation to patient harm; educational institutions need to develop rigorous scientific studies to evaluate simulation pedagogy and its place in graduate nursing education (Institute of Medicine [IOM], 2015). This is the first study to investigate the effect of simulation and DML on diagnostic reasoning ability in FNP-s.

REFERENCES

Adler, M. (2014). *Review of measuring the impacts of teachers*. Retrieved from National Education Policy Center: http://nepc.colorado.edu/thinktank/review-measuring-impact-of-teachers

Afzal, A., & Babar, S. (2016). Making lectures memorable: A cognitive perspective. *Journal of Pakistan Medical Association*, *66*(8), 1024-1025.

Alteen, A. M., Didham, P., & Stratton, C. (2009, June). Reflecting, refueling, and reframing: A 10-year retrospective model for faculty development and its implications for nursing scholarship. *The Journal of Continuing Education in Nursing*, *40*(6), 267-272.

American Association of Colleges of Nursing. (2011). *The essentials of master's education in nursing: core competencies*. Retrieved from http://www.aacn.nche.edu/education-resources/MastersEssentials11.pdf

American Association of Colleges of Nursing. (2012). *Graduate-level QSEN competencies: Knowledge, skills and attitudes*. Retrieved from http://www.aacn.nche.edu/faculty/qsen/competencies.pdf

American Association of Colleges of Nursing. (2016). *Adult-gerontology acute care and primary care NP competencies*. Retrieved from http://www.aacn.nche.edu/education-resources/Adult-Gero-NP-Comp-2016.pdf

American Association of Colleges of Nursing and National Organization of Nurse Practitioner Faculties. (2012-2013). *Enrollment and graduations*. Retrieved from http://c.ymcdn.com/sites/www.nonpf.org/resource/resmgr/imported/NPTables2012-2013.pdf

Anderson, A. K. (2006). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology: General*, *134*(2), 258-281.

Appel, S. J., Wades, T. M., Talley, M. H., & Williams, A. M. (2013,). Teaching diagnostic reasoning: Transitioning from a live to a distance accessible online classroom in an adult acute care nurse practitioner program. *Journal of Nursing Education and Practice*, *3*(2), 125-132.

Ark, T. K., Brooks, L. R., & Eva, K. W. (2007). The benefits of flexibility: The pedagogical value of instructions to adopt multifaceted diagnostic reasoning strategies. *Medical Education*, *41*(3), 281-287.

Balla, J., Heneghan, C., Goyder, C., & Thompson, M. (*2*012). Identifying early warning signs for diagnostic errors in primary care: A qualitative study. *BMJ Open*, *2*(5), 1-9. Retrieved from http://dx.doi.org/10.1136/bmjopen-2012-001539

Barnes, H. (2015, July-Sept). Nurse practitioner role transition: A concept analysis. *Nurse Forum*, *50*(3), 137-146.

Becker, D. E. (2007). *The effect of patient simulation on the critical thinking of advanced practice nursing students* (Doctoral dissertation). Retrieved from https://idea.library.drexel.edu/islandora/object/idea%3A1758

Bender, J., Kennally, K., Shields, R., & Overly, F. (2014, September). Does simulation booster impact retention of resuscitation procedural skills and teamwork? *Journal of Perinatology*, *34*(9), 664-668.

Benner, P. (1984). *From novice to expert: Excellence and power in clinical nursing practice*. Menlo Park, CA: Addison-Wesley.

Benner, P., Sutphen, M., Leonard, V., & Day, L. (2010). *Educating nurses: A call for radical transformation*. San Francisco, CA: Jossey-Bass.

Beullens, J., Struyf, E., & Damme, B. V. (2006). Diagnostic ability in relation to clinical seminars and extended-matching questions examinations. *Medical Education, 40*(12), 1173-1179.

Bland, A. J., & Tobbell, J. (2016). Towards an understanding of the attributes of simulation that enable learning in undergraduate nurse education: A grounded theory study. *Nurse Education Today, 44,* 8-13.

Blondon, K. S., Maitre, F., Muller-Juge, V., Bochatay, N., Cullati, S., Hudelson, P., ... Nendaz, M. R. (2017, June 8). Interprofessional collaborative reasoning by residents and nurses in internal medicine: Evidence from a simulation study. *Medical Teacher*, *34*(4), 360-367.

Bond, W. F., Deitrick, L. M., Eberhardt, M., Barr, G. C., Kane, B. G., Worrilow, C. C., ... Croskerry, P. (2006). Cognitive verses technical debriefing after simulation training. *Academic Emergency Medicine*, *13*(3), 276-283.

Bonnevier, A. (2015). *Understanding learning and learning for understanding* (Doctoral dissertation). Retrieved from http://su.diva-portal.org/smash/get/diva2:792037/FULLTEXT01.pdf

Bordage, G., Grant, J., & Marsden, P. (1990, September 24). Quantitative assessment of diagnostic ability. *Medical Education*, *24*(5), 413-425.

