

Exploring the development of diagnostic reasoning among nurse practitioner students at two
Canadian universities

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Abstract

Background

Diagnostic Reasoning (DR) is a core competency for entry-level nurse practitioner (NP) practice and is fundamental to safe and effective clinical decision-making. Although numerous educational strategies have been proposed to strengthen DR, limited research has explored how NP students experience and develop DR throughout their educational journey.

Purpose

The purpose of this dissertation was to explore how NP students develop DR during their educational programs at two Canadian universities.

Methods

This qualitative dissertation employed Interpretive Description and comprised three interconnected manuscripts derived from a larger study. Twenty-four NP students in the final semester of their programs at two Canadian universities participated in semi-structured interviews conducted between May and June 2025. Interview transcripts were analyzed inductively using iterative coding, constant comparison, and Bingham's five-phase qualitative analysis framework to generate clinically relevant interpretations.

Results

Across three manuscripts, the findings demonstrate that DR development extends beyond acquiring diagnostic knowledge and technical skills. Rather, it is the developmental process involving professional identity transformation, metacognitive growth, and learning within complex educational and clinical environments. Participants described the transition from registered nurses to NP as a shift toward diagnostic accountability while simultaneously developing the ability to calibrate intuition and analytical reasoning, recognize and regulate cognitive biases, reflect on clinical decision-making, and tolerate diagnostic uncertainty. DR development was further shaped by curriculum design, simulation, clinical preceptors, peer learning, and opportunities for deliberate practice.

Conclusion

This dissertation contributes a learner-centered understanding of DR development and addresses an important gap in NP education literature. The findings support explicit, longitudinal, and practice-oriented approaches to teaching DR that integrate classroom, simulation, and clinical learning experiences. These insights have implications for NP education, preceptor development, curriculum design, and future research aimed at preparing graduates for safe and independent diagnostic practice.

Keywords: diagnostic reasoning, clinical reasoning, metacognition, cognitive bias, reflective practice, nurse practitioner education, nurse practitioner students, professional identity formation, RN-to-NP transition

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Chapter 1: Background

Introduction

Diagnostic reasoning (DR) is a complex cognitive process of collecting, interpreting, and analyzing multiple data sources during a patient encounter to ascertain diagnoses and guide the development of treatment plans (Nordick, 2021; Smith et al., 2022). In the literature, DR and clinical reasoning (CR) are often used interchangeably (Smith et al., 2025; Young et al., 2020). Diagnostic reasoning is an iterative rather than strictly sequential process. It includes hypothesis-driven history taking and physical examination, developing a working diagnosis and differential diagnoses, and ordering diagnostic investigations to confirm the working diagnosis and/or rule out the differential diagnoses (Nordick, 2021). Errors in DR are the leading contributors to patient harm, such as delayed diagnosis and treatment and increases in patient morbidity and mortality, which are also the basis for successful malpractice claims (Smith & Benbenek, 2025; Sweeney et al., 2017).

Background

DR is widely used in many health professions, such as dentistry, medicine, nursing, and physiotherapy (Young et al., 2020). As nurse practitioner (NP) students transition from registered nurses (RNs) to NPs, they require a higher level of DR (Nordick, 2021). Furthermore, this skill is arguably the most crucial step in the transition process. NPs are advanced practice nurses with a unique blend of advanced nursing and biomedical knowledge and expertise to comprehensively assess, diagnose, and manage the care of patients across diverse healthcare settings (International Council of Nurses [ICN], 2020). In addition to conducting health assessments, ordering screening and diagnostic investigations, and prescribing medications and other treatments, NPs work collaboratively with patients, families, and communities to promote

health and prevent diseases. Research has shown that NPs make significant contributions to healthcare, including decreased wait times, reduced hospital admissions and length of stay, fewer emergency room visits, improved patient satisfaction and cost savings (Chavez et al., 2018; Woo et al., 2017).

Globally, the NP role was first established in the United States (US) in the 1960s, in Canada and Jamaica in the 1970s, and in Botswana and the United Kingdom (UK) in the 1980s (ICN, 2020). Since then, many more countries and regions have established NP roles and educational programs, such as Australia, the Caribbean region, New Zealand, Oman, and the Republic of Ireland. Although NP education varies internationally, in general, a master's degree is considered the minimum standard, except for the US, which is trending towards the Doctor of Nursing Practice degree as the entry-level requirement (ICN, 2020).

In Canada, NPs are educated at the master's level. Upon entry to the NP program, NP students usually have at least two years of clinical experience working as registered nurses (RN) (British Columbia College of Nurses and Midwives, 2024; Canadian Nurses Association, 2016; College of Nurses of Ontario, 2024b). The Canadian Council of Registered Nurse Regulators (CCRNRR, 2023), which is made up of the provincial regulators, defines the essential competencies that all NPs must demonstrate to qualify and be ready to begin practicing. The NP entry-level competencies (ELCs) include clinician, leader, advocate, educator, and scholar. Successfully passing the NP licensing examination is a key indicator for meeting the NP ELCs. To be a competent health care provider, the entry-level NP must have the knowledge and skills to conduct health assessments, utilize critical inquiry and DR skills to formulate the working diagnosis and differential diagnoses, and establish the management plan (CCRNRR, 2023). Since CCRNRR released the latest NP ELCs in 2023, various Canadian provinces and territories have

adopted or are in the process of adopting the latest NP ELCs (British Columbia College of Nurses and Midwives, 2023; College of Nurses of Ontario, 2024a).

Significance of DR

Developing competent DR skills is critical for NPs because accurate diagnosis leads to appropriate treatment plans that significantly improve patient outcomes. The DR process involves a thorough analysis of data gathered from history taking and physical examination, interpretation of the results from investigations, and formulation of working diagnoses and differential diagnoses based on all available data. The process further entails creating a mutual understanding of the findings from assessments, the conditions diagnosed, the expected outcomes, and the prognosis. Ultimately, this culminates in pinpointing the primary diagnosis by leveraging clinical expertise and diagnostic reasoning (CCRN, 2023).

DR is a critical component in healthcare, significantly impacting patient safety, outcomes, and healthcare costs. According to the US National Academies of Sciences, Engineering, and Medicine, diagnostic error is defined as “the failure to (a) establish an accurate and timely explanation of the patient’s health problem(s) or (b) communicate that explanation to the patient” (2015, p.xiii). Diagnostic errors can cause significant patient harm, including emotional or physical injuries, which could be temporary or permanent. In some instances, brain damage and even death can occur (Sweeney et al., 2017; Singh et al., 2021). Researchers have used the US National Practitioner Data Bank (NPDB) to analyze NP malpractice claims. Those study results further highlight the importance of DR, and below are two examples (Brock et al., 2017; Sweeney et al., 2017).

Brock et al. (2017) used the NPDB and analyzed the trends in malpractice claims and disciplinary actions from 2005 to 2014 among physicians, physician assistants (PAs), and NPs.

The results indicated that physicians had a higher frequency of malpractice reports (ranging from 11.2 to 19.0 per 1,000) compared to NPs (1.1 to 1.4 per 1,000) and PAs (1.4 to 2.4 per 1,000). Furthermore, the median malpractice payments for physicians were 1.3 to 2.3 times higher than those for PAs or NPs. This could be partly because surgeons and anesthesiologists were also included in the physicians' group, and they had a much higher percentage of surgery-related claims (26.7% for physicians, 4.0% for PAs, and 1.8% for NPs). However, the diagnosis-related malpractice claims were more prevalent among PAs (52.8%) and NPs (40.6%) than among physicians (31.9%). Despite their expanded roles and scope of practice, PAs and NPs had fewer malpractice claims compared to physicians, suggesting potentially lower liability risks associated with their practice. It is important to note that the number of patients seen, patient acuity, and patients' perception of higher awards obtained from suits against physicians could have contributed to the malpractice claim differences. Liability rates based on the acuity of patient encounters and number of patients seen would offer a more precise understanding of malpractice among different provider groups. This analysis underlines the importance of continued monitoring and analysis of malpractice trends to guide policy development and education for healthcare professionals (Brock et al., 2017).

Another similar study by Sweeney et al. (2017) analyzed the US NPDB, specifically for NP malpractice claims ($N = 1715$) from 1990 to 2014, classifying them by clinical settings, event types, and patient outcomes. The results showed that diagnostic errors are the most common allegations against NPs, accounting for 41.46% of claims ($n = 711$), followed by treatment-related claims at 30.79% ($n = 528$). Among the diagnostic errors, the largest proportion was due to "failure to diagnose" and "delay to diagnosis", followed by "misdiagnosis". Errors resulting in serious consequences, such as permanent poor outcomes or

death, were more frequently observed in outpatient settings, where most NPs typically work. The authors noted a significant gap in NP education: malpractice data is not commonly used to guide the development of NP educational curricula. They argue that integrating this data to specifically target areas prone to errors can improve NP training, leading to better patient outcomes and reduced medical errors. By doing so, educational standards can be better aligned with the practical demands of NP roles, ultimately improving the quality and safety of healthcare delivery. This approach addresses clinical and educational gaps and aligns with broader healthcare safety and quality initiatives, offering a strategic pathway to reduce preventable medical errors in NP practice (Sweeney et al., 2017).

The above US malpractice data helps shed light on the prevalence and significance of diagnostic errors. In July 2024, the writer reached out to the Canadian Nurses Protective Society (CNPS) to inquire about the malpractice claims statistics for NPs in Canada. Although these data were not available, CNPS explained that the rapidly evolving nature of NP practice, combined with the slow pace of litigation and the relatively small number of NPs in Canada, makes it difficult to draw reliable conclusions from past legal cases alone (personal communication, July 2024).

Factors Contributing to DR Errors

There are many complex factors affecting DR and clinical decision-making in real-life situations. For instance, providers may have positive feelings towards some patients and negative feelings towards other patients, which could affect their DR process. Mental fatigue associated with shift work or lack of sleep, distractions, and noisy, chaotic work environment can compromise the quality and accuracy of the DR process (Croskerry, 2020; Ko et al., 2024). Diagnostic error is also related to the level of uncertainty. Certain disciplines, such as family

medicine, emergency medicine, and internal medicine, have the most uncertainty compared to other disciplines, such as orthopedics or plastic surgery (Han et al., 2021; Platts-Mills et al., 2020). This greater uncertainty is due to the need to evaluate patients with undifferentiated presentations, broad differential diagnoses, and incomplete clinical information before a definitive diagnosis can be established.

Barriers to DR

There are many barriers to DR, including knowledge deficits and a lack of alternative hypotheses (Crookery, 2017). Cognitive and affective biases, illogical thinking, and inadequate communication with patients, families, and the healthcare team further impede DR. Additionally, accepting things at face value and having an unquestioning attitude are also significant obstacles to DR (Crookery, 2017). Cognitive biases, a frequently studied barrier to DR, can lead to incorrect judgments or decisions during the diagnostic process. These biases include anchoring bias, where providers fixate on the initial impressions and fail to make adjustments in the context of later information; confirmation bias, where they seek out information that confirms their initial diagnosis; and availability bias, where memorable or recent cases influence their decision-making (National Academies of Sciences, Engineering, and Medicine, 2015; Whelehan et al., 2020).

Crookery and Campbell (2021) conducted an in-depth analysis of 30 anonymized emergency room cases of diagnostic errors through root cause analysis; their goal was to gain insights into the origins of the diagnostic errors and identify error-producing conditions. The results showed that biases such as anchoring and confirmation bias, premature closure, and diagnosis momentum (i.e., tendency to carry forward an established diagnosis) were common. However, medical knowledge-based errors were minimal, highlighting that cognitive biases are a

more substantial barrier to accurate diagnosis than a lack of medical knowledge (Croskerry & Campbell, 2021).

Facilitators to Improve DR

History taking and physical examination skills, knowledge about disease processes including pertinent positive and pertinent negative characteristics, and diagnostic tests are the foundational components of the DR process (Nordick, 2021). Facilitators to improve DR include awareness and education about cognitive biases, debiasing strategies, metacognitive approaches, and systematic practices aimed at enhancing clinical decision-making (Ko et al., 2024).

Debiasing strategies are crucial in mitigating cognitive biases. For instance, cognitive and affective autopsies involve a thorough search for the root causes of adverse patient outcomes, providing critical insights into potential errors and areas for improvement (Croskerry & Campbell, 2021). In addition, cognitive forcing functions, such as consistently creating a differential diagnosis and using checklists, help prevent cognitive errors like premature closure and diagnosis momentum. Prospective hindsight, which is assuming one might be wrong and considering alternative diagnoses, further mitigates bias. Awareness and interrogation of one's opinions over time, contextualized by patient outcomes, also contribute to improved DR (Ko et al., 2024).

Self-care and situational strategies, along with consistent feedback, have been proven effective in promoting better diagnostic outcomes. The adaptive toolbox, which includes strategies such as self-care, emotional intelligence, and cultural humility, helps clinicians combat the negative effects of bias and optimize their cognitive functions during decision-making processes (Ko et al., 2024). Metacognition, or thinking about how we think, allows practitioners to evaluate and refine their cognitive processes, leading to more accurate diagnoses (Croskerry,

2017; Ko et al., 2024). Furthermore, deliberate practice, which involves setting measurable goals and seeking opportunities for repetitive practice and refinement with immediate feedback from mentors or teachers, fosters continuous improvement in diagnostic skills (Ericsson & Pool, 2016).

Importance of DR for NP Students

DR skills are one of the essential NP Entry Level Competencies (CCRN, 2023). Making accurate diagnoses is crucial for safe and effective patient care. In real-life clinical practice, some diseases can be diagnosed by history and physical exam, such as varicella zoster and gastroesophageal reflux disease (Erickson & Parker, 2023). In contrast, others need diagnostic tests in addition to history and physical exam to confirm the diagnosis, such as streptococcal pharyngitis and mononucleosis (Erickson & Parker, 2023). Although patients with Bell's palsy and stroke both can present with facial paralysis, the urgency and management of these two conditions are drastically different. Mistaking one for the other can lead to significant patient harm (Erickson & Parker, 2023).

Once the accurate diagnosis is identified, the treatment plan becomes much easier to determine. Therefore, it is crucial to include effective educational interventions to improve NP students' DR skills. NP students are a unique group of health professionals entering graduate education with prior RN experience, including the clinical reasoning and critical thinking skills they developed during their RN practice. These experiences form an important foundation for the development of DR and the transition to the NP role. While the acquisition of DR skills is a focus of many NP programs, there is limited understanding of how NP students experience and develop DR during their education.

Research Purpose and Questions

The purpose of this doctoral research is to gain a comprehensive understanding of how DR develops among NP students during their educational programs at two Canadian universities.

The overarching research question is:

- How do NP students develop DR during their educational program?

The depth and breadth of data generated during this research extended beyond what could be reasonably reported in a single manuscript. Consequently, the final dissertation is presented as three interconnected qualitative manuscripts, each with its own aim and research questions focused on a distinct but complementary dimension of DR development among NP students. Together, these manuscripts provide a comprehensive understanding of DR development from experiential, metacognitive, and educational perspectives. Below are the research aims and questions for each manuscript.

Research Aims and Questions

Manuscript #1:

Aim

To explore how NP students understand, experience, and develop DR, how they learn it during their NP education, and the challenges they encounter in developing DR.

Research Questions

1. How do NP students define and make meaning of DR?
2. How does prior nursing experience influence the development of DR among NP students?
3. What learning experiences provide opportunities for NP students to apply and develop DR?

4. What challenges do NP students encounter in developing DR, and how do they address these challenges?

Manuscript #2:

Aim

To examine how NP students engage in metacognitive regulation and calibration of DR throughout their education.

Research Questions

1. How do NP students use and balance intuitive and analytical approaches in their DR?
2. How do they recognize and navigate cognitive biases and emotional influences in DR?
3. How do they engage in reflective processes to regulate and calibrate their DR?
4. How do they describe the development of their DR throughout NP education?

Manuscript #3:

Aim

To explore NP students' perspectives on the educational experiences that shape DR development, including curriculum, instructional approaches, preceptor and peer support, and recommendations for strengthening DR education.

Research Questions

1. How do NP students describe the role of instructional strategies and the NP program curriculum in DR development?
2. How do NP students describe the role of preceptors in DR development?
3. How do NP students describe the role of peer interactions in DR development?
4. What recommendations do NP students offer to strengthen DR education in the NP program?

Summary of Chapter One

To summarize, the ability to make accurate diagnoses is crucial for safe and effective patient care and is a required competency for entry-level NP practice. Diagnostic errors can lead to significant patient harm, increased healthcare costs, and malpractice claims. Understanding the various factors contributing to diagnostic error has significant implications for NP education, clinical practice, and policy development. As NP students transition from RN to NP roles, they must develop the DR capabilities required for independent NP practice upon graduation. While effective educational strategies are important for supporting this development, it is equally important to understand how NP students experience and develop DR throughout their education. The following chapters present the literature review, philosophical and theoretical foundations, methods, and three manuscripts. The final chapter integrates the findings and discusses their implications for NP education, clinical practice, and future research.

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Chapter 2 Literature Review

The ability of health care providers (HCPs) to make accurate diagnoses is crucial for safe and effective patient care. It is essential for nurse practitioner (NP) students to develop diagnostic reasoning (DR) skills as they make the transition from registered nurses (RNs) to NPs. Of note, DR and clinical reasoning (CR) are often used interchangeably in the literature. Although they have overlapping components, they are two distinct skills (Young et al., 2020). CR is the cornerstone for developing more advanced DR skills used by NPs, and it involves the cognitive process underlying clinical judgment, appropriate decision-making, and enhancing nursing quality, ultimately leading to professional competence in nursing (Mohammadi-Shahboulaghi et al., 2021). DR is the process of using CR to make a diagnosis, and it is a component of CR (Smith, Benbenek, & Petersen, 2025). As nurses transition to NP roles, the ability to make accurate diagnoses using advanced DR skills becomes essential (Nordick, 2021). DR skills are a core competency for NPs, crucial for providing timely and safe patient-centered care (Rogers & Steinke, 2022).

In this doctoral thesis, DR is defined as a complex cognitive process of interpreting and analyzing multiple data sources during a patient encounter to ascertain the diagnoses and guide the development of treatment plans (Nordick, 2021; Smith et al., 2022a). The purpose of this doctoral research is to gain a comprehensive understanding of how DR develops among NP students during their educational program in Canada. The following research question was used to guide the literature review: How do NP students develop DR during their educational program? The population of interest is NP students in Canada, the concept is diagnostic reasoning, and the context is the educational setting.

Search Strategy

The search strategy (see Table 2.1) was developed in consultation with health sciences librarians at the University of Ottawa and the University of Victoria. Using the above research question, the following electronic databases were searched: Cumulative Index to Nursing and Allied Health Literature (CINAHL), MEDLINE, and ERIC. The following keywords were used in the literature search: diagnostic reasoning, clinical reasoning, nurse practitioner student, NP student, advanced practice registered nurse (APRN) student, and nurse practitioner education. Boolean operators and truncations were used to refine the searches further. Inclusion criteria included English-language articles, full-text availability, and published within the previous 10 years at the time of the initial search (2014-2024). A hand search of reference lists was also conducted. The literature search was updated in summer 2025 and again in 2026 to identify and incorporate relevant publications that had emerged since the initial search.

After screening for titles and abstracts, 54 articles were retrieved for full-text review. Twenty-two articles were excluded due to topic or population. This review comprised a total of 32 articles (see Figure 2.1 PRISMA), including various types of studies, such as qualitative, quantitative, mixed-methods, quality improvement, and review articles, as well as studies involving DR tool development and psychometric testing, and articles describing teaching innovations related to DR. Most of the studies and teaching innovation reports originated from the United States (US), and two were international studies. There were a variety of interventions used in these studies and teaching innovations reports, such as simulations (Barber & Schuessler, 2018; Bradford et al., 2021; Buterakos & Keiser, 2021; Colella & Beery, 2014; Dugan & Lebo, 2023; Hammersla et al., 2023; Hogg et al., 2025), structured reflection (Griffith et al., 2023a; Griffith et al., 2023b), unfolding case studies (Ellis et al., 2023; Granger et al., 2018), a single

case study (Cantero et al., 2024), experiential assessment exercise (Dugan, 2016), self-explanation during DR (Burt et al., 2021), problem-based learning and illness script (Durham et al., 2014), and a differential diagnosis concept map (Reinoso et al., 2018). The studies reviewed included the number of participants and statistical results; however, most of the teaching innovation reports used data from course evaluation surveys, and many did not report the number of participants or statistical results.

Diagnostic Reasoning Teaching Approaches

Differential Concept Map

Reinoso et al. (2018) argued that the mental models RNs develop through critical thinking and clinical experience provide an important foundation for NP education. NPs approach patient complaints differently than RNs. For NP students, the key developmental issue in learning differential diagnosis is the shift from implementing interventions based on given diagnoses to independently determining diagnoses and care plans. To bridge the gap between the mental models of RN experts and NPs, the authors developed the Differential Concept Map to help guide NP students in developing differential diagnoses. Student feedback on the Differential Concept Map was overwhelmingly positive. Students recognized the importance of preparing a list of potential diagnoses before encountering the patient. They found that this methodical approach prevented them from making hasty judgments while simultaneously encouraging them to consider a broader range of possibilities from the start. It also helped broaden their thinking, clarify their focus, and aid treatment planning. All students planned to continue using it in their clinical practice.

Self-Explanation

A study by Burt, Corbridge, et al. (2021) investigated how NP students used self-explanation during DR. Family NP (FNP) students ($n = 37$) from a Doctor of Nursing Practice (DNP) program diagnosed three written case studies while verbalizing and articulating their thought processes. Using dual methodology content analysis, including both inductive qualitative descriptive analysis and deductive categorization during the first phase of a two-phase study, the researchers identified 17 categories of self-explanations, divided into inference and non-inference types. Inference self-explanations, consisting of clinical and biological inferences, integrate information above and beyond the materials provided in the case. Clinical inferences emphasize patient symptoms and disease attributes, for instance, principle-based reasoning, classifying, stratifying risk, prioritizing, and connecting clinical information to organ system or diagnosis, whereas biological inferences emphasize the mechanisms, etiology, and pathophysiology of the underlying disease processes. Non-inference self-explanations, reflecting superficial information processing, included monitoring statements where students assess their understanding, seeking information, assuming and speculating, surface-level awareness, or paraphrasing without adding significant insight. The authors reported that the findings demonstrated credibility, dependability, confirmability, and transferability (Lincoln & Guba, 1986). The results showed that NP students utilize clinical and biological knowledge in their self-explanations, actively improving their knowledge structures. This understanding can inform educational strategies to foster high-quality self-explanation, enhancing diagnostic accuracy. Overall, the study provided a valuable glimpse into the knowledge structures of NP students and highlighted the potential of self-explanation as an educational tool to improve DR.