Braude, H. D. (2012). Conciliating cognition and consciousness: The perceptual foundations of clinical reasoning. *Journal of Evaluation in Clinical Practice, 18*(5), 945-950.

Brett-Fleegler, M., Rudolph, J., Eppich, W., Monuteaux, M., Fleegler, E., Cheng, A., & Simon, R. (2012). Debriefing assessment for simulation in healthcare: Development and psychometric properties. *Simulation in Healthcare*, *7*(5), 288-294.

Cant, R. P., & Cooper, S. J. (2009, November 27). Simulation-based learning in nursing education: Systematic review. *Journal of Advanced Nursing*, *66*(1), 3-15.

Cardoza, M. P. (2011). Neuroscience and simulation: An evolving theory of brain-based education. *Clinical Simulations in Nursing, 7*(6), e205-e208.

Center for Medical Simulation. (2010). *Debriefing Assessment for Simulation in Healthcare (DASH)© – Student version, long form*. Retrieved from Harvard Medical Simulation Organization: https://harvardmedsim.org/debriefing-assesment-simulation-healthcare.php

Charness, G., Karni, E., & Levin, D. (2009, September 26). On the conjunction fallacy in probability judgement: New experimental evidence regarding Linda. *Games and Economic Behavior*, *68*, 551-556. http://dx.doi.org/Retrieved from http.//www.umass.edu/preferen/You%20Must%20Read%20This/Charness-Karni-Levin-Linda.pdf

Chee, J. (2014). Clinical simulation using deliberate practice in nursing education: A Wilsonian concept analysis. *Nurse Education in Practice*, *14*(3), 247-252.

Cicero, M. X., Auerbach, M. A., Zigmont, J., Riera, A., Ching, K., & Baum, C. R. (2012, June). Simulation training with structured debriefing improves resident's pediatric disaster triage performance. *Prehospital and Disaster Medicine, 27*(3), 239-244.

CNA and NSO. (2012). *Nurse practitioner 2012 liability update: A three-part approach*. Retrieved from http://www.hpso.com/Documents/Risk%20Education/individuals/NP_Claims_Study_2012.pdf

Colella, C. L., & Beery, T. A. (2014, August). Teaching differential diagnosis to nurse practitioner students in a distance program. *Journal of Nursing Education, 53*(8), 433-438.

Crawford, C. L., & Lopez, C. M. (2014). The research process and simulation in nursing. *Journal for Nurses in Professional Development, 30*(3), 127-133.

Creswell, J. (2015). Experimental design. In *Educational research planning, conducting and evaluating quantitative and qualitative research* (5th ed. (pp. 293-337). Upper Saddle River, NJ: Pearson.

Creswell, J. W. (2013). *Qualitative inquiry & research design* (3rd ed.). Thousand Oaks, Ca: Sage.

Croskerry, P. (2001, August). The importance of cognitive errors in diagnosis and strategies to minimize them. *Academic Medicine*, *78*(8), 775-780.

Croskerry, P. (2009, August). A universal model of diagnostic reasoning. *Academic Medicine*, *84*(8), 1022-1028.

Croskerry, P. (2009). Clinical cognition and diagnostic error: applications of a dual process model of reasoning. *Advances in Health Science Education*, *14*(1), 27-35.

Croskerry, P. (2013, June 27). From mindless to mindful practice cognitive bias in clinical decision-making. *The New England Journal of Medicine*, *368*(26), 2445-2448.

Davis, S. C., & Pruitt, R. H. (2014, Spring). Mastering the differential diagnosis in nurse practitioner students. *International Journal of Nurse Practitioner Educators*, *3*(1).

De Neys, W. (2006). Automatic heuristic and executive analytic processing during reasoning: Chronometric and dual task considerations. *The Quarterly Journal of Experimental Psychology*, *59*(6), 1070-1100.

De Neys, W. (2014). Conflict detection, dual process and logical intuitions: Some clarifications. *Thinking & Reasoning*, *20(2)*, 167-187.

De Neys, W., & Glumicic, T. (2008). Conflict monitoring in dual process theoroes of reasoning. *Cognition*, *106*(3), 1249-1299.

Dowding, D., & Thompson, C. (2003, June 18). Measuring the quality of judgement and decision-making in nursing. *Issues and Innovations in Nursing Practice*, *44*(1), 49-57.

Dreifuerst, K. T. (2009, March/April). The essentials of debriefing in simulation learning: A concept analysis. *Nursing Education Perspectives*, *30*(2), 109-114.

Dreifuerst, K. (2012). Using debriefing for meaningful learning to foster development of clinical reasoning in simulation. *Journal of Nursing Education*, *51*(6), 326-333.

Dreifuerst, K. T. (2015). Getting started with debriefing for meaningful learning. *Clinical Simulation in Nursing*, *11*(5), 268-275.

Durham, C. O., Fowler, T., & Kennedy, S. (2014). Teaching dual process diagnostic reasoning to doctor of nursing practice students: Problem-based learning and the illness script. *Journal of Nursing Education*, *53*(1), 646-650.

Durning, S. J., Costanzo, M. E., Beckman, T. J., Artino, A. R., Roy, M. J., Vleuten, C. V., ... Schuwirth, L. (2016). Functional neural imaging correlates of thinking, flexibility and knowledge structure in memory: Exploring the relationships between clinical reasoning and diagnostic thinking. *Medical Teacher*, *38*(6), 570-577.

Durning, S. J., Dong, T., & Artino, A. R. (2015). Dual processing theory and experts' reasoning: Exploring thinking on national multiple-choice questions. *Perspectives on Medical Education*, *4*(4), 168-175.

Durning, S. J., Ratcliffe, T., Artino, A. R., Vleuten, C. V., Beckman, T. J., Lipner, R. S., & Schuwirth, L. (2013). How is clinical reasoning developed, maintained and objectively assessed? Views from expert internists and internal medicine interns. *Journal of Continuing Education in the Health Professions*, *33*(4), 215-223.

Elstein, A. S. (2009, July 14). Thinking about diagnostic thinking: A thirty-year perspective. *Advances in Health Science Education*, *14*(1), 7-18.

Ely, J. W., Kaldjian, L. C., & D'Alessandro, D. M. (2012). Diagnostic errors in primary care: Lessons learned. *Journal of the American Board of Family Medicine*, *25*(1), 87-97.

Ericsson, K. A. (2008). Deliberate practice and acquisition of expert performance: A general overview. *Academic Emergency Medicine, 15*(11), 988-994.

Eva, K. W., Hatala, R. M., LeBlanc, V. R., & Brooks, L. R. (2007). Teaching from clinical reasoning literature: Combined reasoning strategies help novice diagnosticians overcome misleading information. *Medical Education*, *41*(12), 1152-1158.

Evans, J. S. (2003, October). In two minds: Dual- process accounts of reasoning. *TRENDS in Cognitive Science*, *7*(10), 454-459.

Evans, J. S. (2007). *Hypothetical thinking*. New York NY: Psychology Press.

Evans, J. S. (2008). Dual processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology*, *59*, 255-278.

Evans, J. S., & Stanovich, K. E. (2013). Dual process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science*, *8*(3), 223-241.

Fey, M. K., Scrandis, D., Daniels, A., & Haut, C. (2014). Learning through debriefing: Student's perspectives. *Clinical Simulation in Nursing*, *10*(5), e249-e256.

Field, A. (2009). *Discovering statistics using SPSS* (3rd ed.). Los Angeles, CA: Sage.

Findyartini, A., Hawthorne, L., McColl, G., & Chiavaroli, N. (2016). How clinical reasoning is taught and learned: Cultural perspectives from the University of Melbourne and Universitas Indonesia. *BMC Medical Education*, *16*(185), 1-10.

Fisher, B., & Rourke, L. (2016). Developing maintaining and teaching clinical diagnostic expertise. *Canadian Journal of General Internal Medicine*, *11*(1), 1-9.

Forneris, S. G., Neal, D. O., Tiffany, J., Kuehn, M. B., Meyer, H. M., Blazovich, L. M., Smerillo, M. (2015, September/October). Enhancing clinical reasoning through simulation debriefing: A multisite study. *Nursing educational perspectives*, *36*(5), 304-310.

Gale, J., & Marsden, P. (1982). Clinical problem solving: The beginning of the process. *Medical Education*, *16*(1), 22-26.

Gehlhar, K., Klimke-Jung, K., Stosch, C., & Fischer, M. R. (2014). Do different medical curricula influence self-assessed clinical thinking of students? *GMS Zeitschrift für Medizinische Ausbildung*, *31*(2), 11-20. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4027808/

Giddens, J. F., Lauzon-Clabo, L., Morton, P. G., Jeffries, P., Jones, B. M., & Ryan, S. (2014). Re-envisioning clinical education for nurse practitioner programs: *Themes from a national leader's dialogue*, *30*(3), 273-278.

Gorton, K. L. (2010). *An investigation into the relationship between critical thinking skills and clinical judgement in the nurse practitioner student* (Doctoral dissertation). Retrieved from http://0-search.proquest.com.www.consuls.org/pqdtglobal/docview/856133409/previewPDF/163A022B19004F83PQ/9?accountid=40083

Goss, B., Reid, K., Dodds, A., & McColl, G. (2011). Comparison of medical students' diagnostic reasoning skills in a traditional and a problem based learning curriculum. *International Journal of Medical Education,* 2, 87-93.

Graber, M. L., Franklin, N., & Gordon, R. (2005). Diagnostic error in internal medicine. *Archives of Internal Medicine*, *165*(13), 1493-1499.