During the second phase of the two-phase study, Burt, Finnegan, et al. (2021) used quantitative methodology to explore the relationship between ways of self-explaining and

diagnostic accuracy levels and compare the differences in ways of self-explaining and diagnostic accuracy between third-year and fourth-year FNP students. FNP students ($n = 37$) from a DNP program participated in the study, including 18 third-year students (novice students) who had not started clinical placements and 19 fourth-year students (expert students) who were in the final clinical placement. Correlation and multiple regression analysis were used to analyze the data. The results showed a significant negative correlation between diagnostic accuracy scores and non-inference scores, with $r(35) = -0.36$ ($p < .03$). Conversely, there was a significant positive correlation between the diagnostic accuracy scores and biological inference scores: $r(35) = 0.49$ ($p < .002$). The authors reported no significant correlation between the clinical inference scores and diagnostic accuracy scores: $r(35) = 0.14$ ($p < .39$). Furthermore, there was no significant correlation between years of RN work experience and diagnostic accuracy scores: $r(35) = -0.04$ ($p < .82$), clinical inference scores: $r(35) = -0.08$ ($p < .65$), or biological inference scores: $r(35) = 0.07$ ($p < .66$). The multiple regression analysis, which examined the relationship between diagnostic accuracy scores and the independent variables of biological and clinical inference scores, was statistically significant. Biological and clinical inference scores together accounted for 27% of the variance in diagnostic accuracy scores, with biological inference scores having a statistically significant effect on improving diagnostic accuracy. The authors concluded that emphasizing biologically focused self-explanations is crucial for diagnostic accuracy. These self-explanations help novice learners form cohesive mental frameworks to interpret challenging patient presentations. The authors argued that although NP students possess nursing knowledge, this knowledge is not yet fully developed for advanced practice roles and does not enhance diagnostic accuracy. NP curricula should implement educational strategies incorporating anatomy, physiology, and pathophysiology into disease-state courses, supporting the

development of diagnostically competent NPs. Limitations of the study include its small sample size and focus on a single educational program, which may affect the generalizability of findings.

Didactic Education

Cantero et al. (2024) assessed the impact of a didactic education intervention on improving clinical reasoning skills among NP students. During this activity, a primary care clinical case scenario on adult acute viral gastroenteritis was shared with the NP students, who worked in small groups and discussed the case and developed responses to the case questions. The intervention was developed using the clinical judgment action model (CJAM) (c, 2019). It involved a single case study about an adult patient with acute gastroenteritis and structured case questions. Twenty-two ($N = 22$) NP students participated in this study, including FNP students ($n = 20$) and adult gerontology primary care NP students ($n = 2$). The intervention was implemented within a classroom setting before the start of the second clinical placement. Pre- and post-intervention surveys were administered. The results showed that the mean score on self-reported confidence in diagnostic ability increased from 5.8 pre-intervention ($N = 22$) to 6.6 post-intervention ($N = 18$). It is worth noting that nine participants reported an increase in self-perceived diagnostic ability post-intervention, and three reported a decrease. The limitations of this study included the small sample size in the number of participants, and the case (only one clinical case was used during the intervention). Although the authors reported post-intervention mean score change, inferential statistics (e.g., t-tests and p values) were not reported. Moreover, pre- and post-intervention survey questions were not included in the article, making it challenging to assess the construct of those survey questions.

Structured Reflection

Griffith et al. (2023a) mixed-methods study aimed to assess the impact of structured reflection on the DR competency and accuracy of NP students ($n = 38$). As a debiasing strategy, structured reflection uses a series of guided questions to challenge a HCP's DR process. Using this strategy, after identifying the initial, intuitive hypothesis, the provider must list the findings that support or refute the diagnosis and the typical findings expected with this diagnosis but are notably absent in this patient (Mamede et al., 2014). Griffith et al. (2023a) compared a structured reflection template with a presentation organizing template in a simulation-based setting. The Diagnostic Reasoning Assessment (DRA) was employed to evaluate competencies across scenarios of chronic obstructive pulmonary disease, aortic stenosis, and acute decompensated heart failure. The DRA is a psychometrically validated tool to assess DR competencies (generalizability coefficient = 0.81) (Pintz, 2006). The main quantitative outcome results showed no significant improvements in DR competency or accuracy with structured reflection. However, post hoc Wilcoxon analysis found a significant change in DR competency between the aortic stenosis and the acute decompensated heart failure scenarios ($p = .003$), indicating that potential benefits of structured reflection not captured by the study's main results were likely due to its limited power. The quantitative findings suggest the value of integrating structured reflection in NP education for enhancing DR. However, future research with larger samples and repeated scenarios is recommended for a more definitive analysis. Results from this mixed-method study's qualitative arm (Griffith et al., 2023b) showed that structured reflection was a helpful strategy for students' DR process. It helped organize their thoughts and highlight the flaws in their DR.

Experiential Assessment Exercise (EAE)

Dugan (2016) designed and implemented an EAE, aiming to sharpen NP students' observational skills in the community setting. Good observation skills are critical for developing

differential diagnoses, which are fine-tuned through the DR process to reach a final diagnosis. Every week, students were given specific “undercover” assignments that involved conducting assessments in various community settings like restaurants, grocery stores, gas stations, or airports. In these environments, students observed individuals as potential patients, identified risk factors, and established differential diagnoses based on their observations. These findings were then shared and discussed on an online discussion board. Students’ feedback indicated that the assignment helped them develop a keener perception, pay closer attention to detail, think critically, apply their learning immediately, and better understand both verbal and nonverbal cues of potential patients.

Case Studies and Illness Scripts

Durham et al. (2014) taught the dual-process DR to NP students in the DNP Practice program. They described a teaching strategy using problem-based learning (PBL) case studies and illness scripts to teach NP students the dual process of analytic reasoning and pattern recognition (nonanalytic). The authors conceptualized DR into three variables: problem-solving approach--analytic versus nonanalytic; clinical experience--novice to expert; and perceived level of certainty. They designed four scenarios with PBL cases with the same chief complaints. However, patients in those cases had different diagnoses. The illness script included chief complaint, working hypothesis, pathophysiology, predisposing conditions, discriminating and defining features, and problem representation. The authors shared a few student comments from the course evaluation, and most of those comments were positive, supporting the use of this teaching strategy.

Ellis et al. (2023) developed and implemented an unfolding case study to promote NP students’ clinical reasoning skills. This learning activity was implemented during a skills

laboratory immersion experience for NP students ($N = 33$) from different tracks, including family, adult gerontology acute care, pediatric primary care, pediatric acute care, and psychiatric mental health. The faculty team created the unfolding case that would be applicable to all students from different tracks. The case was about a 17-year-old male patient diagnosed with major depressive disorder. The patient overdosed on antidepressants, attempting suicide. He presented to the emergency department and developed serotonin syndrome. Out of those students, 23 of them completed the survey evaluation. 83% ($n = 19$) of the survey respondents reported that the case was “very or extremely valuable” in problem solving and developing a differential diagnosis for the patient. 78.3% ($n = 18$) reported “very to extremely effective” in facilitating clinical reasoning. The authors concluded that unfolding case studies were perceived by participant students as a valuable teaching strategy to support NP students in developing their clinical reasoning skills.

Deliberate Practice

Buterakos and Keiser (2021) designed and implemented on-campus in-person residencies for adult geriatric acute care NP students in the online program, using a scaffolding strategy. These residencies aimed to improve students' CR skills through deliberate practice, empower them to move from collecting and reporting to interpreting the information, and facilitate the transition from the RN to NP role. The authors defined CR as arriving at a diagnosis by collecting information from history, physical examination, and diagnostic tests and critically evaluating that knowledge, which is very similar to the definition of DR used in this doctoral thesis. The learning activities for the on-campus residencies were scaffolded into four semesters, including interprofessional simulation focusing on role development and communication skills, simulations focusing on assessing, diagnosing, and treating patients with acute health conditions,

and various acute care procedural skills. The feedback from students on the course evaluations of the on-campus residencies was positive. Learners found it a valuable experience that allowed them to engage with peers and instructors and promoted hands-on, active learning.

Similarly, Kopelson et al. (2024) examined the implementation of the One-Minute Preceptor model and the Reporter-Interpreter-Manager-Educator (RIME) framework within a primary care NP residency program as strategies to enhance trainees' DR abilities. Following a 12-week intervention that standardized preceptor teaching practices and learner evaluation processes, participants demonstrated higher RIME scores over time, indicating progression in DR competence. The authors suggested that structured clinical teaching approaches that incorporated targeted questioning and ongoing formative evaluation may promote the growth of DR and contribute to greater standardization in precepting practices and learner feedback.

Cognitive Biases and Debiasing Strategies

A literature review by Lawson (2018) examined the DR and cognitive biases of NPs. The author used theoretical sampling to seek conceptual insights into DR. Initially, the authors limited the literature search to NPs only, and it yielded only eight articles. Due to the similarities between physician and NP diagnosing, the search was expanded to include NPs, NP students, medical students, physician assistants, and physicians. A total of 26 articles were included in this review. The author noted that simulation was a frequently used tool to help students develop DR skills. Despite widespread use of the term, most articles did not provide a clear or theoretically grounded definition of DR. The results revealed four common themes: the dual process theory (intuitive and analytical processes), cognitive biases and debiasing strategies, diagnostic error, and patient harm. The author concluded that incorporating these themes into NP education and practice may help improve the accuracy of DR of NPs.

A scoping review by Griffith et al. (2021) examined cognitive debiasing educational strategies to reduce diagnostic error and improve diagnostic accuracy among student providers. Their review included 33 studies with a total of 2,266 participants, who were either medical students or residents. The authors concluded four debiasing strategies categories: guided reflection, increased medical knowledge or experience, checklists to expand possible diagnosis, and self-explanation of reasoning. Among these strategies, guided reflection showed the most promise based on the statistical results of the studies that used this strategy. Notably, NP students were not included in those 33 studies. However, their search strategy and inclusion criteria for the scoping review included students, interns, residents, or fellow trainees for the role of an NP or physician. The authors stressed the need for future research on DR strategies inclusive of NP students, highlighting the importance of this area of study for the advancement of NP education.

Other Reviews on Diagnostic Reasoning

Burt and Corbridge (2018) conducted an integrative literature review of evidence-based interventions to teach DR. Of the 18 studies included in this review, 14 used quantitative experimental or quasi-experimental design, one study used quantitative descriptive design, and three used mixed methods design. In terms of the study population, only one study (Colella & Beery, 2014) focused on NP students ($N = 291$). Most studies ($n = 15$) used medical students ($N = 1,220$) as participants. There was also one study about resident physicians ($N = 91$) and one study involved physician assistants ($N = 56$). The authors concluded that evidence-based interventions to teach DR fit into five educational themes: simulation programs, testing strategies, instructional approaches, cognitive biases, and course formats. Except for cognitive bias, outcomes associated with other interventions were generally positive. However, 80% of the participants in this review were medical students, and there were no randomized, experimental

trials focusing on NP students at the time of this review. Due to the differences in educational background and clinical experience, transferability between medical and NP students is too complex to assume. The authors proposed that future research should focus on understanding the DR phenomenon within NP students to advance NP education.

Smith et al. (2022a) conducted a scoping review of DR-related content in US primary care NP programs to ascertain whether and how DR is addressed in NP education. The review included 41 relevant articles, most of which were descriptions of teaching interventions, and only 10 articles directly referenced the theory and science of DR. DR components frequently identified include conducting focused histories and physical examinations, creating problem statements, developing differential diagnoses, ordering relevant diagnostic tests, and developing evidence-based, patient-centered management plans. Despite the recognized importance of DR, the review reveals a lack of consistent conceptualization and robust teaching frameworks within NP education. While there is some integration of DR in primary care NP programs, research on the effectiveness of these educational outcomes remains limited. The study highlights the need for a more comprehensive integration of DR content and additional educational research to enhance DR competencies in NP education, thereby contributing to reduced diagnostic errors and improved patient care quality. These findings underscore the necessity of embedding structured and intentional DR education within NP curricula to strengthen diagnostic capabilities among NP students.

Smith, Benbenek, and Petersen (2025) also provided a narrative review of the theoretical foundations and core processes of DR in NP practice. The authors synthesized DR into eight interconnected components, including illness scripts, patient interaction, hypothesis-directed evaluation, problem representation and differential diagnosis, value-based testing, working

diagnosis, management planning, and metacognition. Building on these components, they proposed competency areas for NP education and emphasized the need to explicitly teach and assess DR, rather than relying primarily on clinical experience and preceptor role modelling.

A scoping review by Griffith et al. (2022) examined the DR outcomes in NP education. This review included 12 quantitative studies that evaluated NP students' DR competency. The authors assessed specific DR components using the CR assessment framework by Daniel et al. (2019). The results revealed that the most frequently measured DR components were gathering information and formulating differential and working diagnoses. The most common interventions were simulation and objective structured clinical examinations (OSCEs), which used assessment tools such as checklists and patient management problems. The authors argued the need for future studies to assess more covert DR components, such as problem representation, hypothesis generation, and diagnostic justification.

Petersen et al. (2025) provided an overview of teaching strategies designed to support DR development among APRN students. Drawing on the DR literature, the authors described educational approaches that supported the development of clinical knowledge, differential diagnosis generation, and reflective learning. Key strategies included illness scripts, problem representation statements, differential diagnosis grids, cognitive debiasing techniques, self-explanation exercises, and structured reflection. The authors emphasized the importance of embedding DR throughout APRN curricula and tailoring learning activities to students' developmental stage and clinical experience.

Smith, Benbenek, Meyer et al. (2025) conducted an updated scoping review examining the incorporation of DR within NP education. Reviewing 26 publications between 2021 and 2024, the authors found increasing integration of DR concepts, theories, teaching strategies, and

assessment approaches across NP curricula. Commonly reported educational methods included simulation, OSCEs, unfolding case studies, virtual learning activities, and scaffolded learning experiences. The review also identified growing attention to metacognition, structured reflection, diagnostic accuracy, and competency-based assessment as important components of DR development. In contrast to earlier literature, DR was increasingly positioned as the primary framework for understanding clinical problem-solving in NP education. The authors concluded that NP education has made notable progress in incorporating DR-focused educational and evaluation strategies, while emphasizing the need for continued faculty development, curriculum refinement, and research to further strengthen DR education and assessment.

Burt et al. (2025) conducted an integrative review of DR competency assessment tools used in NP and medical education. The review identified 12 assessment tools with varying levels of psychometric support, assessing a broad spectrum of DR competencies, including information gathering, data synthesis, diagnostic decision-making, and management planning. Most of the identified instruments had been developed and evaluated with medical learners, while only a small number had been applied to NP students. The authors emphasized the importance of psychometrically sound assessment strategies for competency-based education programs and suggested that DR competency is best evaluated through a combination of assessment modalities, including simulation activities, clinical practice experiences, oral case presentations, and written documentation. They also identified a need for additional research to refine and strengthen DR assessment approaches specifically for NP education.

Diagnostic Reasoning Using Simulation

In-Person Simulation Using Standardized Patients (SPs)

Simulations often involve the use of SPs, who have been a key element in health care education for many years (Ballman et al., 2016). The primary value of SPs is their standardization; each actor is meticulously trained to deliver a consistent history and illness presentation. This enables uniform evaluation of student actions, similar to standardized testing. Their thorough preparation and acting skills result in compelling simulations. SPs have been utilized in both in-person and virtual learning environments (Ballman et al., 2016).

Hammersla et al. (2023) reported an innovative strategy for teaching DR to NP students using a formative simulation. Beginning-level NP students worked in small groups through the DR process with faculty facilitators. There were three SP cases with the same chief complaint of cough, yet each case had a different underlying etiology and history components. During the simulation, students took a focused history, performed physical examinations, and presented their differential diagnoses in order of priority. During the “time-out” period, faculty facilitators coached DR, hypothesis generation and how to prioritize the key findings. Students’ feedback on this simulation was collected via the Course Evaluation Questionnaires (CEQ). A total of 132 students responded to the survey (response rate 72.5%), and 48 out of the 132 respondents (36.3%) wrote free-text comments about the simulation experience. Students commented that the simulation was very helpful in building their DR, and they would like to have more simulations and opportunities to work with SPs. However, the author did not share or discuss the overall CEQ results. It would be helpful for readers to know the data from the overall CEQ results so that they can make an informed decision about whether to adopt this teaching strategy in their respective NP programs.

Unfolding Case Simulation Using SPs

Similarly, Barber and Schuessler (2018) described using an innovative SP simulation in the FNP program ($n = 25$). The simulation involved an unfolding case with three separate encounters. During the first encounter, the SP presented with pain in the hands, hips, and knees, consistent with osteoarthritis. In the second encounter, the same SP presented with abdominal and other symptoms consistent with peptic ulcer disease induced by nonsteroidal anti-inflammatory drugs. In the third encounter, the same SP presented with severe abdominal pain and hematemesis. During the simulation, the students performed focused history-taking and physical examinations, formulated differential diagnoses, and developed a plan of care, including ordering diagnostic tests and writing prescriptions. Faculty facilitated the debriefing using a series of guiding questions, including questions about differential diagnoses. Students' feedback was overwhelmingly positive: this simulation reinforced their clinical knowledge and provided them with an opportunity to identify knowledge gaps.

Comparing In-Person SP Encounters with Virtual SP Encounters

Colella and Beery's (2014) mixed-method study, with a quantitative dominant design, evaluated the effectiveness of an interactive case study (ICS) in teaching differential diagnosis to distance learning NP students compared to on-campus students interacting with SPs. The study aimed to determine if distance learners could achieve similar learning outcomes as on-campus students. Data collection was embedded in the Differential Diagnosis course design. Data were collected from 291 students over two academic years, including 150 distance-learning and 141 on-campus students. The primary measure was the accuracy of differential diagnosis lists, with equivalency testing assessing clinical significance. Results showed a difference of only 4.9% between the groups, well within the predefined equivalence margin of 10%, indicating comparable performance. To enhance clarity, the authors could have specified that distance

students scored 4.9% lower than in-person students rather than using a "difference of only 4.9% between the groups". Qualitative data highlighted students' increased confidence, the importance of experiential learning, and the value of role modelling. The study concluded that ICS is an effective tool for distance learners, providing a comparable learning experience to traditional face-to-face interactions with standardized patients. The findings support further exploration of ICS as a valuable teaching strategy in NP education.

Ballman et al. (2016) compared NP students participating in in-person SP encounters with distance-learning students using virtual interactive case studies (ICS) to support differential diagnosis development. In the virtual ICS format, a faculty member conducted the history taking and physical examination with the SP, and the remote students viewed the encounter in segments, pausing to determine which questions to ask, which body systems to assess, what diagnostic tests to order, and how to formulate differential diagnosis with supporting rationales. The authors reported comparable performance between virtual and in-person formats in students' ability to develop differential diagnoses. However, the study did not report the number of participants or statistical results. The authors suggested that virtual ICS encounters may expand access to experiential learning opportunities for distance-learning NP students.

A study by Posey et al. (2018) evaluated NP students' ($n = 41$) DR performance in face-to-face SP encounters (FSPEs) compared to telehealth SP encounters (TSPEs). The researchers used a randomized, crossover study design. Participants were assigned to one of four groups, including FSPE/asthma first, FSPE/pneumonia first, TSPE/asthma first, or TSPE/pneumonia first. The Diagnostic Reasoning Assessment (DRA) tool was used to assess the accuracy of their diagnosis, students' DR performance, and SOAP notes (subjective, objective, assessment, and plan). The DRA is a psychometrically validated tool to assess DR competencies (generalizability

coefficient = 0.81) (Pintz, 2006). It has six items: history taking, physical examination, classification of findings, analysis and interpretation of findings, differential diagnosis, and final diagnosis. The results indicated no significant difference in students' diagnostic accuracy or DRA scores between FSPE and TSPE. However, a sequence effect was observed for the DRA scores. Students who first engaged in TSPE had significantly lower DRA scores compared to their subsequent FSPE. Additionally, the sequence of both encounters and cases significantly impacted the students' diagnostic accuracy. Students who initially encountered either asthma or FSPE were more likely to achieve the correct diagnosis. In conclusion, this study suggests that students exhibit similar DR skills in both TSPEs and FSPEs. Future research should explore the effectiveness of TSPEs in various environments to teach and assess a range of clinical competencies among diverse groups of NP students.

Virtual Simulations

With advancements in digital technologies, virtual simulation has been widely used in nursing education, offering interactive and near-reality learning experiences (Cant et al., 2019). Virtual simulation modalities include screen-based simulation, web-based simulation, virtual patients or virtual environments, serious games, and virtual reality. There are three components in virtual simulation: fidelity, immersion, and patients. The fidelity can vary from low to high; the immersion level, referring to the level of emotional, sensory, and cognitive engagement, can also vary; and patients can be through computer-generated avatars, video recordings, or real actors (Cant et al., 2019).

During the COVID-19 pandemic, Bradford et al. (2021) created synchronous and asynchronous simulation learning activities for students in the midwifery and women's health NP programs. The existing OSCEs were converted to a virtual format to simulate telehealth

visits. They provided opportunities for students to take a history, conduct a review of pertinent body systems, demonstrate the diagnostic reasoning process, and develop a management plan. The faculty also developed on-call simulations to address phone triage skills. Additionally, students were provided an optional asynchronous simulation learning opportunity via a software platform simulating a patient encounter with animated avatars. Students and faculty reported positive experiences, particularly with the virtual OSCEs and telehealth activities.

Dugan and Lebo (2023) described a series of three consecutive telehealth simulations for NP students ($N = 3$) designed to replicate episodic primary care encounters. Students completed focused assessments, developed differential diagnoses and management plans, and communicated prescriptions to a pharmacist. Participants valued the autonomy and realism of the experience, although the small sample size and resource-intensive format may limit broader implementation.

Beebe et al. (2024) explored the impact of a 5-week screen-based simulation (iHuman Patients) intervention on metacognitive awareness, knowledge, and DR among FNP students ($N = 72$) in their final clinical semester. Using a quasi-experimental one-group pretest-posttest design, the authors measured metacognition with the Metacognitive Awareness Inventory (MAI) and knowledge using the Diagnostic Readiness Test. The findings showed significant improvements ($p < .001$) in knowledge, metacognitive awareness, and DR scores following the intervention. The authors concluded that these improvements could enhance diagnostic accuracy and reduce errors. However, a key limitation was that the study was conducted during the FNP students' final semester while they were still completing their clinical placements and seeing patients in real life. Clinical experience gained during the five-week study period may have contributed to the observed improvements in posttest scores, although this possibility was not

discussed by the authors. Additional limitations included the use of self-reported measures of metacognition, potential misalignment between the simulation cases and the DRT, recruitment from two programs within the same region, and the absence of a control group, all of which may have limited generalizability.

Hogg et al. (2025) examined diagnostic test-ordering practices among FNP students ($N = 98$) using screen-based simulation cases and faculty-led debriefing sessions. Analysis of a complex case showed that fewer than half of the students selected all the recommended diagnostic investigations, while all students ordered additional tests that extended beyond those required to establish the diagnosis. Qualitative findings indicated that uncertainty, fear of missing important diagnoses, knowledge gaps, and preceptor influences contributed to excessive test ordering. The authors concluded that screen-based simulation combined with faculty-led debriefing provided a valuable opportunity for students to reflect on their DR processes and test-ordering decisions in a safe learning environment.

Diagnostic Reasoning Measurement Using the Diagnostic Thinking Inventory (DTI)

Rogers and Steinke (2022) investigated the DR abilities of NP students from the United Kingdom (UK) and the US to examine the DR skills of two cohorts of NP students. Their research involved NP students ($N = 22$) completing an online survey using the DTI, a validated DR scale, at the beginning and end of their clinical placements. The DTI tool, developed by Bordage et al. (1990), was a validated DR scale with two subscales: flexibility in thinking (FIT) and knowledge structure in memory (KSM). The tool was validated with 270 participants, including medical students, residents, and experienced physicians, and had an overall reliability of 0.83, with 0.72 for the FIT subscale and 0.74 for the KSM subscale (Bordage et al., 1990). Rogers and Steinke's (2022) study results showed that the NP students' mean total DTI scores

(UK $M = 138.4$, US $M = 140.8$) were lower than those of first-year medical students ($M = 153.9$) in the Bordage et al. (1990) study. However, the authors did not report whether this was statistically significant. There were no significant differences between the UK and US NP students' mean DTI scores, either in flexibility, structure, or combined scores. However, the raw scores showed statistically significant improvement in the structure of memory ($p = .03$) in the second survey, which was done in the last semester of their clinical placements. Nevertheless, these results need to be interpreted with caution as the items on the DTI are all self-rated questions and are subjective in nature. The authors discussed that it is challenging to capture how students gain a deeper understanding of the complexities of human ailments and diseases and how they discern which concerns are relevant to a given situation and which are not. They also emphasized the need for further research to better understand and enhance the DR abilities of NP students.