Grant, J., & Marsden, P. (1987). The structure of memorized knowledge in students and clinicians: An explanation for diagnostic expertise. *Medical Education*, *21*(2), 92-98.

Grant, J., & Marsden, P. (1988). Primary knowledge, medical education and consultant expertise. *Medical Education*, *22*(3), 173-179.

Groves, M. (2007). The diagnostic process in medical practice: The role of clinical reasoning. In E. M. Vargios (Ed.), *Educational Psychology Research Focus* (pp. 133-183). New York: Nova Science.

Groves, M., O'Rourke, P., & Alexander, H. (2003). The association between student characteristics and the development of clinical reasoning in a graduate-entry PBL medical programme. *Medical Teacher*, *25*(6), 626-631.

Haut, C., Fey, M. K., Akintade, B., & Klepper, M. (2014, November/December). Using high-fidelity simulation to teach acute care pediatric nurse practitioner students. *The Journal of Nurse Practitioners*, *10*(10), e870-e90.

Hayden, J. K., Smiley, R. A., Alexander, M. A., Kardong-Edgren, S., & Jeffries, P. R. (2014). The NCSBN national simulation study: A longitudinal, randomized, controlled study replacing clinical hours with simulation in prelicensure nursing education [Supplemental material]. *Journal of Nursing Regulation*, *5*(2), 1-66. Retrieved from https://www.ncsbn.org/JNR_Simulation_Supplement.pdf

Hemming, T. R., Nye, C., & Coram, C. (2015). Using simulation for clinical practice hours in nurse practitioner education in the United States: A systematic review. *Nurse Education Today*, *37*, 128-135.

Hruska, P., Krigolson, O., Coderre, S., McLaughlin, K., Cortese, F., Doig, C., Hecker, K. G. (2015, November 4). Working memory, reasoning and expertise in medicine- insights into their relationship using functional neuroimaging. *Advances in Health Science Education*.

Hsu, C., & Sandford, B. A. (2007, August). The Delphi technique: Making sense of consensus. *Practical Assessment, Research & Evaluation*, *12*(10), 1-8. Retrieved from http://pareonline.net/pdf/v12n10.pdf

IIgen, J. S., Humbet, A. J., Kuhn, G., Hanson, M. L., Norman, G. R., Eva, K. W., ... Sherbino, J. (2012). Assessing diagnostic reasoning: A consensus statement summarizing theory, practice and future needs. *Academic Emergency Medicine*, *19*(12), 1454-1461.

Institute of Medicine. (2015). *Improving diagnosis in healthcare*. Retrieved from http://www.nationalacademies.org/hmd/~/media/Files/Report%20Files/2015/Improving-Diagnosis/DiagnosticError_ReportBrief.pdf

Institute of Medicine. (2015). *Recommendations: Improving diagnosis in healthcare*. Retrieved from http://www.nationalacademies.org/hmd/~/media/Files/Report%20Files/2015/Improving-Diagnosis/Diagnosis_Recommendations.pdf

International Nursing Association for Simulation for Clinical Simulation in Learning. (2016). *INACSL standards of best practice: Simulation*. Retrieved from http://www.inacsl.org/i4a/pages/index.cfm?pageid=3407

Issenberg, S. B., McGaghie, W. C., Gordon, D. L., Symes, S., Petrusa, E. R., Hart, I. R., & Harden, R. M. (2002). Effectiveness of a cardiology review course for internal medicine residents using simulation technology and deliberate practice. *Teaching and Learning in Medicine*, *14*(4), 223-228.

Jacobs, S., Wilkes, L., Taylor, C., & Dixon, K. (2016). Addressing the challenge of developing a conceptual definition for clinical judgment. *Nursing and Health*, *4*(1), 1-8.

James, J. T. (2013, September). A new evidence-based estimate of patient harms associated with hospital care. *Journal of Patient Safety*, *9*(3), 122-128.

Jeffries, P. R. (2005, March/April). A framework for designing, implementing and evaluating simulations used as teaching strategies in nursing. *Nursing Education Perspectives*, *26*(2), 96-103.

Jeffries, P. R. (2016). *The NLN Jeffries simulation theory*. Philadelphia, PA: Wolters Kluwer.

Jeffries, P. R., Beach, M., Decker, S. I., Dlugasch, L., Groom, J., Settles, J., & O'Donnell, J. M. (2011). Multicenter development and testing of a simulation-based cardiovascular assessment curriculum for advanced practice nurses. *Nursing Education Perspectives, 32*(5), 316-322.

Johns, A., & Christensen, R. (2018). A preclinical course to develop clinical reasoning skills in first year medical students. *Journal of Regional Medical Campuses*, 1(1).

Johnson, M. P., Hickey, K. T., Scopa-Goldman, J., Andrews, T., Boerem, P., Covec, M., & Larson, E. (2014). Manikin versus web-based simulation for advanced practice nursing students. *Clinical Simulation in Nursing*, *10*(6), e317-e323.

Jones, U. F. (1997, June). The reliability and validity of the Borage, Grant and Marsden diagnostic thinking inventory for use with physiotherapists. *Medical Teacher*, *19*(2), 1-12.

Kassirer, J. P. (2010, July). Teaching clinical reasoning: Case based and coached. *Academic Medicine*, *85*(7), 1118-1124.

Kesten, K. S., Brown, H. F., & Meeker, M. C. (2015). Assessment of APRN student competency using simulation: A pilot study. *Nursing Education Perspectives, 36*(5), 332-334.

King, P. L. (2006). *A consideration of diagnostic reasoning skills in nurse practitioners measures and influences* (Doctoral dissertation). Retrieved from http://0-search.proquest.com.www.consuls.org/pqdtglobal

Kolb, A. Y., & Kolb, D. A. (2008). The learning way: Meta-cognitive aspects of experiential learning. *Simulation & Gaming*, *40*(3), 297-327.

Kolb, D. A. (1984). *Experiential learning*. New Jersey: Prentice Hall.

Kolb, D. A., & Kolb, A. Y. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education*, *4*(2), 193-212.

Kost, A., & Chen, F. M. (2015). Socrates was not a pimp: Changing the paradigm of questioning in medical education. *Academic Medicine*, *90*(1), 20-24.

Kuiper, R. A., & Pesut, D. J. (2004). Promoting cognitive and metacognitive reflective reasoning skills in nursing practice: self-regulated learning theory. *Issues and Innovations in Nursing Education*, *45*(4), 381-391.

LaFond, C. M., & Van Hulle Vincent, C. (2013). A critique of the National League for Nursing/Jeffries simulation framework. *Journal of Advanced Nursing*, *69*(2), 465-480.

Lange, L. L., Haak, S. W., Lincoln, M. J., Thompson, C. B., Turner, C. W., Weir, C., ... Reeves, R. (1997, January). Use of IIiad to improve diagnostic ability of nurse practitioner students. *Journal of Nursing Education*, *36*(1), 36-45.

Lapkin, S., Jones, T. L., Bellchambers, H., & Fernandez, R. (2010, November). Effectiveness of patient simulation manikins in teaching clinical reasoning in nursing students: A systematic review. *Clinical Simulation in Nursing*, *6*(6), e207-e222.

Lasater, K. (2007, November). Clinical judgement development: Using simulation to create an assessment rubric. *Journal of Nursing Education*, *46*(11), 496-503.

Lawson, T. N. (2018). Diagnostic reasoning and cognitive bias of nurse practitioners. *Journal of Nursing Education*, *57*(4), 203-208.

Leigh, J., & Flynn, J. (2013). Enhance patient safety by identifying and minimizing risk exposures affecting nurse practitioner practice. *American Society for Healthcare Risk Management*, *33*(2), 27-35.

Leon, A. C., Davis, L. L., & Kraemer, H. C. (2011, May). The role and interpretation of pilot studies in clinical research. *Journal of Psychiatric Research*, *45*(5), 626-629.

Lusk, J. M., & Fater, K. (2013). Post simulation debriefing to maximize clinical judgment development. *Nurse Educator*, *38*(1), 16-19.

Mamede, S., Schmidt, H., & Rikers, R. (2007). Diagnostic errors and reflective practice in medicine. *Journal of Evaluation in Clinical Practice*, *13*(1), 138-145.

Mamede, S., Schmidt, H., Rikers, R., Penaforte, J., & Cuelho-Filho, J. (2007). Breaking down automaticity: Case ambiguity and the shift to reflective approaches in clinical reasoning. *Medical Education, 41*(1), 1185-1192.

Mamede, S., Van Gog, T., Moura, A. S., De Faria, R. M., Peixoto, J. M., Rikers, R. M., & Schmidt, H. G. (2012). Reflection has a strategy to foster medical student's acquisition of diagnostic competence. *Medical Education*, *46*(5), 464-472.

Marcum, J. (2012). An integrated model of clinical reasoning: Dual-process theory of cognition and metacognition. *Journal of Evaluation in Clinical Practice*, *18*(5), 954-961.

Mariani, B., Cantrell, M. A., & Meakim, C. (2014, September/October). Nurse educators' perceptions about structured debriefing and clinical simulation. *Nursing Education Perspectives*, *35*(5), 330-331.

Mariani, B., & Doolen, J. (2016). Nursing simulation research: What are the perceived gaps? *Clinical Simulation in Nursing*, *12*(1), 30-36.

Martin, C. (2002, September/October). The theory of critical thinking of nursing. *Nursing Education Perspectives, 23*(5), 243-247.