Another study by Rogers et al. (2023) examined the DR skills of NP students internationally from 12 countries and assessed the variability in clinical teaching components across different NP curricula. Similar to the previous study by Rogers and Steinke (2022), this study used the DTI tool via an online survey, which NP students ($N = 152$) completed during their first year of study. The results showed that the mean DTI score was 142, with the FIT mean score at 73 and KSM at 69. These mean scores fell below those of the first-year medical students with DTI score of 153, FIT of 79, and KSM of 74 (Bordage et al., 1990). However, these results need to be interpreted with caution as the items on the DTI are all self-rated questions and are subjective in nature. The study also found that most programs included bioscience courses and provided 500 to 950 hours of precepted clinical practice along with OSCEs. The authors emphasized the importance of foundational biomedical knowledge and the integration of clinical

practice opportunities to enhance DR skills. They suggested that NP programs should ensure dedicated clinical hours, supervised practice experiences, and the use of OSCEs to improve DR.

Diagnostic Reasoning Tools

Burt and Olson (2023) developed and evaluated the psychometric properties of the Diagnostic Competency During Simulation-based (DCDS) Learning Tool. This tool has 28 items, assessing six competencies, including collecting key findings, problem representation, prioritized differential diagnosis, justification, decision support, and cognition. Eight experts confirmed its content validity while four faculty members tested inter-rater reliability across eight simulation scenarios. The content validity index (CVI) scores ranged from 0.9175 to 1.0, with a total CVI of 0.98. The intra-class correlation coefficient (ICC) was 0.548. The findings suggest that the DCDS Learning Tool is a relevant and moderately reliable tool for assessing diagnostic reasoning competencies, offering NP educators detailed, actionable assessment measures.

Schumaker and Bergeron (2016) presented the Clock Model as a structured framework for teaching CR to NP students in emergency settings. The model focuses on the DR component of CR and guides learners through key diagnostic processes, including assessment of the presenting complaint, differential diagnosis development, diagnostic testing, and formulation of a working diagnosis. The model incorporates both medical and nursing perspectives, leveraging pattern recognition and the scientific method to guide clinical decisions.

Summary of Chapter Two

While there were 11 studies and nine review articles in this literature review, many others ($n = 12$) were teaching innovation reports without research methodology or scientific reporting of the results. DR skills are crucial for NP students, enabling them to diagnose and treat patients

accurately. However, robust research on DR in the context of NP education is still in its infancy. Additionally, the literature lacks a clear and consistent definition of DR, as many studies use the term informally without offering a specific definition (Lawson, 2018).

The above literature review has highlighted the various educational interventions and assessment methods used in developing DR skills, such as simulations, unfolding case studies, structured reflections, and problem-based learning. These studies and teaching innovation reports underscore the complexity of DR and stress the need for tailored educational strategies to support the development of diagnostic capabilities among NP students. While most of the articles included in this review focused on DR in NP education from the perspectives of educators or evaluated educational interventions, relatively little research has examined how NP students themselves experience and develop DR throughout their educational journey, or how it unfolds over time. Understanding this developmental process from the student perspective may provide insights into how DR evolves throughout NP education. Addressing this gap may provide valuable insights into the cognitive, experiential, and educational factors that shape DR development and inform future NP education, clinical teaching, and curriculum design.

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Table 2.1 Search Strategy

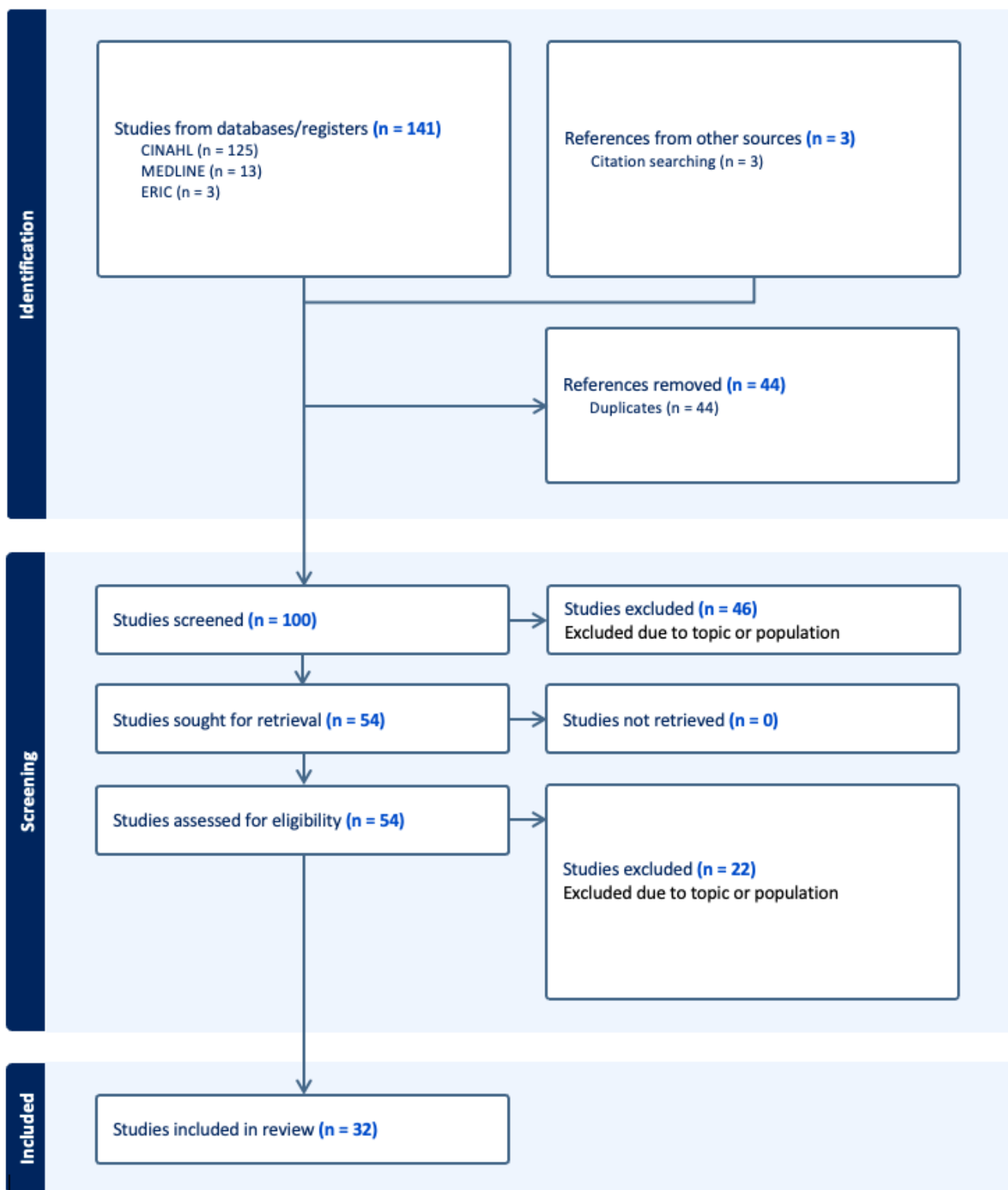


Sat, June 6, 2026 10:43:49 a.m.

#	Query	Limiters/Expanders	Results
S11	(S3 OR S4 OR S5 OR S6 OR S7) AND (S8 AND S9)	Limiters - Publication Date: 20140101-20261231 Search modes - Proximity	125
S10	(S3 OR S4 OR S5 OR S6 OR S7) AND (S8 AND S9)	Search modes - Proximity	166
S9	S3 OR S4 OR S5 OR S6 OR S7	Search modes - Proximity	Display
S8	S1 OR S2	Search modes - Proximity	Display
S7	(MH "Advanced Practice Registered Nurses+") AND (MH "Education+")	Search modes - Proximity	Display
S6	(MH "Nurse Practitioners+") AND (MH "Education+")	Search modes - Proximity	Display
S5	(MH "Advanced Practice Registered Nurses+") AND (MH "Students, Nursing+")	Search modes - Proximity	Display
S4	nurse practitioner student* OR nurse practitioner education OR advanced practice nurs* student* OR advanced practice nurs* education	Search modes - Proximity	Display
S3	(MH "Nurse Practitioners+") AND (MH "Students, Nursing+")	Search modes - Proximity	Display
S2	diagnostic reasoning OR clinical reasoning	Search modes - Proximity	Display

S1	(MH "Diagnostic Reasoning") OR (MH "Clinical Reasoning")	Search modes - Proximity	Display
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Figure 2.1 PRISMA Diagram



Chapter 3 Philosophical Stance

As a pragmatic researcher focused on real-world issues, the researcher identified the development of diagnostic reasoning (DR) skills among nurse practitioner (NP) students as an area requiring further research. Students are active contributors in the learning process, making it essential to examine how they construct meaning from their learning experiences. This chapter outlines the philosophical stance that informed this research, emphasizing constructivism and pragmatism. It includes an overview of these two philosophical stances, their practical implications, and how they can support the current research.

The combination of pragmatism and constructivism offers a robust philosophical framework for understanding and developing DR skills among NP students. Pragmatism highlights the practical consequences and the importance of context, which aligns well with the objectives of this doctoral research. Constructivism, on the other hand, focuses on how students construct meaning from their learning experiences, which is central to this study on developing DR skills among NP students. By providing a theoretical foundation for understanding the active role of learners in constructing knowledge, constructivism complements the practical focus of pragmatism.

Constructivism

Constructivism originated from the work of theorists such as Jean Piaget (1954) and Lev Vygotsky (1978), who developed the foundational ideas behind the constructivist approach to learning. According to their philosophies, the process of learning is grounded in an individual's personal experiences and interactions with their environment. Through these experiences, new knowledge and understanding are actively constructed and internalized within the learner's mind rather than merely being transmitted from an external source (Piaget, 1954; Vygotsky, 1978).

Constructivist philosophy has been widely used in various fields, such as education, psychology, and philosophy. It brought paradigm shifts and significant changes in education and classroom learning. This approach promotes active learning and student engagement with the material and cultivates higher-order thinking skills among learners, such as synthesis, application, and creation (Almulla, 2023; MacDonald et al., 2019; Zhang et al., 2020).

Constructivism highlights the importance of active engagement of students in the learning process, where students take responsibility for their learning and achieve higher levels of understanding with appropriate support from educators (Ekinici et al., 2023; Sumarna & Gunawan, 2022). It challenges the notion that teaching and learning are simply about educators passing on what they know to their students and that students are passive receivers of the knowledge, like empty pails waiting to be filled. Instead, it stresses the crucial role of learners in actively forming their own understanding by incorporating new information with existing knowledge. It posits that students actively construct knowledge and learning through their lived experiences and interactions with the world around them. Educators act as facilitators and motivators to support student learning (Ekinici et al., 2023; Sumarna & Gunawan, 2022).

Instructional Approaches Based on Constructivism

Instructional approaches, such as the flipped classroom and problem-based learning (PBL), were developed based on the constructivist philosophy (Bliss & Aitken, 2018; Ekinici et al., 2023). In the flipped classroom model, students are provided with pre-class learning materials, such as readings and pre-recorded video lectures, to introduce them to the course content before class. The learners gain first exposure to new materials outside of the class. Class time is then dedicated to active learning activities, such as the application of the concepts, discussions, and collaborative teamwork. The instructor acts as a facilitator to help answer

questions, clarify misunderstandings, and guide students in applying the knowledge. This approach allows students to learn at their own pace before class and frees up class time for more engaging, active learning activities. It promotes peer collaboration, teamwork, and student-instructor interaction. It also facilitates the development of higher-order skills, for instance, supporting students' progress from memorizing and understanding the materials to analyzing, evaluating, and applying the concepts (Ekinici et al., 2023).

Similarly, constructivism also provides a robust theoretical foundation for PBL by emphasizing active learning, collaborative problem-solving, and critical thinking (Bliss & Aitken, 2018). In PBL, students work through problems that resemble real-life scenarios. This process requires students to apply their knowledge to find solutions to the problems at hand. Constructivism supports PBL by fostering learner-centered environments and promoting active student engagement and reflection. It empowers students to take responsibility and leadership in their learning, set goals, and seek information to solve the problem. Constructivism underscores self-directed, lifelong learning, which is essential in PBL (Millanzi et al., 2021).

Pragmatism

Pragmatic philosophy emphasizes practical consequences and the importance of context in creating knowledge. It offers a practical approach to understanding and examining phenomena by underscoring the role of human experience and action in knowledge construction (Mayumi & Ota, 2022). Originating in the late 19th and early 20th centuries with philosophers such as Charles Sanders Peirce, William James, and John Dewey, pragmatism focuses on the interplay between theory and practice, highlighting that the value of any theory or concept is determined by its practical effects and implications. It asserts that knowledge is context-dependent and tentative (Kelly & Cordeiro, 2020; Mayumi & Ota, 2022).

Pragmatism contains key concepts such as pluralism and fallibilism, which will be discussed in this section. Within pragmatism, there are diverse opinions and beliefs. As an example, James viewed truth as a tool for happiness and satisfaction; as such, there could be more than one truth (James, 1907). His view of truth was contrary to Peirce's, who believed there was one objective truth, which could be obtained through continuous inquiry as a group (Mayumi & Ota, 2022). On the other hand, Dewey and James had similar views on pragmatism, although Dewey expanded his theories in the field of education (Dewey, 1997; James, 1907). For this dissertation, pragmatism from Jamesian perspectives will be discussed, focusing on concepts such as pluralism and fallibilism, as well as their relevance and practical application to this research.

As a philosophy, pragmatism encourages and supports the use of ideas from multiple sources. Pragmatism has been widely used in various disciplines such as business, nursing, occupational health and safety science, and psychology, demonstrating its versatility and relevance across diverse areas of study (Bell & Warren, 2023; Dolan et al., 2022; Klockner et al., 2021; Lomotey-Nakon, 2018). Moreover, it has been used to guide studies using various methodologies, such as mixed methods (Bell & Warren, 2023), quantitative (D'Souza et al., 2021), and qualitative (Kelly & Cordeiro, 2020) studies.

Pragmatism has been incorporated into nursing education in different ways. For instance, nurse educators play a crucial role in systematically integrating evidence-based practice (EBP) concepts into the nursing curriculum to enhance learners' knowledge and skills in EBP (D'Souza et al., 2021). Pragmatic philosophy in nursing encourages continuous questioning of current knowledge and practices, supporting nurses to adapt and reflect on their practices to foster a dynamic and reflective approach to care (Mayumi & Ota, 2022). An integrative and iterative

approach to pragmatism is conducive to the generation and use of new knowledge in nursing. This philosophical stance can effectively link education, research, practice, and policy within the nursing profession (Dolan et al., 2022).

Pluralism

As one of the key concepts within pragmatism, pluralism encourages and promotes using different ideas to approach complex health issues. There are many examples of plurality in nursing education. For instance, nursing curriculum often includes materials from medicine, nutrition, philosophy, psychology, and sociology. Nursing encompasses knowledge relevant to nursing and other disciplines to optimize education. Additionally, to bridge the theory-practice gap, nursing faculty must ensure that students are learning within a curriculum that is relevant and has practical implications to real-world clinical practice. Pragmatism can help bring together various aspects of the nursing profession, such as education, research, practice, and policy (Dolan et al., 2022). This pluralism and open inquiry are essential for exploring the facilitators and barriers to developing DR skills among NP students and understanding their lived experiences.

Fallibilism

In addition to pluralism, Jamesian pragmatism supports the notion of fallibilism, which means knowledge is tentative and provisional, subject to change with new evidence and experiences. It encourages continuous, iterative cycles of learning, reflection, and modification, and ongoing evaluation and refinement of educational practices, all of which are critical for NP education (Dolan et al., 2022). With medical and health science and technology advancements, new diagnostics and treatment modalities are being developed rapidly. Due to the ever-changing healthcare landscape, NPs are expected to be lifelong learners and reflective practitioners who

stay current in their practice. Therefore, educators must cultivate these values among NP students and support them in meeting entry-level competencies (Canadian Council of Registered Nurse Regulators, 2023). Similarly, as new evidence emerges, NP programs need to evolve with time and enhance the education of NPs, preparing them for the complexities and challenges of real-life practice.

Practical Application of Constructivism and Pragmatism to this Research

Constructivism provides the primary theoretical lens for understanding how NP students construct meaning from their educational experiences, while pragmatism complements this perspective by emphasizing the practical application of knowledge to improve educational practice and outcomes. Together, constructivism and pragmatism provide a philosophical foundation for examining how NP students develop DR and for generating findings that can inform educational practice.

This doctoral research explored how NP students develop DR throughout their educational program. This aligns with the constructivist emphasis on understanding individual experiences and meaning-making processes, recognizing that students actively construct their understanding of DR through interactions with educators, preceptors, patients, and learning environments. This research also aligns with pragmatism by examining how NP students develop DR in educational contexts and by generating findings that may inform improvements in NP education. By focusing on the practical implications of DR development, this research will offer actionable recommendations for educators and policymakers. These recommendations may include strategies to address barriers to DR development, enhance experiential learning opportunities, and inform curriculum design and clinical teaching.

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Chapter 4 Theoretical Framework

The purpose of this doctoral research is to explore how nurse practitioner (NP) students develop diagnostic reasoning (DR) during their educational program. The Metacognitive Diagnostic Reasoning (MDR) Model by Beebe et al. (2024) was selected as an emerging conceptual model and sensitizing theoretical framework to inform this research. This chapter describes the MDR model, examines its origin and major components, considers the strengths and limitations, and examines its application to this study.

Description of the MDR Model

Beebe et al. (2024) developed the MDR Model, which contains the various factors related to DR in Advanced Practice Registered Nurses (APRNs). APRN is a title used in the US to describe nurses who have met the education and certification requirements to practice in one of the following four roles: certified NP, clinical nurse specialist (CNS), nurse-midwife (CNM), and certified registered nurse anesthetist (CRNA) (APRN Consensus Group Work Group & NCSBN APRN Advisory Committee, 2008). In Canada, there are two types of advanced practice nursing roles, including the CNS and NP (Canadian Nurses Association, 2019). The purpose of the MDR model is to provide a structured method for teaching and assessing DR and a framework to guide educational research on DR for APRNs (Beebe et al., 2024).

The MDR model includes three main pillars: metacognition, the dual process model, and knowledge representation (Beebe et al., 2024). The authors adopted the following definitions for the key terms used in the MDR model: DR is a complex cognitive process that enables a provider to arrive at an accurate diagnosis (Lawson, 2018). Metacognition refers to the capacity to reflect on, understand, and regulate one's own thought processes (Schraw & Dennison, 1994). Knowledge representation involves the collection and classification of information, as well as the

knowledge-building strategies an individual holds about a specific topic (McLane & Turley, 2009; Peace & Brennan, 2009). It includes not only the knowledge of a subject but also how one categorizes information related to that subject and the strategies and experiences used to retrieve and process it (Beebe et al., 2024).

The MDR model (Beebe et al., 2024) integrates metacognition (aware versus unaware) (Schraw & Dennison, 1994), the dual process model (system 1: intuitive versus system 2: analytical) (Croskerry, 2009), and knowledge representation (McLane & Turley, 2009; Peace & Brennan, 2009) to provide a structured approach to improve diagnostic accuracy and reduce errors in clinical practice. It includes many factors involved in the DR process: patient data gathered from history taking, physical examination, laboratory and diagnostic investigations; filtering, framing and processing the data; ruling in and ruling out differential diagnoses. The DR process involves both intuitive and analytical thinking and is prone to cognitive biases. Once a diagnosis is established, it informs treatment planning and ongoing evaluation of patient outcomes. Metacognition has a central role to play in the DR process. The experience gained from the previous encounters will in turn help inform future encounters (Beebe et al., 2024). The following section will discuss the origins of its major components, including metacognition, the dual process model, and knowledge representation (Beebe et al., 2024).

Metacognition

The MDR model emphasizes the central role of metacognition in DR. Metacognition, defined as the ability to reflect on, understand, and regulate one's own thinking (Schraw & Dennison, 1994), acts as the driving force behind the diagnostic process (Beebe et al., 2024). Flavell (1979) described metacognition as an awareness of one's own cognitive processes, including four categories: metacognitive knowledge, metacognitive experiences, goals, and

actions. Later, Brown (1987) expanded the definition by adding the regulation and control of cognition. Knowledge about cognition and regulation of cognition are the two pillars of metacognition. Knowledge about cognition encompasses three types: declarative (awareness of strategies and oneself), procedural (knowing how to use strategies), and conditional (knowing when and why to use strategies) knowledge. Regulation of cognition involves the ability to control cognitive activities through skills like planning, managing information, monitoring, and evaluating.

Dual Process Model

The dual process model for DR by Croskerry (2009) involves two types of mental processes based on the dual-process theory (System 1 and System 2 processes) and pattern recognition. System 1 is fast, automatic, and intuitive thinking. It requires less mental effort and cognitive awareness but is prone to errors. System 2 is slow, systematic, and analytical thinking. It requires more mental effort and cognitive awareness and is less prone to errors. This is a linear model, going from left to right. A real-life clinical application of this model could look like the following: if a patient presents with a condition recognized by the health care provider (HCP), the DR goes through the System 1 process, which is fast and intuitive. If the HCP does not recognize the condition, then the DR goes through the System 2 process, which is slower and analytical. The two systems can interact with and may even override each other. For instance, repetitions of System 2 processes can lead to pattern recognition and subsequent System 1 processes. There are modifiers to the dual processes, such as different types of cognitive biases, HCP's affective state, age and experience, intellectual ability, and education. Additionally, interactions may occur between the two systems with various factors such as lack of sleep and/or

overtaxing of physical or mental capacity. The outputs from both systems pass through a calibration process before reaching the final diagnosis (Croskerry, 2009).

Knowledge Representation

Building upon prior nursing education and experience, APRNs and NP students are expected to have an in-depth understanding of the nursing process and DR skills (Beebe et al., 2024). As explained by Kuiper et al. (2016), APRNs utilize knowledge representation techniques to filter, structure, and prioritize information and knowledge to make diagnoses and treatment decisions. They highlighted that nurses interpret patient encounters through a unique lens shaped by their nursing knowledge and experience, a process referred to as "making meaning" or framing. In this process, nurses draw on their past experiences, available patient information, and various forms of knowledge classification to filter relevant patient data. The organization and classification of this information are crucial, often facilitated by standardized methods such as electronic health records, which help guide the HCP's processing of patient data (McLane & Turley, 2009; Peace & Brennan, 2009). By employing these framing and filtering approaches, APRNs may incorporate biases into their decision-making processes.

Strengths and Limitations of the MDR Model

The MDR model is a comprehensive framework that integrates multiple aspects of the DR process. It offers a holistic approach to understanding and improving this complex process and provides a structured method for teaching and assessing DR. Emphasizing metacognition encourages learners and HCPs to reflect on their thinking processes, potentially reducing diagnostic errors. The model can be used in various educational and clinical settings, making it a practical and versatile tool for improving DR.