McDonald, K., Matesic, B., Contopoulos-Inannidis, D. G., Lonhart, J., Schmidt, E., Pineda, N., & Ioannidinis, J. P. (2013, March 5). Patient safety strategies targeted at diagnostic errors: A systematic review. *Annals of Internal Medicine*, *158*(5), 381-389.

McGaghie, W. C., Issenberg, S. B., Cohen, E. R., Barsuk, J. H., & Wayne, D. B. (2011, June). The simulation-based medical education with deliberate practice yield better results than traditional clinical education? A meta-analytic comparative review of the evidence. *Academic Medicine*, *86*(6), 706-711.

Miller, B., & Carr, K. C. (2016, May). Integrating standardized patients and objective structured clinical examinations into nurse practitioner curriculum. *The Journal for Nurse Practitioners*, *12*(5), 201-210.

Miller, K. (2013, October). The National Practitioner Data Bank: An annual update. *The Journal of Nurse Practitioners*, *9*(9), 576-580.

Miller, K. P. (2011, October). Malpractice: Nurse practitioners and claims reported to the National Practitioner Data Bank. *The Journal for Nurse Practitioners*, *7*(9), 761-763.

Miloslavsky, E. M., Hayden, E. M., Currier, P. F., Mathai, S. K., Contreras-Valdes, F., & Gordon, J. A. (2012, December). Pilot Program using medical simulation in clinical decision-making training for internal medicine interns. *Journal of Graduate Medical Education*, *4*(4), 490-495.

Mompoint-Williams, D., Brooks, A., Lee, L., Watts, P., & Moss, J. (2014). Using high-fidelity simulation to prepare advanced practice nursing students. *Clinical Simulation in Nursing*, *10*(1), e5-e10.

Morris, N. S., & Rosenbloom, D. A. (2017, March). Defining and understanding pilot and other feasibility studies. *American Journal of Nursing*, *117*(3), 38-45.

Morse, K. J. (2015). Structured model of debriefing on perspective transformation of NP students. *Clinical Simulation in Nursing*, *11*(3), 172-179.

Moseley, B. D., Smith, J. H., Diaz Medina, G. E., Mateo, M., Paz Solero, P. S., Dhamija, R., ... Britters, J. W. (2012, September 4). Standardized sign-out improves completeness and perceived accuracy of inpatient neurology handoffs. *Neurology*, *79*(10), 1060-1064.

Myung, S. J., Kang, S. H., Phyo, S. R., Shin, J. S., & Park, W. B. (2013). Effect of enhanced analytic reasoning on diagnostic accuracy: A randomized controlled study. *Medical Teacher*, *35*(3), 248-250.

National League for Nursing. (2016). *NLN research priorities in nursing education 2016-2019*. Retrieved from http://www.nln.org/docs/default-source/professional-development-programs/nln-research-priorities-in-nursing-education-single-pages.pdf?sfvrsn=2

National League of Nursing. (2009). *Simulation design template*. Retrieved from http://sirc.nln.org/mod/forum/discuss.php?d=83

National League of Nursing Board of Governors. (2015). *Debriefing across the curriculum: A living document from the National League of Nursing in collaboration with the International Nursing Association for Clinical Simulation and Learning* . Retrieved from http://www.nln.org/docs/default-source/about/nln-vision-series-(position-statements)/nln-vision-debriefing-across-the-curriculum.pdf?sfvrsn=0

National Organization of Nurse Practitioner Faculties (The) (2014). *Nurse practitioner core competencies content*. Retrieved from http://c.ymcdn.com/sites/nonpf.site-ym.com/resource/resmgr/Competencies/NPCoreCompsContentFinalNov20.pdf

National Organization of Nurse Practitioner Faculties (The) (2018, May). *The Doctor of Nursing Practice degree: Entry to nurse practitioner practice by 2025* [Press release]. Retrieved from https://c.ymcdn.com/sites/www.nonpf.org/resource/resmgr/dnp/v3_05.2018_NONPF_DNP_Stateme.pdf

Neill, M. A., & Wotton, K. (2011). High- fidelity simulation debriefing in nursing education: A literature review. *Clinical Simulation in Nursing*, *7*(5), e161-e168.

Nendaz, M., & Perrier, A. (2012). Diagnostic errors and flaws in clinical reasoning: Mechanisms and prevention in practice. *Swiss Medical Weekly*, *142*(w13706), 1-9.

Norman, G., Young, M., & Brooks, L. (2007). Non-analytical models of clinical reasoning: the role of experience. *Medical Education*, *41*(12), 1140-1145.

Norman, G. R., & Eva, K. W. (2010). Diagnostic error and clinical reasoning. *Medical Education*, *44*(1), 94-100.

O'Donnell, J., Decker, S., Howard, V., Levett-Jones, T., & Miller, C. W. (2014). NLN/ Jeffries simulation framework state of the science project simulation learning outcomes. *Clinical Simulation in Nursing*, *10*(7), 373-382.