However, it is challenging to apply the MDR tool without a thorough understanding of its components. This is largely due to the model's integration of different cognitive processes and the need for users to be proficient in both intuitive and analytical reasoning. Furthermore, application of the model requires a thorough understanding of its major concepts, such as metacognition, dual process theory, and knowledge representation, which may not always be covered in the NP curriculum. Differences in individual clinical experiences and cognitive processes further complicate the consistent application of the model. For instance, experienced HCPs may rely more on intuitive thinking, whereas novices may depend more heavily on analytical processes. These variations can lead to inconsistencies in how the model is interpreted and used, potentially impacting the accuracy and effectiveness of DR among different learners and HCPs. Additionally, cognitive biases, self-reflection capabilities, and the ability to integrate new learning into existing knowledge can vary widely, which can further affect the consistent adoption and application of the MDR model.

Application of the MDR to this Doctoral Research

The MDR model provided a sensitizing conceptual framework for exploring how NP students develop DR throughout their educational program. It served as a comprehensive conceptual framework for understanding the various components of DR and informed the development of the interview guide. NP students who participated in the study described their experiences of developing DR skills, including perceived facilitators and barriers, their use of metacognitive strategies, and how they balanced intuitive and analytical thinking (Beebe et al., 2024). Two examples of interview questions informed by the MDR model are presented below:

- Do you incorporate a reflective process in your DR process? If so, can you describe a time when this approach significantly affected your diagnostic decision-making?

- How do you balance intuitive (System 1) and analytical (System 2) thinking when diagnosing a patient? Can you describe a situation where you relied more heavily on one type of thinking? What was the outcome?

Summary of Chapter 4

The MDR model is a comprehensive and robust framework integrating multiple aspects of the DR process. By integrating metacognition, the dual process model, and knowledge representation, the MDR model offers a holistic approach to understanding and improving the DR process, while also providing a structured method for teaching and assessing DR. Its emphasis on metacognition, self-reflection, and awareness of cognitive processes provides a useful lens for understanding how DR develops among NP students. It supports this doctoral research by providing a practical framework for understanding and advancing DR development in NP education.

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Metacognitive Diagnostic Reasoning Model

The MDR Model is not reproduced here for copyright reasons. See Figure 2 in Beebe, S. L., McNelis, A. M., El-Banna, M., & Dreifuerst, K. T. (2024). Reflecting on diagnosis: The Metacognitive Diagnostic Reasoning Model. *Journal of the American Association of Nurse Practitioners*. <https://doi.org/10.1097/JXX.0000000000001018>

Chapter 5 Methods

As discussed in Chapter One, this dissertation comprises three interconnected qualitative manuscripts, each exploring a distinct yet complementary aspect of diagnostic reasoning (DR) development among nurse practitioner (NP) students. Although each manuscript addresses a specific research aim and set of research questions, all are derived from a broader qualitative study examining how NP students develop DR throughout their educational program. This chapter outlines the study aims and research questions, research design, sample and setting, recruitment procedures, data collection, data analysis, ethical considerations, and strategies used to ensure trustworthiness.

Study Purpose

The purpose of this study was to explore how NP students develop DR skills throughout their educational program at two Canadian universities.

Research Aims and Questions

Manuscript #1:

Aim

To explore how NP students understand, experience, and develop DR, how they learn it during their NP education, and the challenges they encounter in developing DR.

Research Questions

- How do NP students define and make meaning of DR?
- How does prior nursing experience influence the development of DR among NP students?
- What learning experiences provide opportunities for NP students to apply and develop DR?

- What challenges do NP students encounter in developing DR, and how do they address these challenges?

Manuscript #2:

Aim

To examine how NP students engage in metacognitive regulation and calibration of DR throughout their education.

Research Questions

- How do NP students use and balance intuitive and analytical approaches in their DR?
- How do they recognize and navigate cognitive biases and emotional influences in DR?
- How do they engage in reflective processes to regulate and calibrate their DR?
- How do they describe the development of their DR throughout NP education?

Manuscript #3:

Aim

To explore NP students' perspectives on the educational experiences that shape DR development, including curriculum, instructional approaches, preceptor and peer support, and recommendations for strengthening DR education.

Research Questions

- How do NP students describe the role of instructional strategies and the NP program curriculum in DR development?
- How do NP students describe the role of preceptors in DR development?
- How do NP students describe the role of peer interactions in DR development?
- What recommendations do NP students offer to strengthen DR education in the NP program?

Research Design

This study employed Interpretive Description (ID), a qualitative methodology developed within the applied health disciplines to generate clinically meaningful and practice-relevant knowledge (Thorne, 2025). ID recognizes that human experiences are socially and contextually situated and that researchers bring disciplinary knowledge to the interpretive process. It acknowledges multiple, context-dependent realities and recognizes the researcher as an active participant in the construction and interpretation of knowledge rather than a detached observer. Unlike methodologies aimed primarily at theory generation or description, ID seeks to develop understandings that inform clinical practice, education, and policy.

Rather than seeking a purely descriptive account of participants' experiences, ID emphasizes identifying patterns and relationships within subjective experiences and interpreting these patterns in ways that inform applied disciplinary knowledge and practice (Thompson-Burdine et al., 2021; Thorne, 2025). This orientation aligned closely with the overarching research question of how NP students develop DR during their educational programs. The purpose was not only to understand students' experiences of learning DR, but also to identify patterns across those experiences and consider what could be learned to strengthen NP education.

ID was well suited to this study because the development of DR among NP students is a complex educational and clinical phenomenon shaped by multiple contextual factors, including prior nursing experience, clinical placements, interactions with instructors and preceptors, and learning opportunities within NP curricula. ID also recognizes variation among individual experiences while seeking shared patterns across participants' accounts (Thorne, 2025). This was particularly appropriate because NP students enter their educational program with diverse nursing backgrounds and encounter varied educational and clinical experiences.

Consistent with the goals of ID, this study sought to move beyond description to generate practical insights that could inform NP education and support the development of DR among NP students. This applied orientation was also congruent with the pragmatic philosophical stance underpinning this dissertation, which emphasizes the practical usefulness of knowledge. ID therefore provided a coherent methodological approach for examining the contextual and experiential complexity of DR development while generating knowledge relevant to NP education, practice, and research.

Sample and Setting

This study was conducted in Canada and involved NP students enrolled in programs at universities in British Columbia (University of Victoria) and Ontario (University of Ottawa). The selection of these two research sites reflected both pragmatic and methodological considerations. The University of Ottawa is the researcher's home institution for doctoral studies. It was also the institution where initial ethics approval was obtained, making it a pragmatic choice for institutional access and recruitment. Moreover, the University of Ottawa is one of nine universities participating in the Ontario Nurse Practitioner Education Consortium (2026), in which all nine universities deliver the same NP curriculum. The University of Victoria provided access to a second NP program within a different provincial and educational context. Including two sites therefore introduced variation in students' educational and clinical experiences and allowed DR development to be explored across more than one program context. This approach was consistent with ID, which seeks to identify patterns across experiences while remaining attentive to contextual variation (Thorne, 2025).

Criterion sampling was used to recruit participants who met the predefined eligibility criteria, supplemented by convenience sampling to facilitate recruitment (Creswell & Poth,

2024). Eligibility required participants to 1) be currently enrolled in one of the participating NP programs; 2) have completed at least 20 hours of NP clinical practicum; 3) be able to participate in an English-language interview. The minimum practicum threshold ensured that participants had progressed beyond shadowing their preceptors and had begun providing patient care under preceptor supervision, thereby gaining exposure to DR in clinical practice. No additional exclusion criteria were applied beyond the predefined inclusion criteria. Recruitment took place in spring 2025. NP program coordinators and course faculty at both sites assisted in disseminating recruitment information to students. In addition, the researcher attended scheduled Zoom classes with instructor permission to briefly introduce the study and invite participation. Recruitment materials were also distributed via email (see Appendix A).

A total of 24 NP students participated in the study. Sampling adequacy was guided by the concept of information power (Malterud et al., 2016), whereby sample size is determined by the relevance, richness, and specificity of the information obtained in relation to the study aims. Recruitment concluded when sufficient depth and breadth of data had been obtained to address the research questions and additional interviews no longer contributed substantially new interpretive insights.

Data Collection and Ethical Considerations

Ethical approval was obtained from the research ethics board at the University of Ottawa (file number H-02-25-11219) and the University of Victoria (file number 25-0124). Following informed consent (see Appendix B), data collection took place between May and June 2025. Demographic information (see Appendix C) was collected via SurveyMonkey. One-on-one semi-structured interviews were conducted by the same researcher to ensure consistency. Each interview was conducted virtually via Zoom and lasted approximately 90 minutes. An interview

guide (see Appendix D) was emailed to participants one week prior to the interview to allow time for reflection on their experiences of developing DR during their NP education. The interviews were audio-recorded using Zoom and transcribed using Otter.ai. Each transcript was reviewed multiple times by the researcher, and errors were corrected using the original audio recording to ensure accuracy. Audio recordings and transcripts were stored on password-protected, university-approved secure storage systems accessible only to the research team. Transcripts were anonymized prior to analysis, and participant numbers were used during analysis and reporting to protect confidentiality.

Data Analysis

Excel was used to organize and analyze the demographic data. NVivo15 (Lumivero, 2024) software was used to organize and analyze qualitative data. Consistent with the principles of ID, data analysis was iterative and interpretive, with ongoing comparison within and across participants' accounts (Thorne, 2025). Bingham's (2023) five-phase qualitative analysis provided a practical structure for organizing and documenting this process, including organizing, sorting, understanding, interpreting, and explaining the data. This approach was selected because it provided a systematic framework while allowing the analysis to remain flexible and iterative. First, the data were organized and categorized based on the key aspects of the research questions. Next, inductive analysis was conducted through open coding and line-by-line analysis in NVivo to identify emerging ideas in the data. Alongside coding, the researcher engaged in constant comparison to iteratively assess whether newly analyzed data warranted the creation of new codes. Codes were iteratively reviewed, refined, and consolidated to ensure accurate representation of participants' meanings, and were subsequently developed into overarching themes and findings. Beyond coding, the interpretive process supported the generation of themes

that reflected shared patterns and meanings across participants' experiences rather than merely descriptive categories.

Rigor and Trustworthiness

Multiple strategies were implemented to ensure credibility and trustworthiness, consistent with established qualitative standards (Lincoln & Guba, 1986). Rigor was further considered using Thorne's (2025) four criteria for qualitative research: epistemological integrity, representative credibility, analytic logic, and interpretive authority. These criteria provide a basis for evaluating rigor and credibility within ID. Epistemological integrity refers to coherence between the study's epistemological positioning, research questions, methodological decisions, and interpretations. Representative credibility requires that knowledge claims remain consistent with the sample and contexts from which the data were generated. Analytic logic requires transparency in the reasoning and decision-making processes through which interpretations are developed, while interpretive authority requires that interpretations be trustworthy, grounded in the data, and critically examined in relation to the researcher's own perspectives and experiences (Thorne, 2025).

Several strategies were used to support these dimensions of rigor. Interviews were audio-recorded. The interviewer routinely summarized or paraphrased complex concepts and clinical experiences during interviews to confirm shared understanding. Interview transcripts were reviewed multiple times and compared with the audio recordings to ensure accuracy. The researcher conducted regular debriefing sessions with her PhD supervisor (JT) throughout the study. These discussions included reviewing of coding and thematic development to enhance analytic rigor. The iterative analytic process involved comparing data within and across participants and continually examining developing interpretations against the dataset. An audit

trail documenting methodological decisions and analytic processes was maintained to make the progression from data to interpretations transparent and support analytic logic. Participant quotations were used throughout the findings to demonstrate the connection between the data and the resulting interpretations.

Representative credibility was supported through criterion sampling of NP students who had relevant experience with DR in both educational and clinical contexts and through the inclusion of participants from two NP programs with varied nursing and clinical backgrounds. Interpretive findings were developed through attention to both shared patterns and variation across participants' accounts. Epistemological integrity was supported through alignment among the study's constructivist and pragmatic philosophical positioning, the research question, and the interpretive approach to data generation and analysis.

Together, these strategies supported alignment among the study purpose, sampling, data generation, analysis, and the resulting knowledge. Consistent with ID, rigor was therefore approached not simply through the application of individual techniques, but through coherence among the study's purpose, process, and context (Thorne, 2025). Beyond these evaluation criteria, Thorne (2025) emphasized moral defensibility, disciplinary relevance, and pragmatic obligation as important considerations for applied qualitative research. In this study, moral defensibility was reflected in the purpose of generating knowledge that could contribute to strengthening NP education and supporting the development of DR among NP students. Disciplinary relevance was addressed by examining a problem directly relevant to NP education and practice, and generating knowledge intended to advance understanding of how NP students develop DR. Pragmatic obligation was addressed by considering the potential educational and

clinical implications of the findings while recognizing that findings generated within specific educational contexts should be interpreted and applied with appropriate attention to context.

Reflexivity

Reflexivity was an ongoing component of data collection and analysis. Consistent with ID, Thorne (2025) describes the researcher as an active participant in the interpretive process whose disciplinary knowledge and experiences can contribute to interpretation while also shaping what is noticed, explored, and understood. As a practicing NP and educator involved in NP education, the researcher remained attentive to how her professional background and prior experiences could shape data collection, analysis, and interpretation. This positionality provided familiarity with NP curricula, clinical education, and the transition from RN to NP practice, which supported interpretation of participants' descriptions of learning DR. At the same time, this familiarity created the potential for the researcher's own experiences and assumptions to influence how participants' accounts were understood. Reflexivity therefore involved recognizing disciplinary knowledge as a valuable interpretive resource, while critically examining how it could shape data collection and interpretation.

The researcher maintained a reflexive journal and field notes throughout data collection and analysis. The reflexive journal was used to document reactions to interviews, emerging assumptions, unexpected findings, and instances in which the researcher's experiences as an NP educator differed from those described by participants. These reflections encouraged the researcher to consider alternative interpretations and remain attentive to perspectives that challenged her existing assumptions. The reflexive journal also informed data collection. For example, when cognitive bias emerged spontaneously during the first interview, the researcher documented its potential importance and subsequently explored the concept with other

participants, rather than assuming from a single account that it represented a broader pattern. Regular discussions with her PhD supervisor provided additional opportunities to critically examine developing interpretations and challenge assumptions.

Specific instances demonstrated how reflexivity influenced the researcher's responses to and interpretation of participants' accounts. For example, some participants described clinical logs as having limited value to their learning. As an NP educator, the researcher was familiar with the educational purpose of clinical logs for monitoring students' clinical exposure and level of involvement in patient care. Recognizing this difference in perspective helped the researcher avoid privileging the educator's perspective or interpreting participants' comments as reflecting a lack of understanding of the purpose of clinical logs. Instead, participants' perspectives were examined as accounts of how they experienced the educational value of clinical logs.

In another instance, a participant described learning from a preceptor to generate three differential diagnoses before entering the patient's room. The researcher recognized that she had previously taught this student and the class this strategy earlier in the NP program. Rather than correcting the participant or emphasizing that the strategy had previously been taught, the researcher remained focused on understanding why the preceptor interaction had been particularly meaningful to the participant. These instances reinforced the distinction between the researcher's roles as educator and researcher, and supported interpretations grounded in participants' experiences rather than the researcher's expectations.

The researcher's insider position also required attention to the power differential associated with being an NP educator interviewing NP students. Although some participants were recruited from an institution at which the researcher taught, the researcher was not teaching the eligible students during the study period and had no evaluative role in their current courses.

Participants were in their final semester before graduation; therefore, the researcher would not teach them in future courses. Participation was voluntary, and participants were informed that they could withdraw from the study without consequence. Confidentiality was emphasized throughout the research process, and participant numbers (P1-P24) were used in reporting the findings. During interviews, the researcher encouraged participants to express both positive and critical perspectives about their educational experiences without judgment or correction. Attention was given to comments that differed from the researcher's own views as an educator. These strategies were intended to reduce the educator-student power differential and support participants in sharing their experiences openly.

Rather than attempting to eliminate the researcher's insider perspective, reflexivity involved making that perspective visible and subjecting it to ongoing critical examination. This process supported interpretive authority by helping the researcher distinguish participants' accounts from her own assumptions, remain open to unexpected or contradictory perspectives, and ensure that interpretations remained grounded in the data (Thorne, 2025).

This dissertation includes three manuscripts derived from the same interview dataset, and each addressing complementary dimensions of the overarching study purpose. Manuscript One examines the broader RN-to-NP transition and participants' meaning-making about diagnostic accountability. Manuscript Two focuses on cognitive and metacognitive regulation. Manuscript Three examines educational conditions, including curriculum, preceptors, and peers. Some interview material informs more than one analysis; however, each manuscript uses a distinct analytic question and interpretive focus.

The following chapters present the three manuscripts reporting the findings of this research. Supporting materials, including manuscript abstracts and tables containing participant

demographic information, themes, and subthemes, are also provided. The integrated discussion examines relationships across the three analyses rather than treating them as independent studies.

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Chapter 6: Manuscript One

Diagnostic Reasoning in the RN-to-NP Transition: An Interpretive Description Study

Manuscript #1 was published in Nurse Education Today in 2026.

Pirani, S., Tyerman, J., Lalonde, M., & Ziegler, E. (2026). Diagnostic reasoning in the RN-to-NP transition: An interpretive description study. *Nurse Education Today*, 166, Article 107307. <https://doi.org/10.1016/j.nedt.2026.107307>

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Manuscript One Abstract

Aim: To explore how nurse practitioner (NP) students understand, experience, and develop diagnostic reasoning (DR) during their NP education, and to examine how prior nursing experience and clinical learning environments shape this development.

Background: DR is a core competency for NP practice and represents a significant shift in responsibility during the transition from registered nurse (RN) to NP. While existing literature has focused primarily on teaching strategies, limited research has examined DR from the learner perspective.

Methods: This qualitative study employed Interpretive Description. Twenty-four NP students in their final semester from two Canadian universities participated in semi-structured interviews. Data were analyzed using a five-phase qualitative analytic process. Themes were developed

through iterative coding and constant comparison.

Results: Four themes emerged: (1) structured sense-making and professional identity transformation (2) prior RN experience as a double-edged influence (3) developing DR under conditions of complexity and constraint, and (4) scaffolded and iterative pathways to diagnostic development. Participants described DR as the “biggest leap” in the RN-to-NP transition, representing not only systematic hypothesis refinement but also diagnostic accountability as the most responsible provider. DR was experienced as inherently relational and co-constructed within the clinical encounter. Prior RN experience provided experiential foundations that supported pattern recognition, while at times narrowing diagnostic breadth due to specialization and habituated practice patterns. Developing DR in primary care was experienced as intellectually taxing, shaped by cognitive load, uncertainty, and contextual fragmentation. Students actively strengthened their DR through self-regulated strategies, while simulation, engaged preceptors, and iterative reassessment functioned as scaffolded supports for DR development.

Conclusion: NP students experience DR as a cognitive, relational, and identity-forming process that extends beyond technical skill acquisition to encompass diagnostic accountability. Educational approaches that explicitly address role transition, relational competencies, and structured reasoning may better prepare learners to assume diagnostic responsibility and navigate clinical uncertainty in NP practice.

Keywords: diagnostic reasoning, nurse practitioner education, professional identity formation, interpretive description, RN-to-NP transition

Diagnostic Reasoning in the RN-to-NP Transition: An Interpretive Description Study

Introduction and Background

Nurse Practitioners (NPs) are advanced practice nurses who integrate nursing and medical knowledge to assess patients, establish diagnoses, and develop treatment plans across diverse healthcare settings.¹ In Canada, NP education is delivered at the master's level, and students typically enter NP programs with at least two years of clinical experience as registered nurses (RNs).² Transitioning from RN to NP role involves expanded diagnostic responsibility and advancement of diagnostic reasoning (DR) skills.³ Accordingly, DR has been identified as an essential entry-level competency for NP practice by the Canadian Council of Registered Nurse Regulators.⁴

DR is a complex cognitive process that involves collecting, interpreting, and integrating data from the patient history, physical examination, and investigations to generate and refine differential diagnoses and guide treatment decisions.^{3,5} Competence in DR forms the foundation for safe and effective NP practice, as diagnostic decisions directly influence treatment planning and patient outcomes. In the literature, DR and clinical reasoning (CR) are often used interchangeably, although they represent related but distinct constructs.^{5,6} CR refers to the broader cognitive process underlying clinical judgment and professional decision-making.⁷ DR, by contrast, focuses on establishing and justifying diagnoses through hypothesis-driven data gathering and synthesis.⁵ This distinction matters in NP education because students must develop analytic and interpretive skills required to justify diagnostic decisions and translate uncertainty into safe and patient-centered plans.

Despite the recognized importance of DR in NP practice, research of DR in NP education has largely focused on teaching strategies from faculty perspectives,⁸⁻¹² with limited research on

how NP students understand, experience, and develop DR during their educational programs. The learner perspective on DR development remains underexplored, particularly within the context of RN-to-NP transition, where prior nursing experience may influence the process. Understanding how NP students experience and develop DR is essential to effectively support cognitive development and role transition.

Aims

As a part of a larger project, the study aims to explore how NP students understand, experience, and develop DR, how they learn it during their NP education, and the challenges they encounter in developing this skill. The research questions are as follows:

1. How do NP students define and make meaning of DR?
2. What learning experiences provide opportunities for NP students to apply and develop DR skills?
3. How does prior nursing experience influence the development of DR among NP students?
4. What challenges do NP students encounter in developing DR, and how do they address these challenges?

Methods

Design

This study employed Interpretive Description, a qualitative methodology grounded in applied health disciplines and intended to generate practice-relevant knowledge.¹³ Interpretive Description recognizes that experience is contextual and shaped by disciplinary influences. It aims to generate insights that can inform clinical education and practice. This methodology was

well-suited to explore how NP students understand, experience, and develop DR within NP education.

Sample and Setting

This study was conducted in Canada and involved NP students from two universities in British Columbia and Ontario. Criterion sampling was used to recruit participants who met the predefined eligibility criteria, supplemented by convenience sampling to facilitate recruitment.¹⁴ Sampling adequacy was guided by principles of information power, and interviews concluded when additional data no longer contributed substantially new interpretive insights related to DR development¹⁵. Participants were required to have completed at least 20 clinical practicum hours, ensuring exposure to NP clinical learning environments and DR, and progressing beyond merely shadowing their preceptors during the first one or two shifts. Although the threshold for eligibility was intentionally broad to support recruitment across different stages of practicum experiences, participants had completed several hundred clinical hours at the time of interview. Recruitment took place in spring 2025 through email-based recruitment, program coordinators, course faculty, and brief Zoom class visits.

Data Collection and Ethical Considerations

Ethical approval was obtained from the research ethics board at two universities (file numbers: 25-0124; H-02-25-11219). Following informed consent, data collection took place in summer 2025. Demographic information was collected via SurveyMonkey. One-on-one semi-structured interviews were conducted by the same researcher to ensure consistency. Each interview was conducted virtually via Zoom and lasted approximately 90 minutes. An interview guide was emailed to participants one week before the interview to allow time for reflection. Interviews were audio-recorded using Zoom and transcribed using Otter.ai. Transcripts were

reviewed against the original audio recordings for accuracy. Audio recordings and transcripts were stored on password-protected university-approved secure storage systems accessible only to the research team. Transcripts were anonymized prior to analysis, and participant numbers were used during analysis and reporting to maintain confidentiality.

Data Analysis

Excel was used to organize the demographic data. NVivo software¹⁶ was used to organize and analyze qualitative data. The five-phase qualitative analysis by Bingham¹⁷ guided the analytic process, including organizing, sorting, coding, constant comparison, and theme development. Inductive line-by-line coding and constant comparison were used to identify, refine, and consolidate codes into themes. The interpretive process focused on how participants made meaning of DR development within the RN-to-NP transition, allowing themes to reflect shared meanings related to this developmental process rather than merely descriptive categories.

Trustworthiness

Credibility and trustworthiness were supported through audio-recorded interviews, in-interview member checking, repeated transcript review, supervisory debriefing, reflexive journaling, field notes, and an audit trail.¹⁸ As a practicing NP and educator involved in NP education, the interviewer remained attentive to how her professional background and prior experiences could influence data collection and interpretation. The interviewer was not assigned to teach any of the participants during the final semester, which helped minimize power differentials and encourage more open sharing. Her familiarity with NP education and practice also supported focused follow-up questions to further explore participants' DR experiences and meanings.

Results

Participants Demographics

A total of 24 NP students participated in this study (see Table 6.1). Participants had a mean age of 37, with an average of 11 years of prior RN experience. The sample included 20 females, 2 males, and 2 nonbinary participants. Participants came from diverse nursing backgrounds. All participants were in their final semester of the NP program, with an average of 510 completed clinical hours at the time of the interview. Most had entered the program with a bachelor's degree in nursing, while a small number held graduate or other professional degrees. Two participants were enrolled in the French program, where French was the language of instruction. For the remaining 22 participants, the language of instruction was English.

Themes and Subthemes

The themes and subthemes are presented in Table 6.2, along with representative codes.

Theme 1: Structured Sense-Making and Professional Identity Transformation

Subtheme A: Systematic Integration and Hypothesis Refinement. Participants described DR as a systematic and integrative process of gathering, synthesizing, and weighing clinical data to generate differential diagnoses. They characterized it as structured and iterative, grounded in purposeful history taking, focused physical examination, and targeted investigations. Central to this process was identifying pertinent positives and negatives, contextualizing findings within the broader clinical picture, and revisiting hypotheses as new information emerged.

One participant emphasized that DR involved “collecting and then weighing data”, describing it as a process of “sitting with” clinical information to determine how strongly each data point supported or refuted potential diagnoses (P4).

The integration of subjective and objective data was central to participants' understanding of DR. "Synthesizing information taken from history taking and physical exam to distill that information down into a most likely or working diagnosis, and alternative explanations for the presenting concern" (P17). Another participant described DR as "a step-by-step, systematic process to help identify, differentiate, and prioritize, some possible causes of the patient's signs and symptoms" (P13).

Pertinent positives and negatives were described as essential for narrowing down differentials and guiding investigations: "Collecting subjective and objective data to form a hypothesis... and then using pertinent negatives and positives to direct investigations and diagnostics" (P18).

Participants also underscored that DR is "a learned skill that requires practice" (P21). One participant described DR using metaphors such as "solving a puzzle" (P22), highlighting the interpretive aspect of the process. Others emphasized its iterative nature, noting that it can take time to work through the DR process.

Beyond its cognitive components, participants emphasized the relational dimensions of DR. Engaging with patients, eliciting complete histories, and clarifying priorities were described as integral to accurate DR. Incomplete patient disclosure was described as directly affecting the process. "It's a process that you engage with the patient, and it involves a relationship with another person...I've had cases where somebody didn't offer me information...that then impacted the diagnostic process as well" (P20).

Subtheme B: Assuming Diagnostic Accountability. Participants consistently described DR as the biggest leap in their transition from RN to NP students. DR was framed as "the hardest part" of the NP role by many participants, representing a fundamental shift in responsibility,

cognitive work, and professional identity. “I saw it as the goal of the program. It felt to me like that was the big thing that differentiates the role between an RN and an NP” (P11).

“It’s the thing that makes me feel the most different, the thing that I’m most proud of developing within the program, and the thing that I think is the coolest part of our job, it’s like that detective work” (P16).

Participants emphasized that this shift required a new way of thinking, even before patient interaction began. DR involved anticipating what information would be clinically meaningful and tailoring the assessments accordingly, rather than collecting data broadly. “Trying to figure out what is pertinent to ask before you ask...it requires that high-level thinking before you even start asking questions” (P17).

Another participant described DR as introducing a new type of cognitive load, moving beyond assessment toward interpretation, synthesis, and decision-making. “It felt like a new type of cognitive load...moving beyond assessment and moving into what do you think this means, and what do you want to do with this” (P11).

The cognitive shift was closely tied to assuming the role of the most responsible provider (MRP). Unlike their RN roles, where diagnostic decisions ultimately rested with others, participants described having the responsibility to make the diagnosis and subsequently develop the management plans under the supervision of their preceptors. This shift brought heightened pressure. “There’s a lot of pressure to make sure you get it right, and you don’t miss something or misdiagnose or mistreat” (P22).

Multiple participants noted knowing which questions to ask during history taking as the steepest learning curve. “That is the hardest part...history is king...the biggest learning curve is knowing what questions to ask that will help you formulate a picture or a hypothesis” (P19).

This transition was accompanied by strong emotional responses. Participants described DR as intimidating and overwhelming, yet also exciting and professionally fulfilling. “That's intimidating at first...but also it's exciting...now you're the one that's figuring it out...So yeah, both scary and exciting” (P20).

Over time, participants’ understanding of DR evolved. While some initially viewed DR as a destination to be achieved, they later came to understand it as an ongoing, iterative process requiring tolerance of uncertainty and continual refinement. Importantly, DR also provided support and structure during this transition. “It definitely gives me a lane to work in and provide support and even comfort in processing through my steps” (P13). “I would really say it’s been a big adjustment for me, looking at a more formal process for working through a problem” (P12).

Theme 2: Prior RN Experience as a Double-Edged Influence

Participants consistently described prior RN experience as a double-edged influence: providing experiential foundations while introducing constraints related to specialization and role-based habits.

Subtheme A: Experiential Foundations for DR. Most participants described prior RN experience as foundational to their development of DR, particularly through repeated exposure to diverse clinical presentations. Experience across acute, community, and specialized settings supported early pattern recognition and red flag identification, enabling them to generate and refine differential diagnoses more efficiently. “DR is helped by the fact that we have experience as nurses...I have experience and exposure that is informing my understanding of the differentials” (P4). “I think my experience at triage made a huge difference. I get to do my own differentials when a patient comes to triage” (P9).

Participants with emergency backgrounds emphasized comfort working with undifferentiated patients and tolerance of uncertainty: “I think emergency department nursing is almost an ideal thing to come in with, because you're used to working with an undifferentiated patient...so you have a tolerance for that discomfort of not exactly knowing what's going on right away” (P16).

Similarly, community-based roles strengthened independent clinical decision making: “My work was mostly in the community...you're by yourself and having to make a choice about whether to send someone to hospital or support them in community. There is that piece of clinical decision making that comes into DR” (P17).

Some participants described specialty RN training (e.g., emergency certification or rural first call program) as early exposure to structured DR frameworks and red flag recognition: “My emergency nursing training...helped me recognize red flags more quickly” (P8). “I did the rural nursing program...the RN health assessment and first call course was an introduction to DR...it gave me a foundation for understanding pertinent positives and pertinent negatives” (P17).

Subtheme B: Constraints of Prior RN Experience. While prior RN experience often supported DR, participants also described ways it constrained development. Specialization, protocol-driven care, and role-based expectations sometimes narrowed diagnostic breadth and reinforced habitual thinking patterns. Transitioning to the NP role required intentional broadening and, in some cases, unlearning. Prior experience also created uneven exposure across clinical domains, leading to gaps that become apparent during NP education.

Participants from highly specialized areas described limited exposure to diverse presentations. They shared concerns regarding narrower diagnostic thinking due to their RN specialization. “Because I worked mostly in clinical research, my practice was so specialized...

I'm always wary that I'm going to miss something critical" (P1). "I've always worried about anchoring myself to all complaints must be about the heart, because that's kind of been my world" (P5).

Others described RN roles that did not routinely require diagnostic inquiry, limiting development of what one participant termed diagnostic "muscle". "In palliative care, we're not always looking for a diagnosis. We're looking to manage symptoms... it has limited the way that I ask questions...it hasn't really developed that muscle as much" (P4).

Transitions to NP practice revealed these uneven experiential foundations, particularly in pediatrics, preventive care, and less acute conditions. "I find the areas that I've been exposed to heavily as an RN, I feel much more comfortable...versus the areas I don't have any exposure to" (P12). "Having not worked with kids at all, I find peds very challenging" (P9). "What hasn't helped me with ER would be some of the less acute situations such as ENT, MSK" (P8).

Participants with acute care backgrounds described a significant mismatch between prior practice and the demands of DR in primary care. In acute care, patients were often already diagnosed, and the focus was on immediate stabilization rather than working through diagnostic uncertainty longitudinally. "The program is primary care, and my background is in ICU, med-surg, emergency. It's really two different worlds. We're always dealing with patients who are already diagnosed" (P3).

Some also recognized that repeated exposure to common acute presentations led to habituation and automaticity, requiring deliberate slowing and more intentional reasoning during NP training. "Because you're used to certain presentations, you get habituated to the emergency department. I'd have to slow myself down, trying to break some of those habits of robotically thinking" (P16).

Institutional structures such as medical directives and RN role expectations also constrained DR. Protocol-driven care sometimes restricted flexibility and reinforced task-oriented practice. “In the ER, I have to follow a protocol...which can limit considering alternative diagnoses beyond the presenting complaint” (P9).

Participants also described how RN role boundaries limited opportunities to fully engage in DR, making the transition to NP challenging. “As nurses...ultimately that's not my responsibility, but now we are the most responsible provider, so that is very different” (P23).

Finally, one participant acknowledged that prolonged exposure to a specific population could introduce bias over time: “Biases are probably my number one risk factor for skewing DR over time. You can build a sense of opinion bias, become jaded” (P13).

While most participants described prior RN experience as both facilitating and constraining their development of DR, one participant viewed it as largely neutral, neither clearly helpful nor hindering (P11).

Theme 3: Developing DR Under Conditions of Complexity and Constraint

Subtheme A: Cognitive Load and Contextual Challenges. Participants described developing DR as cognitively demanding and affected by the contextual realities of clinical education. Challenges included time pressures in clinical placements, limited experiential exposure, the breadth and complexity of primary care, and the structure of short-term clinical rotations, which contributed to cognitive overload and disrupted consolidation of DR skills.

Many participants emphasized the breadth and depth of knowledge required in primary care. The need to generate comprehensive differentials, manage atypical presentations, and integrate foundational knowledge created a steep learning curve. “I feel like DR has been a very steep uphill climb for me, and I've had to put in hours and hours of work” (P7). “One of the

trickiest parts about learning DR is there's so much foundation that needs to go underneath that to make sure we're effective at it" (P4).

Several reported difficulties generating differential diagnoses, particularly when encountering unfamiliar conditions or systems. "One of the biggest challenges is knowing the conditions that could be differentials. It's really that piece of not having enough clinical experience in a primary care setting" (P4).

Participants attributed these struggles to experiential gaps in diagnostic pattern recognition. Without prior exposure to certain clinical presentations, consolidating and translating knowledge into effective DR proved difficult. "If I haven't seen it in practice, I have a hard time consolidating that information" (P7). "Dermatology is one where I didn't have illness scripts to begin with and relied heavily on assessment templates...and same with musculoskeletal, it's not something that as an RN you do a lot of hands-on assessment with" (P16).

Primary care also required participants' greater tolerance of uncertainty. Rather than seeking immediate diagnostic closure, participants described learning to allow diagnostic impressions to unfold over time. This longitudinal nature of primary care required acceptance of provisional DR and iterative reassessment. "One of the big challenges was dealing with uncertainty and not having immediate answers...there's a lot of ambiguity, learning to tolerate the uncertainty while staying thorough has been really tough" (P10). "Being comfortable with the unknown and then coming back to it again and letting it unfold over a series of visits" (P4).

Contextual factors compounded these cognitive demands. Time pressure was frequently identified as a major barrier: "In a clinical environment, it's easy to feel quite rushed and want to skip...and just get to the answer" (P5). "Time constraint is the biggest challenge...trying to meet

those time constraints and make those decisions really quickly and then also be confident in them” (P15).

Furthermore, limited follow-up opportunities and short-term placements disrupted the continuity in learning. “We don't always get the follow-through...it can take months to really resolve a case” (P4).

Frequent placement changes introduced additional layers of adjustment, including learning new electronic medical records, workflows, referral systems, and regional resources. Differences in patient populations further limited transfer of previous learning. This fragmented exposure limited continuity in developing DR skills. “The 78 hours that we need to get from each placement...it's just not enough to gain confidence” (P22).

Students in the French-language stream described additional structural barriers: “I am in the French program, but all the resources are in English, like UpToDate, Rxfiles, the textbooks...They do have French translations. However, they're not updated at the same time” (P9). “Some classmates requested a change before placement had started because they couldn't communicate with preceptors who only spoke English” (P10).

Subtheme B: Self-Regulated Strengthening of DR. In response to the challenges described above, participants described intentional strategies to strengthen DR, including strategic use of clinical resources, structured approaches, deliberate practice, and workflow adaptations to protect diagnostic quality. These strategies helped them remain systematic and continue consolidating skills despite uncertainty.

Participants frequently relied on trusted clinical resources to support real-time DR. Commonly cited tools included UpToDate, the Edmonton Manual, RxFiles, clinical guidelines, and dermatology photo libraries. Some also used podcasts, mobile apps, or self-testing quizzes to

reinforce learning. Bookmarking frequently used resources enabled quicker access during busy clinics.

“I use a lot of resources for DR: UpToDate, the Edmonton manual, the Calgary black book, that one with the flow sheets with the symptom up at the top that helps me really think through all the different options” (P24).

Many participants described intentionally structuring their DR process to avoid premature closure on a diagnosis before fully considering alternative possibilities. They relied on structured frameworks such as OLDCARTS¹⁹ and VITAMINSABCDE,²⁰ templates for history and physical examinations, and illness scripts to maintain systematic thinking. “I have some templates set up...I have my illness script set up that I can rely on quickly to help me be more structured and systematic” (P23).

Participants also identified distinguishing or pathognomonic features as an important strategy for narrowing differentials: “One of the things I always ask myself is: what is the distinguishing thing about this disease process? What makes it pathognomonic?” (P20).

Developing illness scripts is another commonly described strategy to support DR: “I’ve been developing the illness scripts throughout the program for the common conditions” (P14). These structured approaches helped students organize their thinking, particularly in unfamiliar or complex clinical situations.

Repeated exposure and deliberate practice were viewed as essential for strengthening DR and reducing uncertainty. Participants actively sought additional clinical learning opportunities to consolidate their skills. Several described doing independent “deep dives” into conditions they found challenging or pursuing additional coursework to further enhance their DR. “I think that it’s all about exposure and practice, because you need to see a condition so many different times

before you're comfortable managing that condition.” (P23)

Amid ongoing time pressures in clinical placements, participants adopted workflow strategies to protect diagnostic quality. One common strategy was anticipatory preparation through morning chart review: “I always found the morning chart review is just super helpful...popping in 30 minutes early...I’ll look things up and feel more prepared” (P11).

Together, these strategies reflect deliberate efforts to balance analytic thoroughness with real-world clinical pace. Participants adapted their workflow to safeguard DR under time pressure. Collaborative agenda-setting with patients at the start of visits helps maintain focus in time-constrained primary care encounters. “I’m learning strategies, opening the visit saying, what’s one or two things I can help you with today, and narrowing down the concern list, triaging that accordingly” (P13).

Integrating assessment into natural clinical flow also helped increase efficiency: “I’m learning how to assess without pausing to assess...watching their gait as they come in and out of the room” (P13). Some preceptors also structured time intentionally to build DR efficiency for students: “My preceptor set a timer for me...15 minutes for assessment and five minutes for the physical” (P22).

Theme 4: Scaffolded and Iterative Pathways to DR Development

Subtheme A: Enacted DR in Simulated and Clinical Context. Participants described both simulated and real-world clinical experiences as critical opportunities to apply DR skills. Across settings, learning was most impactful when students were required to generate differential diagnoses, gather data systematically, reflect on their DR, and recalibrate their approach as needed.

Simulation provided a structured space to practice DR in a deliberate and systematic way. At the start of the visit, it was helpful to think of a list of potential diagnoses based on the presenting concern, then approach the situation systematically through thorough history taking to narrow down the possibilities using pertinent information. Post-simulation debriefing allowed reflection, recalibration, and refinement, with particularly meaningful learning occurring when students made errors and adjusted their DR.

One participant recalled a simulation scenario involving fatigue as a presenting complaint: “Fatigue was huge. It could be anything...I wrote down all the possible differentials... like anemia, thyroid, not sleeping, and that guided my history taking...collecting information and thinking about a huge list of possibilities and then trying to narrow it down” (P5).

In clinical practice, participants learned to recognize red flags and escalate care appropriately. Several described encounters in which careful reassessment prompted reconsideration of the initial impressions. One participant described caring for a male patient presenting with metallic taste, sore throat, and epigastric pain in the emergency department. Although gastroesophageal reflux disease was a plausible initial diagnosis, ongoing assessment revealed concerning features.

“Despite multiple IV hydromorphone, his pain was 10 out of 10, radiating to the back on reassessment; his blood pressure was very high. I spoke to my preceptor, and he thought it's probably best to CT scan him to see if it's an aortic dissection. It turns out that's what it was” (P8).

Another participant described identifying neurological findings that led to urgent imaging: “A healthy young male...having intermittent dizziness and blurred vision...I got him to

do a tandem gait, and he was all over the place. And then I triggered nystagmus with the HINTs exam...urgent MRI was arranged and it ended up being a Chiari 1 malformation” (P19).

Participants also described learning DR through moments when preceptors challenged premature anchoring on an initial diagnosis and prompted broader thinking. These moments of diagnostic recalibration were often described as the most impactful learning experiences, with knowledge that “stuck” over time.

“Within 30 seconds of saying it was a radiculopathy, my preceptor said, ‘but it's both sides, both legs’, and had me zoom out and think of it in more of a systemic way, considering other possibilities like diabetes, B12 deficiency” (P16).

Participants further described learning to avoid jumping into conclusions too early by attending closely to patients’ current presentations rather than anchoring to prior diagnoses.

“She has this migraine, PTSD history, but rather than anchoring on that as the cause of dizziness, I examined her ears and found a ruptured tympanic membrane, obliterated, with quite a significant infection...it was really good that I listened to this patient” (P7).

Subtheme B: Conditions that Facilitate DR. Participants identified several contextual, relational, and educational factors that enabled them to apply DR effectively during simulation and clinical practice. These included structured assessment frameworks, engaged preceptors, opportunities for reassessment, strong foundational knowledge, and timely access to diagnostic tests. Collectively, these factors supported clearer thinking, broader differentials, and increased confidence.

Several participants emphasized the importance of maintaining a systematic approach, particularly in high-pressure environments. “Just digging a bit further, taking the time to do your

OLDCARTS...especially in the ER environment” (P8). “It's so important to do it every single time...as a student...just stay systematic” (P18).

One participant noted that structured frameworks prevented cognitive overwhelm: “Having a framework to pull from, because without that, it's easy to get scattered as a student and feel really overwhelmed” (P17).

Opportunities for iterative reassessment further strengthened DR: “Once I was able to broaden my lens, zoom out, think about systemic causes, and walk back to the patient and go through the rule in, rule out again” (P16).

Several participants described engaged preceptors as an important enabler: “What went well was having a preceptor who was invested in teaching me through that and saying, these are the things you've identified. Here's maybe a couple you forgot. How are we going to rule that in or rule that out?” (P17).

Overall, participants described DR development as an iterative process shaped through repeated engagement across simulation and clinical context. Learning was strengthened through cycles of application, feedback, and recalibration, supported by structured frameworks. Together, these experiences enabled learners to progressively refine their DR and build confidence in managing diagnostic uncertainty.

Discussion

This study explored how NP students understand, experience, and develop DR during their NP education. Participants framed DR as the biggest leap in the RN-to-NP transition, reflecting a transformation in how they think, assume diagnostic responsibility, and engage with uncertainty. The findings suggest that DR development in NP education emerges through the interaction of identity transition, experiential learning, prior RN experience, and contextual

constraints. Consistent with literature that distinguishes clinical reasoning from DR,^{5,6} participants described DR as moving beyond assessment toward interpretation, hypothesis refinement, and diagnostic justification. This study extends existing literature by demonstrating that participants experienced DR not only as cognitive progression, but also as a role-based shift in accountability. Becoming the MRP introduced emotional weight, pressure, and vulnerability, alongside excitement and professional pride.

Rather than simply acquiring a new clinical skill, participants described entering a new professional way of thinking and practicing that required them to assume diagnostic accountability as the MRP. In line with prior research on professional identity formation, this finding suggests that DR development in NP education is closely intertwined with the development of an NP professional identity, as students progressively internalize the responsibilities, expectations, and clinical authority associated with the NP role during the transition from RN to NP practice.²¹ This process reflects the broader development of professional identity as an NP, whereby learners begin to see themselves as members of the NP profession and increasingly identify with its distinct scopes of practice and responsibilities.^{21, 22}

Consistent with experiential learning theory,²³ participants gradually strengthened their DR capabilities through repeated cycles of clinical experience, reflection, preceptor feedback, and recalibration of their diagnostic thinking. Learning occurred through repeated application of knowledge in clinical encounters, reflection on uncertainty and mistakes, refinement of diagnostic thinking, and subsequent application in future patient encounters. These iterative cycles appeared central to the gradual development of DR competence.

A novel contribution of this study is the identification of DR as inherently relational. While much of the literature frames DR primarily as a cognitive process,²⁴⁻²⁶ participants

emphasized that accurate DR depended heavily on eliciting complete patient narratives and establishing therapeutic rapport. These findings suggest that DR relies not only on analytical thinking, but also on creating relational conditions that support open disclosure of sensitive, nuanced, and clinically relevant information. When patient histories were incomplete, fragmented, or partially withheld, diagnostic accuracy was compromised, highlighting the extent to which diagnostic information is shaped by the quality of the provider-patient relationship. These findings suggest that DR in NP practice is a relational process that is co-constructed within the clinical encounter and mediated by trust. Specifically, the diagnostic process is co-constructed as patients contribute symptom narratives, contextual information, and ongoing clarification, while providers interpret, probe, and iteratively refine diagnostic hypotheses based on this evolving information. Thus, DR education cannot be conceptualized as solely cognitive, knowledge-based, or algorithmic; it must also attend to communication, contextual, and relational competencies that shape diagnostic accuracy.

This study advances understanding of the RN-to-NP transition by conceptualizing prior RN experience as a double-edged influence. While experiential exposure supported pattern recognition and early hypothesis generation, it could also constrain DR by reinforcing habitual, protocol-driven thinking and anchoring tendencies. Consistent with prior research, some participants experienced a mismatch between prior nursing roles and the NP student role, requiring a shift from making nursing diagnoses to medical diagnoses.²⁷ According to Barnes,²⁸ prior RN experience was neither a promoter nor inhibitor of the NP role transition, although the author also cautioned that its impact appears to be context-dependent, influenced by both the amount and type of RN experience and its alignment with subsequent NP practice settings. Together, these findings challenge the assumption that prior RN experience uniformly

accelerates DR development and highlight the need for deliberate educational support to facilitate cognitive recalibration and DR development in NP students.