Osman, M. (2004, January). An evaluation of dual-process theories of reasoning. *Psychologic Bulletin & Review*, *11*(6), 988-1010.

Pelaccia, T., Tardif, J., Triby, E., & Charlin, B. (2011, March 14). An analysis of clinical reasoning through a recent and comprehensive approach: The dual-process theory. *Medical Education Online*, *16*(5890), 1-9.

Philipsen, N. C. (2011, October). The criminalization of mistakes in nursing. *The Journal of Nurse Practitioners*, *7*(9), 719-725.

Pirret, A. M. (2013). *Nurse practitioner diagnostic reasoning* (Doctoral dissertation, Massey University). Retrieved from http://mro.massey.ac.nz/xmlui/bitstream/handle/10179/4929/02_whole.pdf?sequence=2&isAllowed=y

Polit, C., & Beck, C. T. (2012). *Nursing research generating and assessing evidence for nursing practice* (9th ed.). India Pvt Ltd, New Delhi: Wolters Kluwer.

Proust, J. (2015). The representational structure of feelings. In T. Metzinger & J. M. Windt (Eds.), *Open MIND*. http://dx.doi.org/ 10.15502/9783958570047

Rajkomar, A., & Dhaliwal, G. (2011, Summer). Improving diagnostic reasoning to improve patient safety. *The Permanente Journal*, *15*(1), 68-73.

Rao, G. (2009, April). Probability error in diagnosis: The conjunction fallacy among beginning medical students. *Family Medicine*, *41*(4), 262-265.

Rew, L. (2000, June). Acknowledging intuition in clinical decision making. *Journal of Holistic Nursing*, *18*(2), 94-108.

Ritter, B. J. (2003, March). An analysis of expert nurse practitioners' diagnostic reasoning. *The Journal of the American Academy of Nurse Practitioners*, *16*(3), 137-141.

Rogers, D. L. (2015). The biological basis of learning: Neuroeducation through simulation. *Simulation & Gaming*, *46*(2), 175-186.

Round, A. (2001). Introduction to clinical reasoning. *Journal of Evaluation in Clinical Practice, 7*(2), 109-117.

Round, A. P. (1999). Teaching clinical reasoning- a preliminary controlled study. *Medical Education*, *33*, 480-483.

Sands, H. M. (2001). *Making the diagnosis: Factors shaping diagnostic reasoning among entry-level nurse practitioners* (Doctoral dissertation). Retrieved from http://0-search.proquest.com.www.consuls.org/pqdtglobal/docview/275820371/fulltextPDF/3BC91EBDFEF4A9EPQ/1?accountid=40083

Sawyer, T., Sierocka-Castaneda, A., Chan, D., Berg, B., Lustik, M., & Thompson, M. (2011, December). Deliberate practice using simulation improves neonatal resuscitation performance. *Society for Simulation in Healthcare*, *6*(6), 327-336.

Scheffer, B. K., & Reubenfeld, M. G. (2000). A consensus statement on critical thinking in nursing. *Journal of Nursing Education*, *39*(8), 352-359.

Scherer, Y. K., Bruce, S. A., & Runkawatt, V. (2007). A comparison of clinical simulation and case study presentation on nurse practitioner students' knowledge and confidence in managing a cardiac event. *International Journal of Nursing Education Scholarship*, *4*(1), 1-13.

Schiff, J. D., Hasan, O., Kim, S., Abrams, R., Crosby, K., Lambert, B. L., ... McNutt, R. A. (2009, November 9). Diagnostic error in medicine: Analysis of 583 physician reported errors. *Archives of Internal Medicine*, *169*(20), 1-11.

Schmidt, E., Goldhaber-Fiebert, S. N., Ho, L. A., & McDonald, K. M. (2013, March 5). Simulation exercises as a patient safety strategy: A systemic review. *Annals of Internal Medicine*, *158*(5), 426-433.

Schon, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Scordo, K. A. (2014). Differential diagnosis: Correctly putting the pieces of the puzzle together. *AACN Advanced Critical Care*, *25*(3), 230-236.

Shinnick, M. A., Woo, A., Horwich, T. B., & Steadman, R. (2011). Debriefing: The most important component in simulation. *Clinical Simulation in Nursing*, *7*(3), e105-e111.

Simmons, B. (2010,). Clinical reasoning: Concept analysis. *Journal of Advanced Nursing*, *66*(5), 1151-1158.

Simon, H. A., & Newell, A. (1971, February). Human problem solving: The state of the theory in 1970. *American Psychologist*, *26*(2), 145-159.