Participants entered NP education with diverse clinical backgrounds, which appeared to shape how they approached DR and interpreted clinical information. This variation suggests that prior clinical experiences may influence not only the pace of DR development, but also the reasoning strategies learners bring to NP education. During analysis, attention was paid to similarities and differences across participants' clinical backgrounds to examine how prior experiences shaped DR development. While specific experiences varied, common patterns related to role transition, diagnostic accountability, uncertainty, and experiential learning were evident across participants. The diversity of participants' prior clinical experiences enriched the findings by capturing multiple pathways into DR development; however, the transferability of specific experiences may vary across clinical backgrounds and practice contexts.

The breadth of primary care was experienced as both expansive and intellectually taxing. Participants viewed primary care as a broad and demanding field requiring both breadth and depth of knowledge, often characterized by ambiguity. Generating comprehensive differential diagnoses across the lifespan, navigating uncertainty, and managing atypical presentations contributed to a steep learning curve. This finding aligns with literature describing the complexity of DR in generalist practice.²⁹ However, this study extends prior work by illustrating how NP students experience this complexity in real time, often as a cognitive overload compounded by time pressures, fragmented clinical placements, and limited follow-up opportunities. The tension between analytic thoroughness and clinical efficiency emerged as a persistent challenge. In response, participants developed workflow strategies to protect diagnostic quality while adapting to the pace of clinical environments.

Implications for NP Education and Research

NP programs should acknowledge that students experience DR as a profound professional transformation, not just a technical competency. Explicitly articulating this shift may help normalize the emotional and cognitive challenges associated with assuming diagnostic responsibility. In Canada, students enter NP education with heterogeneous RN backgrounds. Prior experience may enhance pattern recognition in familiar domains while constraining diagnostic breadth in unfamiliar ones. Educators should recognize this variability and support students in intentionally broadening their diagnostic lens when needed. This study contributes to the existing literature by conceptualizing prior RN experience as a double-edged influence on DR development. Future research should examine how different RN practice contexts shape DR development and identify educational strategies that support this transition.

Although this study was conducted within the Canadian NP educational context, the challenges participants experienced and the developmental processes of DR described are likely relevant to NP education internationally. NP programs require learners to assume diagnostic responsibility, navigate uncertainty, and integrate prior nursing experience into their learning. The relational, experiential, and contextual dimensions of DR identified in this study suggest that DR development is shaped not only by knowledge acquisition, but also by professional role transition, diagnostic accountability, and evolving clinical responsibility. Future research is needed to explore how these dimensions interact longitudinally and across diverse clinical settings.

Strengths and Limitations

This study provides in-depth qualitative insights from interviews with 24 NP students across two Canadian universities, representing diverse prior RN experiences and clinical

exposures. Participants varied widely in clinical backgrounds, including generalist and specialized RN roles, enhancing analytic depth and the transferability of findings. The Interpretive Description approach enabled in-depth exploration of participants' meaning-making about DR. However, findings are situated within the Canadian NP educational context, where a minimum of two years of RN experience is typically required prior to admission. In countries where such experience is not required, NP students' DR development trajectories may differ. Additionally, participation was voluntary, and self-selection bias may have resulted in overrepresentation of students with greater interest in DR. Moreover, participants were in their final semester, and their accounts may reflect a more consolidated or retrospective understanding of DR development.

Conclusion

Participants experienced DR as the most significant leap in the transition from RN to NP, extending beyond cognitive skills acquisition to encompass professional identity transformation and diagnostic accountability. Prior RN experience functioned as both foundation and constraint, highlighting the complexity of DR development during role transition. These findings position DR as a relational, experiential, and context-dependent process shaped by patient engagement, uncertainty, and clinical context. Recognizing DR as a cognitive, relational, and identity-forming process has important implications for NP education and future research aimed at supporting learners as they develop diagnostic competence and assume diagnostic responsibility.

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Table 6.1 Participant Demographic Information (N = 24)

Age in years	Mean=37, Range 28-51
Gender	Female (20), Male (2), Nonbinary (2)
Previous degree	Bachelor of Science in Nursing (18) Doctor of Pharmacy (1) Master's in nursing (4) Master's in history (1)
Years of RN experience	Mean=11, Range 3-25
Primary area of RN specialization	Emergency department (5) Community health center (4) Intensive care unit (4) Inpatient medical/surgical unit (2) Home health care (2) Cardiology (1) Clinical research (1) Hemodialysis (1) Inpatient pediatrics (1) Long term care (1) Mental health (1) Sexual health clinic and abortion care (1)
Year of current enrolment in the NP program	Second year, full time (19) Third year, part time (5)
Clinical hours completed in the NP program at the time of interview	Mean: 510, Range 312-625
Language of instruction used in the NP program	English (22) French (2)

Table 6.2

Manuscript One Themes, Subthemes, and Representative Codes

Themes and Subthemes	Representative Codes
Theme 1: Structured sense-making and professional identity transformation Subtheme A: Systematic integration and hypothesis refinement	<ul style="list-style-type: none"> ● Gathering and integrating data ● Pertinent positives and negatives ● Generating and narrowing differentials ● Systemic process ● Weighing and sifting data ● Cyclical process ● Relational component
Subtheme B: Assuming diagnostic accountability	<ul style="list-style-type: none"> ● Biggest leap in transition from RN to NP ● The hardest part ● Scary, difficult, and exciting ● History is king ● Detective work / coolest part of the job
Theme 2: Prior RN experience as a double-edged influence Subtheme A: Experiential foundations for DR	<ul style="list-style-type: none"> ● Experience and exposure inform DR ● DR knowledge from advanced RN training ● Recognizing need for escalation of care ● Expanding knowledge building on experience ● Interprofessional mentorship
Subtheme B: Constraints of prior RN experience	<ul style="list-style-type: none"> ● Limited diagnostic breadth from specialized practice ● Shifting DR approach from acute to primary care ● Habituation to acute care diagnostic patterns ● Role-based constraints on DR ● Bias accumulation through clinical exposure
Theme 3: Developing DR under conditions of complexity and constraint Subtheme A: Cognitive load and contextual challenges	<ul style="list-style-type: none"> ● Practice environment constraints ● Cognitive overload and complexity of primary care ● Experiential gaps in pattern recognition ● Time constraints ● Uncertainty and ambiguity ● Lack of follow-up opportunities
Subtheme B: Self-regulated strengthening of DR	<ul style="list-style-type: none"> ● Strategic use of clinical resources ● Intentional structuring of DR ● Applying structured assessment frameworks ● Deliberate practice and self-directed learning

	<ul style="list-style-type: none"> ● Illness scripts ● Workflow management and time strategies
Theme 4: Scaffolded and iterative pathways to DR development Subtheme A: Enacted DR in simulated and clinical contexts	<ul style="list-style-type: none"> ● Simulation experience ● Acute neurological presentation ● Abdominal pain presentation ● Peripheral neuropathy case ● Rash/dermatology case
Subtheme B: Conditions that facilitate DR	<ul style="list-style-type: none"> ● Systematic approach ● Preceptor support ● Iterative reassessment ● Severity of disease presentation ● Knowledge base ● Previous clinical experience

Chapter 7: Manuscript Two

Metacognitive Regulation of Diagnostic Reasoning in Nurse Practitioner Students

Manuscript #2 was published in Canadian Nurse Practitioner Journal in 2026.

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Manuscript Two Abstract

Aim: To examine how nurse practitioner (NP) students engage in the metacognitive regulation and calibration of diagnostic reasoning (DR) throughout their education.

Background: DR is a complex cognitive process foundational to NP practice. Increasing attention has been directed toward the role of metacognition in improving diagnostic accuracy; however, little is known about how NP students engage in metacognitive regulation of DR during their training.

Methods: This qualitative study used an interpretive description approach. Twenty-four NP students from two Canadian universities participated in semi-structured Zoom interviews. Data were transcribed verbatim and analyzed iteratively using NVivo. Strategies to enhance trustworthiness included member checking, reflexive journaling, and collaborative analytic discussions.

Findings: Four interrelated themes were identified: (1) calibrating intuition and analytical reasoning, (2) emerging awareness and regulation of cognitive bias and emotional influences, (3) reflection as an active regulatory mechanism, and (4) developmental progression from overwhelm to diagnostic fluency. Participants described moving from reliance on structured, stepwise reasoning toward a more integrated and flexible approach. Metacognitive processes, including bias recognition, emotional self-regulation, and reflection, supported refinement of DR, and increased fluency, confidence, and tolerance for uncertainty.

Conclusion: The development of DR in NP students extends beyond knowledge acquisition to include regulation and recalibration of thinking in response to clinical complexity. These findings highlight the central role of metacognition in shaping DR and underscore the importance of explicitly supporting these processes within NP education.

Keywords: diagnostic reasoning, metacognition, nurse practitioner education, cognitive bias, reflective practice

Metacognitive Regulation of Diagnostic Reasoning in Nurse Practitioner Students

Introduction

Diagnostic reasoning (DR) is a dynamic cognitive process that requires clinicians to interpret complex and evolving patient information (Nordick, 2021). In clinical environments characterized by uncertainty and time pressure, effective DR depends not only on knowledge, but also on the ability to monitor and regulate one's thinking (Croskerry & Campbell, 2021; Ko et al., 2024b). Research on diagnostic errors has demonstrated that inaccuracies often arise from cognitive and affective influences, such as anchoring, confirmation, and availability bias, premature closure, and diagnostic momentum, which affect how information is processed (Daniel et al., 2017). In nurse practitioner (NP) education, DR is a core entry-level competency (CCRN, 2023). As NP students assume increasing diagnostic responsibility, they must develop this competency in increasingly autonomous clinical roles.

Background

Metacognition is the ability to reflect on and regulate one's thinking (Schraw & Dennison, 1994). In DR, it involves monitoring decisions, identifying biases, and adjusting reasoning in response to new information or uncertainty (Beebe et al., 2024). Within the dual-process model, a foundational framework in DR, intuitive (System 1) and analytical (System 2) processes operate in parallel and interact dynamically (Croskerry, 2009). Although intuitive reasoning enables efficient pattern recognition, it is more susceptible to bias, whereas analytical reasoning is slower and more deliberate but cognitively demanding. Effective DR, therefore, requires ongoing calibration between these processes.

The Metacognitive Diagnostic Reasoning (MDR) Model integrates metacognition, dual-process theory, and knowledge representation to support diagnostic accuracy (Beebe et al., 2024). Central to this model is the clinician's ability to reflect on their thinking, identify biases,

question assumptions, and recalibrate DR. This framework provides a useful lens for understanding how learners regulate and refine their DR.

Much of the literature on cognitive biases and debiasing strategies in DR has focused on medical students, residents, and physicians, with limited attention to NP students (Croskerry & Campbell, 2021; Griffith et al., 2021; Ko et al., 2024b; Lawson, 2018). Educational research has begun to examine strategies to strengthen DR through metacognitive and debiasing approaches in NP education. For instance, structured reflection, where clinicians deliberately evaluate and challenge their initial diagnostic hypotheses, has been shown to support NP students' DR by organizing thinking and identifying gaps (Griffith et al., 2023a; 2023b). Similarly, self-explanation enhances diagnostic accuracy by promoting deeper cognitive processing, enabling NP students to integrate clinical and biological knowledge into more robust DR structures (Burt et al., 2021). Overall, these approaches highlight the growing emphasis on metacognitive strategies to support DR, but they offer limited insights into how learners actively enact and regulate these processes in clinical contexts.

Little is known about how NP students monitor, regulate, and recalibrate their thinking in real-time clinical contexts, or how these processes develop over the course of NP education. A deeper understanding of these learner-centered processes is critical to informing educational approaches that support the development of DR. Given the complexity and context-dependent nature of metacognitive processes, a qualitative approach is well-suited to capture how NP students experience and regulate their DR.

Aims

This study aims to examine how NP students engage in metacognitive regulation and calibration of DR throughout their education. The following research questions were used to guide this study:

1. How do NP students use and balance intuitive and analytical approaches in their DR?
2. How do they recognize and navigate cognitive biases and emotional influences in DR?
3. How do they engage in reflective processes to regulate and calibrate their DR?
4. How do they describe the development of their DR throughout NP education?

Methods

Design

This study draws on data from a larger qualitative project examining DR in NP education. Given the richness of the data obtained from 24 participants, findings from this dataset are reported across multiple manuscripts, each addressing a distinct aspect of participants' experiences. An Interpretive Description approach (Thorne, 2025) guided this study, providing a flexible yet rigorous framework for exploring clinically relevant questions within applied health disciplines.

Sample and Setting

Participants were NP students enrolled at two Canadian universities in British Columbia and Ontario. Both NP program curricula include classes, simulations, and clinical practicums. Criterion sampling was used to recruit participants who had completed at least 20 hours of clinical placement. This ensured participants had moved beyond clinical orientation and started seeing patients under supervision. Convenience sampling supported recruitment (Creswell & Poth, 2024). Recruitment took place in spring 2025 through multiple avenues. Program leads and course instructors assisted in disseminating study information, and the researcher also contacted potential participants via email and brief announcements during scheduled Zoom classes, with instructors' permission. Participants were self-selected volunteers who responded to recruitment invitations.

Data Collection and Ethical Considerations

Approval for this study was granted by the research ethics boards at both participating institutions (file numbers: 25-0124; H-02-25-11219). Written informed consent was obtained prior to participation. SurveyMonkey was used to gather participants' demographic information. Data were collected in summer 2025 via semi-structured one-on-one Zoom interviews. Each interview lasted about 90 minutes and was conducted by the same researcher for consistency. Participants were provided with the interview guide one week in advance. Otter.ai was used to transcribe the audio recordings, and each transcription underwent multiple rounds of review and was cross-checked with the original audio to identify and correct inaccuracies.

Data Analysis

Demographic data were summarized using Excel, while qualitative data were managed and analyzed in NVivo15 (Lumivero, 2024). Analysis was guided by Bingham's (2023) five-phase framework, which includes organizing, sorting, understanding, interpreting, and explaining the data. An inductive approach was used, with line-by-line coding conducted to generate initial codes. Codes were iteratively compared, refined, and grouped into higher-order categories, which were subsequently developed into themes reflecting shared patterns in participants' experiences. Coding was conducted by the primary researcher, with regular discussions and review of codes and themes by an experienced researcher.

Trustworthiness

Guided by established qualitative standards (Lincoln & Guba, 1986), trustworthiness was enhanced through multiple strategies, including in-interview member checking through clarification and verification of participants' meanings, verification of transcripts against audio recordings, reflexive journaling, and maintaining an audit trail to support transparency and analytic rigor.

Findings

Participant Characteristics

The study included 24 NP students (Table 7.1). Participants were, on average, 37 years old and had a mean of 11 years of registered nurse (RN) experience prior to entering the NP program. All participants were in the final term of their program, completing their last clinical placements.

Themes and Subthemes

An overview of the themes, subthemes, and representative codes is provided in Table 7.2.

Theme 1: Calibrating Intuition and Analysis in DR

Subtheme A: Intuitive Pattern Recognition. Intuition and pattern recognition supported DR, particularly in familiar or high-acuity clinical situations. Participants drew on their previous RN experience as the foundation for intuitive reasoning, noting greater comfort using pattern recognition in areas of prior clinical expertise.

“The things I've seen a lot as an RN, I'll feel very comfortable using pattern recognition.”
(P24)

Intuitive DR was grounded in repeated exposure, with familiar presentations consolidating into rapid pattern recognition over time. Participants also emphasized the relational dimension of intuition. Drawing from their nursing background, participants described “gut feeling” as awareness of subtle interpersonal and contextual cues.

“I find that gut feeling really helps, and that relational piece of our RN background helps in figuring out what's really going on for people...seeing under the exterior and the layers, helping people feel open...and trust that instinct that something else is going on.” (P18)

Intuition was also used to rapidly assess acuity and guide escalation of care. “I think

pattern recognition really helps me when a patient is really acute in front of me, so my ability to see, sick or not sick.” (P16)

Intuition was described as subconscious data synthesis rather than guesswork.

“Nursing is an art and science, when it comes to human beings, you do need that aspect. You need to incorporate that gut feeling. Because as healthcare providers, subconsciously, you are putting together data you may not even realize you know. You get this gut feeling that something's off.” (P2)

Some questioned whether intuition was, in part, a highly refined observational skill developed through clinical experience. “I was often the person who said ‘something's wrong with this person’...Is that intuition, or is that a really detailed initial inspection that I used a lot as an emergency nurse?” (P20)

Overall, participants viewed intuition as experience-informed pattern recognition shaped by prior clinical exposure and relational awareness. While valuable for rapid acuity assessment and familiar presentations, intuition was often used alongside analytic reasoning to avoid premature closure.

Subtheme B: Deliberate Analytical Reasoning. A deliberate, step-by-step analytical approach was used for complex, unfamiliar, or ambiguous presentations, often replacing intuitive pattern recognition.

“Right now, I am trying very much to use a methodical approach. I don't think I have enough exposure and experience to go with gut feelings on diagnosis...maybe I have this feeling, but feelings aside, what does the data say? If I push myself to be more methodical about it now, then I will be able to trust my gut on it a little bit later.” (P15)

For participants from a highly specialized RN background such as cardiology, adopting a

systematic diagnostic framework was particularly important during the transition to the NP role, helping them compensate for perceived gaps in breadth of experience. Others also described using a step-by-step process, especially early in training, to avoid missing information and to analyze gut feelings more deliberately. This approach also helped prevent over-interpretation or catastrophic thinking.

“I have to go by a step-by-step, eliminate my red flags...I can't trust my gut instinct all the time, because I'm just going to think that everything's wrong” (P9)

Others described deliberately slowing down their thinking to differentiate intuitive reactions from systematic reasoning. “The pause is really key in differentiating gut from systematic. If I just go through quickly, I'm not using any higher levels of my brain. I'm just stuck with what's right at the front of my mind.” (P17)

Analytical reasoning was often triggered by presentations that did not fit familiar patterns.

“Less obvious cases are when I start to use a more systematic approach...palpitations could be caused by so many different things...I have to ask: what systems could be causing this? What are the red flags? And how do I work this up?” (P4)

Overall, analytical reasoning was used to verify intuitive impressions, expand differentials, and justify decisions. Structured frameworks and deliberate slowing acted as safeguards against bias and diagnostic error, particularly early in training.

Theme 2: Emerging Awareness and Regulation of Cognitive Bias and Emotional Influences

Subtheme A: Recognizing Cognitive and Emotional Influences. Many participants identified increasing awareness of cognitive biases affecting DR. These biases impacted diagnostic impressions and could lead to premature conclusions if unchecked. Anchoring bias was one of the most frequently discussed, with early impressions leading to an overly focused

diagnosis.

“There were cases where I relied heavily on intuition...immediate anchoring into a diagnosis and being tunnel visioned...I hadn't really used a systematic approach.” (P1)

Confirmation bias was also commonly recognized, with participants reporting a tendency to seek confirming evidence while overlooking contradictory information. Uncritical acceptance of specialist opinions could reinforce this bias.

“If I read something a specialist says, I just think, of course, that's what it is. I'm not going to question the specialist...and then the patient says something just isn't right.” (P11)

Participants highlighted how prior diagnoses and documentation could influence subsequent assessments, contributing to diagnostic momentum. “Somebody labels a rash as eczema...and others continue treating it that way...until someone reassesses it more carefully, it's actually psoriasis.” (P12)

Availability bias was also evident, particularly with frequent or memorable presentations.

“I had a patient with hip pain...I thought it's osteoarthritis right off the bat. But as I asked more questions, it became clear it wasn't. It was more like trochanteric bursitis...you have to make sure you're not jumping to conclusions before doing your assessments.” (P6)

Participants also described how emotional factors influenced their DR. Strong emotions such as patient frustration and family anxiety could affect their ability to remain focused and systematic.

“When there's more than one person in the room, especially with a strong family voice, my DR can get mixed up... The fear or emotion in the room can weigh heavily on decision-making.” (P4)

Anticipatory emotional responses could influence their approach to clinical encounters,

requiring deliberate self-regulation.

“You see their name on your list and already feel anxious about the encounter. It becomes harder to work through, but you still have to provide the same care. I try to calm myself down so I’m not going in stressed.” (P14)

Emotional responses toward patients could influence how thoroughly concerns were explored:

“We’re less likely to explore offhand concerns with patients we don’t want to spend more time with. If we like the patient, we’re more likely to say, ‘tell me more,’ but after a difficult encounter, we may not pursue those concerns.” (P17)

While many participants demonstrated awareness of cognitive and emotional influences on DR, some reported that they had not been explicitly introduced to these concepts prior to the interview. For these participants, reflecting on cognitive biases during the interview prompted greater awareness of how these biases might influence their DR.

Subtheme B: Strategies for Regulating DR. Participants outlined using strategies to regulate and recalibrate DR in response to cognitive and emotional influences. Rather than passively experiencing bias, they demonstrated emerging metacognitive awareness by actively countering assumptions. A commonly described strategy involved countering anchoring bias through a methodical approach, helping prevent premature closure and maintain broader differentials.

“Writing down differentials is really good to be more deliberate in DR and consider what else it could be, when you have a strong gut instinct, it’s easy to anchor on that and not look for more explanation.” (P24)

In some cases, prior diagnoses were re-evaluated, particularly when clinical presentations

did not align with expected trajectories, resisting diagnostic momentum and critically appraising previous clinical conclusions. “Especially being new, if a more experienced provider made the diagnosis, you think they must know better...but if the plan isn't working, you ask: what else could be going on?” (P14)

Participants balanced intuition with systematic reasoning, using strategies such as slowing down and prioritizing key concerns, which helped maintain diagnostic rigor.

“Pattern recognition is important...but I remind myself there could be other possibilities. With more complex cases, I can feel overwhelmed and lose that structure, so I refocus by asking the patient what concerns them most.” (P1)

In some cases, calibration required challenging long-standing diagnostic assumptions and overcoming self-doubt as a learner, including re-evaluating prior diagnoses that had gone unexamined and identifying previously missed findings.

One participant explicitly described using cognitive forcing strategies to counter confirmation bias. “Making sure that you're really being broad and not letting confirmation bias surface. I try to be mindful of that...but it's forced, because it's easy to fall into old habits.” (P22)

Overall, participants actively used metacognitive strategies to regulate DR. Calibration emerged as an intentional, metacognitive process involving slowing down, questioning assumptions, and remaining open to alternative diagnoses.

Theme 3: Reflection as an Active Regulatory Mechanism in DR

Participants described reflection as a key regulatory process that supported ongoing calibration of their DR in response to uncertainty, cognitive bias, and clinical complexity. Reflection functioned as a metacognitive feedback process, occurring before, during, and after clinical encounters, enacted through post-encounter review, documentation, and discussions with preceptors and patients. Across

these contexts, reflection enabled the identification of missed information, the expansion of differentials, and the refinement of clinical decisions.

Reflection was most often triggered by uncertainty or perceived gaps in reasoning, prompting participants to re-engage with cases after the encounter. Post-encounter reflection frequently led to revisions in diagnostic workup or management plans.

“I was so fixated on the bacteremia...later realized I should have worked up her new acute urinary retention...so I talked to my preceptor about ordering a CT the next day” (P2).

“I got home and thought, should I check for STIs? I actually called LifeLabs to add the STI screening...If it wasn't for that reflection after the fact, I probably would have missed that.” (P7).

These examples demonstrate how reflection extended beyond clinical encounters, enabling identification of overlooked possibilities and modification of diagnostic plans.

“When something doesn't make sense or I feel I've missed something, I go back to the chart, look things up, and review their history...and follow up with the patient to refine the plan.” (P17)

For many participants, written documentation such as clinical logs and charting provided a structured space to revisit diagnostic decisions and reconsider differentials.

“I reflect every night when I do my log, thinking about what I missed and may follow up with patients or add investigations. The ability to reflect on what you did or didn't do and then make changes to it feels like better care.” (P11)

Reflection also occurred through discussion with patients and preceptors.

“What I find really helpful is to do a reflective DR exercise with the patient. Before I run it past my preceptor, I share a snapshot of what I'm thinking and why...It gives them the opportunity to clarify if I've misunderstood something” (P4)

Reflection was also triggered by discrepancies between prior clinical conclusions and evolving patient narratives, prompting re-evaluation of prior assumptions. Together, these findings position reflection as a metacognitive feedback process through which participants identified gaps and iteratively refined their DR.

However, reflection during clinical encounters was inconsistent and often constrained by workload and time pressure.

“If I had more skill to handle the volume of clinical encounters, I might have more space to reflect in the moment; but I sometimes feel like I'm just trying to manage the wave, and don't have as much time to reflect during the day.” (P4)

Theme 4: Developmental Progression from Overwhelm to Diagnostic Fluency

Subtheme A: Expanding and Integrating DR. Participants described a clear evolution in their DR over the course of the NP program, characterized by increasing integration of knowledge, improved organization, and expansion of differentials. Early in training, DR was often experienced as overwhelming, driven by the breadth of knowledge required and uncertainty about how to structure the reasoning process. With time, this shifted toward more integrated, flexible, and clinically meaningful DR.

“The process has come a long way from when we were first exposed to it...Early on, it was difficult to understand why you keep differentials you've ruled out. But I realized that unless you can definitively exclude them, they still belong there. Having a structured process really helps. Things start to organize and make more sense.” (P14)

Participants described a transition from theoretical knowledge to real-time clinical application, with repeated exposure making knowledge becoming more organized, retrievable, and clinically meaningful. They also integrated theoretical knowledge, clinical experience, and

diagnostic frameworks into an internalized archive that could be drawn on during clinical encounters.

“I actually went back to the course where we learned about DR for the first time...it's shocking how much further my development has come...my biggest learning has been from my clinical placements where I could apply knowledge to real patients to formulate a hypothesis” (P7)

“Initially, you don't know what to make of all this, but now, at the end of the program, you have this archive of information you can wheel out...putting it together with your experience to come up with a diagnostic pattern.” (P3)

This integration became most apparent during clinical practicum, where previously fragmented knowledge began to come together. “In practicum, that's when I've noticed all these pieces come together. I've become faster in patient workups.” (P2)

As their knowledge base and integrative capacity developed, their differential diagnoses expanded and became more refined.

“One key moment I realized how my DR had evolved was assessing volume status. Now, when I see bilateral peripheral edema, I consider many factors. Before, I would have just thought hypervolemia, but now I recognize it could be other conditions, even hypovolemia.” (P2)

Importantly, this expansion reflected more deliberate reasoning, including interrupting premature closure and looking for outliers.

“When a patient was reported as confused and likely having a UTI...I considered her history and labs: her corrected calcium had been elevated...I also considered hypercalcemia as a cause. Noticing that I didn't just jump to the first conclusion showed my growth.” (P17)

These findings illustrate a developmental shift from knowledge acquisition toward

integrated DR, in which participants increasingly generate, refine, and evaluate multiple hypotheses in parallel.

Subtheme B: Increasing Diagnostic Fluency and Managing Complexity. Participants described distinct turning points in their learning, often referred to as moments when DR “clicked”, marking a transition from uncertainty toward more clinically grounded DR.

“The whole first year was very confusing...It wasn't until I was in practice, with patients and doing my assessments, it just felt different. I was thinking about my questions because I wanted to know specific information to make decisions. That finally clicked and everything started to make more sense.” (P6)

These shifts were often tied to direct patient care, where participants began to take ownership of DR.

“It was the beginning of my last clinical, when it clicked...By mid-February, I was able to provide working diagnoses and differentials, and give a concise, systematic history and physical to my preceptor in five or six sentences, along with my management plan.” (P8)

As participants progressed, they described a growing sense of fluency in DR, characterized by increased speed, efficiency, and ease. This fluency was reflected in a more refined and efficient diagnostic process. “This last summer semester, it just flows more...more refined diagnostic process...It's faster overall. It's a really big leap forward.” (P18)

The growing fluency became most apparent during later clinical placements, where increased autonomy and confidence contributed to a sense of “finding their stride”.

“In the last few months of my practicums, I really felt it unfold. My preceptor gave me space for autonomy, which boosted my confidence, along with helpful feedback. That's when I started to feel like I found my stride.” (P4)

These findings suggest that fluency in DR reflects not only increased knowledge, but also greater efficiency and ease in processing clinical information, enabling more effective engagement with clinical complexity and uncertainty. With experience, they developed growing comfort with managing uncertainty and undifferentiated presentations.

“When patients come in with vague symptoms, initially, that would set me back, I'd be scrambling...now it doesn't throw me anymore. I feel less overwhelmed...thinking through differentials...I'm not mentally spinning anymore.” (P5)

These findings suggest that the development of DR is not simply a linear accumulation of knowledge, but a progressive transformation in how learners integrate, navigate, and act under clinical complexity. As they progressed, participants moved toward a more adaptive, flexible, and self-directed approach to DR, reflecting increasing clinical maturity.

Discussion

This study examined how NP students engaged in the metacognitive regulation and calibration of DR during NP education. Across four themes, the findings indicate that DR development extends beyond acquiring knowledge to include the ability to monitor, question, and recalibrate thinking in response to uncertainty, cognitive bias, emotion, and growing clinical responsibility. Participants increasingly balanced intuitive and analytical reasoning, became more aware of cognitive and emotional influences, used reflection as an active regulatory mechanism, and gradually developed greater fluency. These findings position metacognition as a primary driver of DR development, aligning with the MDR model (Beebe et al., 2024). Importantly, this study extends the MDR model by demonstrating how metacognitive regulation develops progressively during NP education.

A significant finding was that intuitive and analytical reasoning were not experienced as opposing processes, but as complementary and increasingly calibrated over time. Early in training, participants often relied on structured, step-by-step approaches to reduce error, avoid missing information, and keep broad differentials. With experience, they increasingly trusted intuitive impressions, while continuing to check them against systematic reasoning. This aligns with dual-process theory, which conceptualizes intuitive and analytical reasoning as interacting rather than mutually exclusive processes (Croskerry, 2009). This study adds a developmental dimension. Intuition did not simply emerge from experience; it was actively shaped through repeated use of systematic, step-by-step DR, which functioned both as safeguards against bias and as scaffolds for calibrated intuition. These findings reconceptualize intuition as an outcome of structured DR rather than a separate process.

The role of emotion in DR was integral. Anxiety, frustration, and interpersonal dynamics influenced participants' attention, judgment, and depth of inquiry. They actively regulated these responses to maintain safe and equitable care, an area less emphasized in DR literature (Croskerry, 2018; Ko et al., 2024a). Emotion was not separate from DR but embedded within it, influencing both cognitive processes and clinical decisions.

Reflection emerged as a key metacognitive regulatory process. Participants reflected before, during, and especially after encounters to revisit uncertain cases, identify missed information, refine differentials, and modify plans. These findings indicate that reflection serves as a debiasing strategy, consistent with existing literature (Griffith et al., 2023a, 2023b), and as a metacognitive safety mechanism that enables re-examination of assumptions and reduces premature closure. However, reflection during encounters was often constrained by time pressure and workload.

This study highlights a developmental trajectory of DR. Participants progressed from overwhelm and uncertainty toward greater fluency and increased tolerance for ambiguity. Moments when DR “clicked” often occurred in later clinical placements, as participants assumed greater responsibility for diagnostic decision-making. Efficiency improved not because uncertainty diminished, but because participants became more adept at managing it. These findings align with the MDR model (Beebe et al., 2024), particularly its emphasis on metacognitive regulation and the ongoing calibration of DR with repeated clinical exposure. This study offers a learner-centered perspective on how these processes unfold in practice.

A further noteworthy finding was that not all participants had been explicitly introduced to cognitive bias concepts during their NP education. For some, the interview itself increased their awareness of biases. This suggests that awareness of cognitive biases in DR cannot be assumed and requires explicit teaching and intentional integration into the curriculum. Without this foundation, learners may be less equipped to recognize and mitigate biases in real time, potentially affecting diagnostic accuracy. Explicit integration of cognitive biases and metacognitive strategies is therefore essential to support safe and calibrated DR.

Implications for NP education and research

Metacognitive regulation plays a crucial role in the development of DR. NP students may benefit from explicit teaching on cognitive bias, navigating uncertainty, reflection, and calibration, for instance, through simulations and debriefing, structured case-based discussions, guided reflections, and real-life clinical practicums. While intuitive reasoning develops with experience, systematic approaches remain essential as a foundation for calibrated DR. From a research perspective, this study provides qualitative insight into the applicability of the MDR model in NP education and clarifies how metacognitive processes develop within DR. Future

research should explore how these processes evolve longitudinally and how best to support them across different stages of NP education.

Strengths and Limitations

A key strength of the study is its qualitative, learner-centered focus, drawing on in-depth interviews from 24 NP students to examine how DR is regulated and refined during NP education. In contrast to the existing literature largely based on faculty perspectives, this study brings forward learners' voices, offering insight into how NP students engage in metacognitive regulation and calibration of DR throughout their training.

Several limitations should be considered. Participant recruitment may have introduced self-selection bias toward students with greater interest in DR; however, recruitment across two institutions supported variation in experiences and enhanced transferability. The study relied on self-reported perspectives, which may not fully capture the actual, in-the-moment DR. Participants were recruited from two Canadian universities, which may limit transferability to other contexts. Additionally, all participants were in the final semester of their program, and their reflections may represent a more developed or retrospective understanding of DR.

Conclusion

This study demonstrates that DR development in NP students extends beyond knowledge acquisition to include the regulation of thinking in response to uncertainty, cognitive bias, and emotional influences. Participants integrated intuition and analytical reasoning, with reflection supporting refinement of DR. These findings underscore the central role of metacognition and the need to explicitly support reflection and cognitive bias awareness within NP education.

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Table 7.1***Participant Characteristics (N = 24)***

Age (years)	Mean 37 (range 28-51)
Gender	Female (<i>n</i> = 20, 83%), Male (<i>n</i> = 2, 8%), Nonbinary (<i>n</i> = 2, 8%)
Prior RN experience (years)	Mean 11 (range 3–25), experience across hospital, community, and research settings.
Previous education	Bachelor of Science in Nursing (<i>n</i> = 18, 75%) Master's in Nursing (<i>n</i> = 4, 17%) Master's in History (<i>n</i> = 1, 4%) Doctor of Pharmacy (<i>n</i> = 1, 4%)
Clinical hours completed (NP program)	Mean 510 (range 312–625)
Program status	Two-year full-time (<i>n</i> = 19, 79%) Three-year part-time (<i>n</i> = 5, 21%) All participants were in the final semester, completing their last practicum.
Language of instruction	English (<i>n</i> = 22, 92%), French (<i>n</i> = 2, 8%)

Table 7.2

Manuscript Two Themes, Subthemes, and Representative Codes

Themes and Subthemes	Representative Codes
Theme 1: Calibrating intuition and analysis in DR Subtheme A: Intuitive pattern recognition	<ul style="list-style-type: none"> ● Pattern recognition in familiar clinical presentations ● Intuition as subconscious data synthesis ● Using pattern recognition to identify red flags ● Intuition prompting risk escalation ● Relational and contextual cues informing intuition ● Recognizing limitations of intuition
Subtheme B: Deliberate analytical reasoning	<ul style="list-style-type: none"> ● Systematic verification of intuitive impressions ● Structured frameworks guiding DR ● Complex cases triggering analytical reasoning ● Novice reliance on structured reasoning ● Intentional cognitive slowing ● Safety calibration
Theme 2: Emerging awareness and regulation of cognitive bias and emotional influences Subtheme A: Recognizing cognitive and emotional influences	<ul style="list-style-type: none"> ● Awareness of anchoring bias ● Awareness of confirmation bias ● Awareness of availability bias ● Awareness of emotional influences on DR ● Limited prior awareness of cognitive bias
Subtheme B: Strategies for regulating DR	<ul style="list-style-type: none"> ● Actively countering anchoring bias ● Balancing intuition with systematic thinking ● Re-evaluating prior diagnoses ● Expanding the differential diagnosis ● Emotional self-regulation ● Self-reflection
Theme 3: Reflection as an active regulatory mechanism in DR	<ul style="list-style-type: none"> ● Regular reflection ● Reflection with preceptors ● Revisiting cases to refine differential diagnoses ● Reflexive charting ● Use of logs and journaling ● Time pressure limiting reflection

Theme 4: Developmental progression from overwhelm to diagnostic fluency

Subtheme A: Expanding and integrating DR

- Development of clinically applicable diagnostic knowledge
- Integration of diagnostic information
- Expansion and refinement of differential diagnoses

Subtheme B: Increasing diagnostic fluency and managing complexity

- Transformative moments in DR
 - Development of diagnostic fluency
 - Managing clinical complexity and uncertainty
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Chapter 8: Manuscript Three

Educational Experiences Shaping Diagnostic Reasoning in Nurse Practitioner Students

Manuscript #3 was submitted to the Canadian Nurse Practitioner Journal on June 30, 2026.

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Manuscript Three Abstract

Aim

To explore nurse practitioner (NP) students' perspectives on the educational experiences shaping diagnostic reasoning (DR) during NP education.

Background

DR is a core competency in NP practice, yet developing advanced DR within the compressed timeframe of NP education remains challenging. Although various educational strategies have been proposed to support DR development, little is known about how NP students experience the educational factors that shape their DR.

Methods

This qualitative study used Interpretive Description. Twenty-four NP students from two Canadian universities participated in individual semi-structured interviews between May and June 2025. Interviews were conducted virtually, audio-recorded, transcribed, reviewed for

accuracy, and analyzed inductively using Bingham's five-phase qualitative analysis framework.

Findings

Four themes were identified. (1) Curriculum functioned as both a scaffold and a constraint, with students valuing clinically relevant learning while identifying gaps in diagnostic test interpretation and opportunities for deliberate practice. (2) Clinical preceptors supported DR development through questioning, feedback, role modelling, and graduated autonomy, although variability in teaching approaches influenced learning experiences. (3) Peer learning provided psychologically safe opportunities for collaborative discussion, exposure to diverse clinical perspectives, and co-construction of knowledge. (4) Participants recommended earlier and more intentional DR instruction, increased clinical exposure, and deliberate practice.

Conclusion

DR development is shaped by the interaction of curriculum, preceptorship, peer learning, and clinical experience. Findings suggest that DR should be taught longitudinally throughout NP education using integrated classroom, simulation, and clinical learning experiences.

Strengthening these educational supports may better prepare NP students for diagnostic decision-making in clinical practice.

Keywords: diagnostic reasoning, nurse practitioner education, nurse practitioner students, clinical reasoning, interpretive description

Educational Experiences Shaping Diagnostic Reasoning in Nurse Practitioner Students

Introduction

Diagnostic reasoning (DR) is a core competency in nurse practitioner (NP) practice, underpinning assessment, diagnosis, and management of patients across diverse clinical settings (International Council of Nurses, 2020). Developing DR within NP education is challenging as it requires students to integrate advanced biomedical knowledge, clinical judgment, and diagnostic decision-making within condensed graduate programs (Rogers et al., 2023; Smith et al., 2025). Despite the importance of DR in NP education, limited research has examined how NP students experience the educational processes that affect its development. Understanding the students' perspectives is important for informing educational approaches that better support DR development.

Background

A range of educational strategies has been explored to support DR development in NP students. Simulation-based learning, including in-person and virtual simulations, has been widely used to provide experiential learning opportunities (Barber & Schuessler, 2018; Bavis & Burt, 2026; Beebe et al., 2024; Bradford et al., 2021; Buterakos & Keiser, 2021; Dugan & Lebo, 2023; Hammersla et al., 2023; Hogg et al., 2025; Ridgway et al., 2021). Case-based scenarios have also been shown to enhance DR by allowing students to engage with evolving patient presentations (Ellis et al., 2023; Granger et al., 2018). Structured approaches such as concept mapping (Reinoso et al., 2018) have been used to support systematic DR and knowledge organization. Structured reflection and self-explanation also improve diagnostic accuracy and knowledge integration (Burt et al., 2021; Griffith et al., 2023).

Recent literature suggests that traditional reliance on implicit learning through clinical

exposure and preceptor role modelling alone is insufficient for DR development (Smith et al., 2025). Instead, there is increasing recognition of the need for structured and intentional approaches to teaching DR. These include integrating biomedical knowledge with clinical application, supporting metacognitive development, and providing opportunities for deliberate practice with feedback (Nordick, 2021; Rogers et al., 2023; Smith et al., 2025).

However, limited research has examined how NP students experience these educational strategies throughout NP education, including supports and barriers that influence DR development. This gap is particularly important because advanced DR must be developed within the compressed timeframe of NP education.

Aims

The purpose of this study is to explore students' perspectives on the educational experiences that shape DR development, including curriculum, instructional approaches, preceptor and peer support, and recommendations for strengthening DR education.

Research Questions

1. How do NP students describe the role of instructional strategies and the NP program curriculum in DR development?
2. How do NP students describe the role of preceptors in DR development?
3. How do NP students describe the role of peer interactions in DR development?
4. What recommendations do NP students offer to strengthen DR education in NP programs?

Methods

Design

This study is part of a larger qualitative research project exploring DR development in NP education, with this manuscript focusing on students' perspectives regarding educational supports, barriers, and recommendations. Interpretive Description (Thorne, 2025) guided this study, as it is well-suited to applied health research seeking practice-relevant understanding of complex clinical and educational phenomena.

Study Setting and Recruitment

Participants were NP students from two Canadian universities whose programs included didactic classes, simulations, and clinical practicums (approximately 740 hours in total). Criterion-based convenience sampling was used (Creswell & Poth, 2024). Recruitment occurred in April and May 2025 through email outreach, collaboration with program faculty, and brief researcher appearances in scheduled Zoom classes.

Eligibility required participants to 1) be currently enrolled in one of the participating NP programs; 2) have completed at least 20 hours of NP clinical practicum; 3) be able to participate in an English-language interview. The minimum practicum threshold ensured participants had moved beyond shadowing their preceptors and begun engaging in patient care under preceptor supervision, thereby gaining exposure to DR in clinical practice.

Data Collection

Following written informed consent, demographic data were collected via SurveyMonkey. Individual semi-structured Zoom interviews were conducted from May to June 2025, each lasting approximately 90 minutes, by the first author. Participants received the interview guide one week in advance. Interviews were audio-recorded and transcribed using Otter.ai, with each transcript carefully reviewed against the original recording.

Data Analysis

Excel was used to manage the demographic data, and qualitative analysis was conducted using NVivo (Lumivero, 2024), guided by Bingham's (2023) five-phase framework: organizing, sorting, understanding, interpreting, and explaining. Analysis began with inductive line-by-line coding. Codes were iteratively refined and grouped into broader categories through constant comparison, with categories developed into subthemes and themes reflecting shared patterns across participants' accounts (see Table 8.1).

Ethical Considerations

Ethical approval was granted by one university's Office of Research Ethics and Integrity on February 28, 2025 (Ethics File Number H-02-25-11219) and by another university's Human Research Ethics Board on April 4, 2025 (Ethics Protocol Number 25-0124).

Rigor and Reflexivity

Study rigor was maintained using Lincoln and Guba's (1986) trustworthiness principles. Credibility was supported through ongoing clarification with participants during interviews, and dependability through documentation of analytic decisions, iterative coding, and theme development. Reflexivity was maintained through regular discussions with an experienced researcher, reflexive journaling, and ongoing critical reflection on how the interviewer's role as an NP educator and clinician may have influenced interpretation.

Findings

Characteristics of Participants

A total of 24 NP students participated in this study. All participants were in the final clinical practicum. Participants brought substantial prior nursing experience, averaging 11 years as registered nurses (mean age 37), with backgrounds in acute care, community practice, mental

health, pediatrics, clinical research, and other specialized settings. At the time of the interview, participants had completed an average of 510 NP clinical practicum hours.

Themes and Subthemes

Table 8.1 summarizes the themes, subthemes, and representative codes.

Theme 1: Curriculum as Both Scaffold and Constraint in DR Development

Subtheme A: Curricular Elements Supporting DR Development. Across the curriculum, various instructional approaches supported DR, including case-based learning, simulation, and guided questioning. Participants described curricular scaffolding, deliberate practice, and clinical practicum as interconnected components that helped organize, apply, and refine DR over time.

Participants valued a well-sequenced curriculum that enabled cumulative integration of DR concepts. “I love how the program keeps building...every semester builds on the previous knowledge...that gave the breadth of knowledge to think about different diagnoses.” (P21)

Instructors’ emphasis on key diagnostic features, including distinguishing characteristics and pathognomonic findings, helped guide DR and prioritize clinical information. “I find what’s helpful is when instructors highlight these are the things you really have to look for...these are the things that differentiate this diagnosis from that diagnosis...so I know the foundation where I can start from.” (P1)

Case-based collaborative learning helped participants refine their reasoning through shared discussion and feedback. “Posting real-life case studies with reflection is helpful...you reflect on what went well and what didn’t...and getting peer feedback exposes you to things you didn’t consider.” (P14)

Making DR visible was described as both challenging and valuable for learning. “I knew what I was thinking...but to actually write it out, this is why I think this is my differential, that was challenging but helpful.” (P20)

Illness scripts, structured frameworks for organizing key features of clinical conditions, supported more efficient reasoning. “We started early with illness scripts, organizing information into tables, and then coming back to them, updating them...that repeated layering was very helpful.” (P5)

Simulation-based learning was consistently described as one of the most effective approaches for DR development, bridging theoretical knowledge and clinical application through realistic, low-risk patient encounters. Participants highlighted that standardized patients (SPs), in-person and virtual DR (VDR) simulations, and Objective Structured Clinical Examinations (OSCEs) helped build confidence, identify knowledge gaps, and improve DR fluency. “Starting with SPs was helpful as a low-stress learning environment to practice... Even though OSCEs are very stressful, they are still a good, time-pressured environment for learning and help identify areas where you're struggling.” (P14)

Participants emphasized that repetition was essential for building confidence and fluency in DR. “You really need to do something so many times to demystify it, and get comfortable... It's about repetition and practice doing it again and again.” (P23)

Clinical practicum was essential for integrating theoretical knowledge and simulation-based learning into patient care. Participants consistently described practicum as the setting where DR shifted from abstract and textbook knowledge to applied reasoning with real patients.