Simon, R., Raemer, D., & Rudolph, J. (2010). *Debriefing Assessment for Simulation in Healthcare (DASH) © – Student Version, Long Form.* Retrieved from Center for Medical Simulation, Boston, Massachusetts: https://harvardmedsim.org/_media/DASH.SV.Long.2010.Final.pdf

Simon, R., Raemer, D. B., & Rudolph, J. W. (2012). *Debriefing Assessment for Simulation in Healthcare (DASH)* © [Instructor Version, Long Form.]. Retrieved from Center for Medical Simulation, Boston, Massachusetts. https://harvardmedsim.org/_media/DASH.IV.LongForm.2012.05.pdf

Singh, H., Schiff, G. D., Graber, M. L., Onakpoya, I., & Thompson, M. J. (2016, August 16). The global burden of diagnostic errors in primary care. *BMJ Quality and Safety,* 1-11. bmjqs-2016-005401

Sitter, B. J., Aebersold, M. L., Paige, J. B., Graham, L. L., Schram, A. P., Decker, S. I., & Lioce, L. (2015, September/October). INACSL standards of best practice for simulation: Past, present and future. *Nursing Education Perspectives*, *36*(9), 294-298.

Smith, S. J., & Roehrs, C. J. (2009). High fidelity simulation: Factors correlated with nursing student satisfaction and self-confidence. *Nursing Education Perspectives*, *30*(2), 74-78.

Sobral, D. T. (2000). Appraisal of medical students' diagnostic ability in relation to their learning achievement and self-confidence as a learner. *Medical Teacher*, *22*(1), 59-63.

Standards of best practice: Simulation. [Special issue]. (2016). *Clinical Simulation in Nursing*, *12*.

Stieger, S., Praschinger, A., Kletter, K., & Kainberger, F. (2011). Diagnostic grand rounds: A new teaching concept to train diagnostic reasoning. *European Journal of Radiology*, *78*(3), 349-352.

Su, W. M., Osisek, P. J., & Starnes, B. (2005). Using the Revised Bloom's Taxonomy in the clinical laboratory. *Nurse Educator*, *30*(3), 117-122.

Tanner, C. A. (2006). Thinking like a nurse: A research- based model of clinical judgement in nursing. *Journal of Nursing Education*, *45*(6), 204-2011.

Tehrani, A. S., Lee, H., Mathews, S. C., Shore, A., Makary, M. A., Pronovost, P. J., & Newman-Toker, D. E. (2013, April 22). 25-Year summary of US malpractice claims for diagnostic errors 1986-2010: An analysis from the National Practitioner Data Bank. *BMJ Quality & Safety*, *22*(8), 672-680.

Thompson, C., Aitken, L., Doran, D., & Dowding, D. (2013, May 4). An agenda for clinical decision-making and judgment in nursing research and education. *International Journal of Nursing Studies*, *50*(12), 1720-1726.

Thompson, V. A. (2009). In two minds: Dual processes and beyond. *Oxford University Press*, Oxford. 171-195.

Tiffen, J., Corbridge, S., Shen, B. C., & Robinson, P. (2011). Patient simulator for teaching heart and lung assessment skills to advanced practice nursing students. *Clinical Simulation in Nursing*, *7*(3), e91-e97.

Touchie, C., Humphrey-Murto, S., & Varpio, L. (2013). Teaching and assessing procedural skills: A qualitative study. *BMC Medical Education*, *13*(69), 1-9.

Trommelen, R. D., Karpinski, A., & Chauvin, S. (2017). Impact of case-based learning and reflection on clinical reasoning and reflection abilities in physical therapist students. *Journal of Physical Therapy Education*, *31*(1), 21-30.

Tversky, A., & Kahneman, D. (1983). Extension verses intuitive reasoning: the conjunction fallacy in probability judgment. *Psychological Review*, *90*(4), 293-315.

Wayne, D. B., Butter, J., Siddall, V. J., Fudala, M. J., Wade, L. D., Feinglass, J., & McGaghie, W. C. (2005, October 19). Mastery learning of advanced cardiac life support skills by internal medicine residents using simulation technology and deliberate practice. *Journal of General Internal Medicine*, *21*(3), 251-256.

Whittemore, R., & Knafl, K. (2005, February 16). The integrative review: Updated methodology. *Journal of Advanced Nursing*, *52*(5), 546-553.

Wilkes, L. (2014, January 30). Using the Delphi technique in nursing research. *Nursing Standard*, *29*(39), 43-49.

Wilson, R. D., Klein, J. D., & Hagler, D. (2014, January/February). Computer-based or human patient simulation-based case analysis: Which works better for teaching diagnostic reasoning skills?. *Nursing Education Perspectives*, *25*(1), 14-18.

Yousefichaijan, P., Jafari, F., Kahbazi, M., Rafieri, M., & Pakniyat, A. (2016, July 12). The effect of short-term workshop on improving clinical reasoning skill in medical students. *Medical Journal of the Islamic Republic of Iran*, *30*(396), 1-8.

Zulkosky, K. D., White, K. A., Price, A. L., & Pretz, J. E. (2016). Effects of simulation role on clinical decision-making accuracy. *Clinical Simulation in Nursing*, *12*(3), 98-106.