“Being in practicum really pulled everything together...you have the didactic knowledge, physical assessment skills, and experience working with SPs...but they're still fairly textbook

cases...being in practicum and working with real patients with multiple comorbidities...that's what brought all the pieces together." (P2)

Clinical environments exposed learners to the complexity and variability of real-world presentations, requiring them to adapt their DR beyond textbook cases. "With VDRs and OSCEs, they're fairly textbook presentations...in practice, nothing is aligning the way it's supposed to...how do I marry theory and practice? That's where the clinical piece is really helpful." (P4)

Subtheme B: Curricular Gaps and Misalignments in DR Development. Participants identified gaps and misalignments that hindered the development of DR. These included tensions between expectations for independent learning and the level of instructional support provided, limited opportunities for guided application, and competing curricular demands. "They make it very clear that you're an adult and independent learner...but I'm learning in a format that is completely foreign to me...I wish instructors were more approachable and more involved." (P3)

Participants described gaps between theoretical learning and clinical application. "We have assigned readings...which are important, but if there aren't corresponding case studies or opportunities to work through it in a sim clinic, it's not particularly helpful." (P5). "Learning system by system was challenging...I'd see a patient and feel like I hadn't learned that yet. I knew a list of conditions, but not what steps to take or what tests to order." (P11)

Diagnostic test interpretation was another curricular gap. While many felt comfortable selecting investigations based on differential diagnoses, they were less confident interpreting results and integrating findings into clinical decision-making. "It's far easier for me to decide what diagnostics to order than to interpret the results...we don't spend much time talking about what those results actually mean." (P19). "We know which tests to order...but then what do we do afterwards? I don't feel like we've really learned that process yet." (P1)

Several participants questioned the allocation of curricular time, particularly curricular components less directly relevant to DR development. “The heavy focus on the master’s courses early in the program didn’t contribute effectively to NP preparation...it felt like a poor use of time...we came in wanting more hands-on, clinical learning, but instead it felt like we were just checking boxes.” (P13)

Certain teaching and assessment strategies were perceived as poorly aligned with DR development. Clinical logs, tracking the number and type of patients seen each clinical day, were viewed by some as burdensome with limited educational value. Overly structured case studies limited opportunities to work through diagnostic uncertainty. “We work through case studies, but they feel too structured...they point you too easily in one direction, especially when you know the weekly content...there’s not enough uncertainty.” (P22)

Limited exposure to simulation constrained DR learning. “Aside from a couple of OSCEs, we didn’t have much simulation or SP exposure in our program...many assessments were done on our classmates, which I didn’t find particularly useful.” (P22)

Some clinical placement settings were perceived as offering fewer opportunities for DR development. “My long-term care placement wasn’t helpful...people come with a diagnosis already...I didn’t get the experience of investigating a condition thoroughly... it was more about management.” (P3)

Finally, participants described how the intensity of the program and competing demands limited their ability to engage deeply with DR. “It felt like information coming through a fire hose...sometimes you miss things or aren’t ready to hear them yet.” (P14). Overall, participants highlighted curricular gaps and structural constraints that limited opportunities for DR development.

Theme 2: Clinical Preceptor Scaffolding in DR Development

Subtheme A: Preceptor Teaching Practices That Support DR Development.

Participants described preceptors not only as supervisors but also as key facilitators of DR development. With preceptor support, participants were able to apply, refine, and strengthen DR in real-time clinical contexts.

Participants valued preceptors who supported increasing autonomy while remaining available, providing space for independent patient assessment and DR before discussion. “I found it most helpful when preceptors let me independently assess the patient...then present my differential diagnoses and management plan and receive feedback afterwards.” (P2)

Preceptors supported DR by prompting participants to expand and justify their thinking through targeted questioning. “Pushing me to think broader by asking, ‘What else could it be? What lab work do you want and why?’ So really emphasizing the ‘why’.” (P4)

“One preceptor had me write out my differentials and defend each using the patient’s history, physical exam, and labs, which helped me develop a more systematic approach...they often ask ‘what do you think is going on and why,’ before offering their perspective.” (P10)

Feedback was essential for refining DR, particularly when it was timely, specific, and psychologically safe. “My preceptor gave immediate, supportive feedback without putting me down and was open about not knowing everything, often saying, ‘let’s figure it out together.’” (P12)

Participants also valued preceptors who normalized uncertainty and modeled their DR processes. “One of my preceptors is very open to what she doesn’t know...it made me feel comfortable knowing that even years into practice, you may not have the perfect answer, but you keep working through it.” (P3)

“In the ER, my preceptor reviews the chart at handover as though he has not heard the diagnosis, then goes through the symptoms, labs, and assessment to form his own differentials. He says the highest chance of error is at handover. I found this approach very helpful.” (P9)

Some preceptors intentionally taught structured approaches to DR, helping students organize their thinking. “My preceptor encouraged me to generate a list of differentials before the encounter... and then adjust it using pertinent positive and negative history and physical exam findings. I found this helpful.” (P14)

Finally, participants emphasized that greater patient exposure supported DR development through repeated clinical application. “My preceptor encouraged me to see as many patients as possible to broaden my exposure...I found this approach quite helpful, especially when there was time for discussion and debrief.” (P15)

Subtheme B: Variability and Constraints in Clinical Learning for DR. While participants described positive preceptor experiences, they also identified constraints in how DR was taught in clinical settings. These included limited opportunities to actively engage in DR and teaching approaches that constrained its development.

Some participants described overly directive approaches that limited engagement in DR. “When they just say ‘this is the diagnosis and this is what we do’, I’d call that spoon feeding... working through it myself is far more effective than just being given the answer.” (P13)

The timing and context of feedback also influenced DR. “They were quizzing me in the room with the patient...I felt on the spot...I didn’t know the answers...it felt less helpful than being questioned in a safer space after presenting the case.” (P11)

In some instances, preceptors’ DR processes remained implicit, making it difficult for participants to follow the diagnostic logic. “One preceptor would ask very specific

questions...but it was hard to understand what they were getting at...sometimes the questions felt irrelevant to me without understanding their DR process.” (P24)

One participant described situations where experienced preceptors bypass DR steps due to familiarity with patients. “Sometimes their experience and knowledge of the patients is so good that it cuts that process short... they're like, ‘it's just this, and let's move on’...but we have to go through those steps.” (P3)

Some teaching approaches were perceived as hierarchical and less supportive of collaborative reasoning. “When I'm told, ‘go look at the guidelines and come back’, it feels condescending... Instead of a top-down approach, the conversational approach works better.” (P7)

Overall, participants’ DR development was shaped not only by preceptors’ clinical expertise, but also by how effectively they engaged learners in the reasoning process.

Theme 3: Peer Learning as Space for Collaborative and Low-Stakes DR

Peer interactions were described as an important component of DR development, functioning as a space where learners collaboratively constructed knowledge and refined DR. Through peer engagement, participants expanded their DR perspectives, co-created learning resources, and practiced DR in low-pressure environments.

Participants emphasized that learning from peers’ clinical experiences exposed them to a broader range of presentations than they would encounter individually, prompting reflection on their own diagnostic approaches. “Chatting with other students is an opportunity to hear about clinical presentations I haven’t seen...It makes me ask, would I have picked up on that? Would I have ordered those tests? What would I do differently?” (P5)

In some cases, clinical experiences shared by peers were particularly memorable and directly influenced future DR.

“A classmate shared a case of recurrent ‘sinusitis’ that turned out to be cocaine use, causing septal damage, something that hadn’t even crossed my mind. It really stuck with me...now, when I see repeated sinus symptoms, I ask about substance use.” (P3)

“A classmate shared a case of severe Bell’s palsy that mimicked a stroke. Working through how they ruled out serious causes, like checking if the patient could wrinkle their forehead, helped me understand how to approach and differentiate similar presentations.” (P12)

Exposure to peers with different clinical backgrounds also broadened participants’ diagnostic perspectives. “Hearing colleagues from different backgrounds...what they came up with for differentials and assessment...was helpful because they offered different perspectives.” (P4)

Peer learning also created a low-pressure, psychologically safe space where participants could actively practice and refine their reasoning without the evaluative pressures of formal assessment. “Peer interactions can really help with practicing DR...you can bounce ideas off each other in a low-pressure environment.” (P2). “Our class has a WhatsApp group chat where people talk every day...It was recognized as a safe place to ask ‘dumb’ questions...that helps you work through your DR process.” (P11)

Beyond discussion, participants described co-constructing knowledge with peers through the creation and sharing of learning resources. “We had shared notes and created documents together, like illness scripts and pathognomonic lists...people contributed and built on each other’s work. It’s different when you’re handed resources versus creating them yourself...we learned so much through that process.” (P20)

Finally, teaching peers was described as a particularly powerful mechanism for consolidating learning, as it required participants to articulate and verify their reasoning. “Teaching a peer my differential and pertinent positives and negatives made me ensure I had the correct information, which helped solidify my learning and learn from how others approach cases.” (P1)

Despite these benefits, peer learning was not always comfortable. Participants initially experienced anxiety and self-comparison when peers approached cases differently, although over time, this discomfort often contributed to growth in DR.

“Initially, I didn’t like peer interaction. It felt like conflict when people disagreed on the approach, and that was anxiety-provoking as a student. But over time, hearing others’ approaches made me think about how I would go about it... ‘I never thought about that’.” (P3)

Overall, peer learning supported DR development by exposing participants to diverse clinical experiences, providing low-stakes opportunities for practice, and facilitating collaborative knowledge sharing. Although initially uncomfortable, peer interactions ultimately expanded and refined participants’ DR.

Theme 4: Recommendations for Strengthening DR Development

Subtheme A: Program-Level Recommendations for Strengthening DR

Development. Participants offered recommendations on how NP programs could better support DR development, with particular emphasis on applied and experiential learning approaches.

Participants also recommended expanding opportunities for deliberate, repeated practice of DR, particularly through case-based and interactive formats. “We could take turns being patients and get into small groups and run cases day in and day out...that’s the level of intensity needed to really start understanding how it all works.” (P23)

Participants consistently emphasized the need for increased clinical exposure to support DR development. While clinical practicum was frequently described as one of the most valuable components of DR learning, many perceived the current clinical hours as insufficient. “Clinical practicum is one of the only things that’s helpful...they need to vastly expand the clinical hours, at least double.” (P19). “The 78 hours that we need to get from each placement...it’s almost not enough...it’s just not enough to gain confidence.” (P22)

Participants also proposed structural changes to extend clinical learning beyond the current program model, including the addition of a transition-to-practice or residency-like component. “I think having a year of residency would be really helpful...maybe a longer practicum component after, where you can actually consolidate everything.” (P18)

Participants also recognized the practical constraints of program length, financial burden, and feasibility. Rather than focusing solely on extending program duration, some suggested redistributing existing curricular time to prioritize clinical learning and applied practice. “If there was an opportunity within the two years to reduce some of the course load and add more NP practicum hours, that would be more appealing.” (P8)

Participants emphasized that curricular reform alone was insufficient without supportive clinical learning environments, particularly access to engaged preceptors who fostered psychologically safe DR learning. “It’s so important to have good preceptors...quality over quantity, especially early on...they should be selected for the benefit of students, not convenience.” (P10)

Participants also linked these challenges to how the curriculum is structured and sequenced within the program. A key concern was the mismatch between theoretical instruction and clinical exposure, where students were expected to apply knowledge in practicum before it

had been formally taught. “One of my very first practicum days, a patient presented with headaches, but we hadn’t gone through that yet in theory...in a perfect world, there would be at least an adult primary care course before practicum.” (P5)

Participants emphasized the need to introduce DR earlier in the program, noting that delayed exposure limited opportunities for practice and consolidation. “We didn’t really start DR until very late in the program...this is something that requires exposure and practice, so starting earlier would help.” (P23)

One participant also highlighted the importance of organizing curriculum content in ways that better reflect real-world DR. “Instead of teaching by diagnosis, it would be helpful to go by symptom or complaint...like right lower quadrant pain, and then work through what it could be.” (P9)

Overall, participants’ recommendations suggest that strengthening DR development requires coordinated curricular, clinical, and instructional changes rather than isolated modifications within a single area.

Subtheme B: Learner Recommendations for Navigating DR Development.

Participants emphasized that developing DR requires sustained, active, and intentional practice across multiple contexts. “You think through it, then do it, then go back and study it again...then do it again...that loop of practice is what really helps it stick.” (P23)

Participants advised future NP students to actively leverage clinical experiences as opportunities for deliberate practice, rather than passively participating in patient care. “Come into clinic early...look through the day and say, ‘I don’t think I know what this is, let me look it up’...if you do that every day, it really builds you up.” (P11)

Participants highlighted the importance of taking an active, self-directed approach to learning DR, recognizing that formal instruction alone is insufficient. They also recommended using diverse resources, including videos and podcasts, to complement traditional course materials. “If I had to go back, I would definitely use more YouTube videos...you can only read so much...knowing what your learning style is early is helpful.” (P8)

Participants emphasized the importance of collaborative learning structures to build and engage with peer networks as a strategy to support DR development. “Get yourself a strong study group...we split up readings, created shared documents, and learned together...that was one of the best things I ever did.” (P3)

Beyond practice strategies, participants highlighted the importance of mindset in navigating DR development. They advised future NP students to embrace vulnerability, uncertainty, and knowledge gaps. “It was hard and very humbling to go from a nursing manager to NP student...this is a journey, you’re not going to know everything, and being patient and kind to yourself is key.” (P7)

Participants also encouraged future students to be open about gaps in knowledge, ask questions, and learn from mistakes. “Be humble, be curious, ask questions, check your ego at the door. You’re going to make mistakes, and that’s okay, embrace them because you will learn more from those mistakes than the successes.” (P15)

Overall, participants advised future NP students to approach DR development as an active and intentional process, using deliberate practice, peer collaboration, self-directed learning, and openness to uncertainty.

Discussion

This study explored NP students' perspectives on the educational experiences that supported or constrained the development of DR. Findings suggest that DR development is shaped by curriculum design, simulation and case-based learning, clinical practicum, preceptor support, and peer learning. Across these contexts, participants consistently valued learning experiences that made DR visible, interactive, and clinically relevant.

Consistent with recent literature, participants emphasized that DR development required more than implicit learning through clinical exposure and preceptor role modeling alone (Smith et al., 2025). Instead, they valued structured and active learning approaches, including case discussions, simulation, guided questioning, and repeated opportunities to apply and articulate their reasoning. These findings align with growing calls for more intentional DR instruction within NP education (Burt et al., 2025; Smith et al., 2025).

Simulation-based learning was viewed as particularly valuable because it provided opportunities to practice DR in psychologically safer environments before engaging with real patients. Participants highlighted the importance of repetition, application, and feedback in building confidence and fluency, consistent with previous research (Bavis & Burt, 2026; Beebe et al., 2024; Hogg et al., 2025).

Diagnostic test interpretation was identified as a gap in participants' training. While many participants felt relatively comfortable selecting tests, they were less confident in interpreting findings and integrating results into clinical decision-making. This finding aligns with literature emphasizing that diagnostic interpretation requires an in-depth understanding of the disease processes, test purpose, clinical significance, and diagnostic test characteristics

(Smith et al., 2025). This suggests that diagnostic test interpretation warrants more explicit curricular attention within NP education.

Clinical practicum emerged as a critical context for consolidating DR. Participants particularly valued preceptors who promoted autonomy, challenged their thinking, normalized uncertainty, and provided timely feedback. These findings reinforce the importance of DR teaching within clinical education and suggest that preceptor development initiatives may strengthen consistency in DR teaching approaches (Kopelson et al., 2024).

Peer learning also contributed to DR development by exposing students to diverse perspectives and providing low-stakes opportunities to discuss and refine DR. These findings highlight the value of collaborative discussion and shared clinical experiences in strengthening DR.

Finally, participants highlighted tensions related to curriculum structure, limited NP clinical exposure, and the competing demands of balancing employment with NP education. While some participants advocated for increased clinical practicum hours to enhance DR, they also recognized the financial and logistical challenges associated with extending NP education, particularly within unpaid clinical training models.

Implications for NP Education and Clinical Teaching

These findings have implications for NP education and clinical teaching. DR should be taught longitudinally across classroom, simulation, and clinical settings rather than developing through clinical exposure alone. NP programs may benefit from strengthening educational approaches to diagnostic test interpretation and clinical decision-making after investigations are ordered. Simulation-based learning should continue to be integrated throughout curricula, using progressive formative and summative learning experiences.

Clinical placement design also warrants careful consideration. While exposure to diverse clinical settings broadens DR experience, fragmented placements with limited hours may reduce continuity and opportunities for DR development. Programs may benefit from balancing breadth of exposure with sufficient duration in individual placements to support deeper learning. Regulatory bodies and policymakers should consider whether current clinical hours requirements adequately support entry-level DR competencies.

Preceptor support and development are also essential. Clinical expertise alone does not necessarily translate into effective DR teaching. Providing preceptors with teaching frameworks and professional development opportunities may strengthen consistency in teaching and modelling DR. Encouraging NP educators and preceptors to articulate their DR processes may help students observe and refine their own DR skills.

Finally, NP programs should prepare students to navigate clinical uncertainty, identify knowledge gaps, and engage in self-directed learning, recognizing that not every clinical presentation will align with classroom theory. These capabilities are essential for managing the complexity of entry-level NP practice.

Strengths and Limitations of the Work

This study offers insight into how NP students experience the educational conditions that shape DR development. The use of interpretive description supported the generation of practice-oriented findings relevant to NP education and clinical teaching. Several limitations should be acknowledged. The findings in this study do not include the perspectives of faculty members or preceptors whose views may differ from those of the participants. Educational structures, curricular models, and clinical teaching approaches vary across NP programs, which may affect the transferability of these findings. Additionally, participants who chose to take part in this

study may have been more engaged in discussing their educational experiences, which may have influenced the perspectives represented.

Recommendations for Further Research

Future research should examine how different educational models and clinical placement structures influence DR development, including the optimal integration of classroom, simulation, and clinical learning. Longitudinal research is also needed to understand how DR develops across educational, clinical, and sociocultural contexts. Research exploring preceptor perspectives on teaching DR may also provide important insight into opportunities and challenges within clinical education.

Conclusion

DR development in NP education emerges through the dynamic interplay of curriculum, clinical teaching, and peer learning. It is socially and contextually shaped through interactions with instructors, preceptors, peers, and clinical experiences. NP students valued educational approaches that made DR explicit, interactive, and clinically relevant, while identifying gaps in diagnostic test interpretation, preceptor teaching, and opportunities for applied practice. Strengthening DR education requires longitudinal integration of theoretical, simulated, and clinical learning. Such efforts may better prepare NP students to navigate the complexity, uncertainty, and diagnostic demands of clinical practice.

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Table 8.1

Manuscript Three Themes, Subthemes, and Representative Codes

Themes and Subthemes	Representative Codes
Theme 1: Curriculum as Both Scaffold and Constraint in DR Development Subtheme A: Curricular Elements Supporting DR Development	<ul style="list-style-type: none"> ● Simulation-based learning ● Deliberate practice ● Case-based collaborative learning ● Clinical practicum as the space for integration and development of DR ● Structuring DR through curricular scaffolding ● Class lectures providing foundational knowledge
Subtheme B: Curricular Gaps and Misalignments in DR Development	<ul style="list-style-type: none"> ● Misalignment between theory and practice ● Diagnostic test interpretation gaps ● Ineffective teaching and assessment approaches ● Competing curricular demands and cognitive overload ● Gaps in instructional and program support
Theme 2: Clinical Preceptor Scaffolding in DR Development Subtheme A: Preceptor Teaching Practices That Support DR Development	<ul style="list-style-type: none"> ● Prompting DR through questioning ● Autonomy in DR with support ● Feedback and refinement of DR ● Supportive learning environment ● Role modelling DR ● Structuring DR through explicit teaching
Subtheme B: Variability and Constraints in Clinical Learning for DR	<ul style="list-style-type: none"> ● Inconsistent preceptor approaches to DR teaching ● Spoon feeding ● Insufficient challenge/discussion ● Lack of reasoning transparency ● Preceptor shortcutting DR process ● Hierarchical/top-down teaching approaches

Theme 3: Peer Learning as a Space for Collaborative and Low-Stakes DR

- Expanding DR through exposure to others' experiences
 - Low-stakes practice and refinement of DR
 - Co-constructing knowledge and shared resources
 - Peer learning as both supportive and intimidating
 - Bouncing ideas off each other
 - Peer teaching reinforces learning
-

Theme 4: Recommendations for Strengthening DR Development
 Subtheme A: Program-Level Recommendations for Strengthening DR Development

- Increasing clinical exposure and practice opportunities
 - Optimizing curricular sequencing to support DR
 - Strengthening applied DR teaching and skill development
 - Optimizing learning environment and instructional support
 - NP courses should better support practice needs
 - Earlier introduction of DR in NP education
-

Subtheme B: Learner Recommendations for Navigating DR Development

- Embracing uncertainty and vulnerability
 - Active and deliberate practice of DR
 - Self-directed and adaptive learning
 - Leveraging peer learning supports
 - Developing structured approaches
 - Practice and repetition
-

Chapter 9 Integrated Discussion and Implications

The purpose of this doctoral research was to gain a comprehensive understanding of how nurse practitioner (NP) students develop diagnostic reasoning (DR) during their educational program in Canada. To address this overarching research question, the dissertation was presented as three interconnected manuscripts, each examining a distinct yet complementary dimension of DR development. Collectively, the findings suggest that DR development is an iterative and multifaceted process influenced by NP students' prior experiences as registered nurses (RN), evolving cognitive processes, and educational environments rather than emerging through NP program clinical practicums alone.

Synthesis of Findings Across the Three Manuscripts

These three manuscripts build on one another. The first manuscript explored NP students' experiences of developing DR during the transition from RN to NP, highlighting DR as a process of professional identity transformation. It demonstrated that prior RN experience served as a double-edged influence, providing a valuable experiential foundation while also introducing constraints that required learners to recalibrate their diagnostic thinking. The second manuscript examined the metacognitive processes underlying DR development, demonstrating how students progressively regulated and calibrated their thinking by balancing intuitive and analytical reasoning, recognizing cognitive biases, and engaging in reflective practice. The third manuscript explored the educational experiences shaping DR development, identifying how curriculum design, simulation, clinical practicum, preceptor support, and peer learning collectively facilitated or constrained students' development of DR.

This chapter integrates findings across the three manuscripts to provide a cohesive interpretation of how DR develops throughout NP education. Rather than revisiting each

manuscript individually, the discussion synthesizes the overarching patterns that emerged across the research and considers their contribution to the existing literature and the Metacognitive Diagnostic Reasoning (MDR) model (Beebe et al., 2024) presented in Chapter 4. The integrated findings are then synthesized into a conceptual model that illustrates the process of DR development in NP education. The implications of these integrated findings for NP education, clinical practice, and future research are subsequently discussed.

Integrated Findings and Discussion

DR Development Represents a Multidimensional Transformation

DR development emerged as considerably more than the acquisition of diagnostic knowledge or technical skills. Instead, participants experienced a progressive transformation in how they thought, assumed professional responsibility, engaged with patients, and approached clinical uncertainty. Becoming an NP required a fundamental expansion of clinical reasoning developed through prior RN practice to encompass generating and refining differential diagnoses, assuming diagnostic accountability, and functioning as the most responsible provider. Alongside this transformation, participants developed refined diagnostic fluency, greater tolerance of uncertainty, and more sophisticated approaches to integrating cognitive, relational, and professional aspects of diagnosis. Collectively, these findings suggest that DR development is best understood as a multidimensional transformation in becoming a diagnostician rather than simply learning to diagnose. This transformation also reflects the broader process of professional identity formation, as NP students progressively internalize the diagnostic responsibilities, clinical authority, and accountability associated with the NP role (Owens, 2021; Godfrey & Young, 2020).

DR Develops Through Iterative Metacognitive Calibration Rather Than Accumulated Clinical Experience Alone

The findings demonstrate that NP program clinical practicums alone were insufficient to produce competent DR. Rather, participants actively transformed their experiences through ongoing metacognitive regulation, including balancing intuitive and analytical reasoning, recognizing cognitive biases, reflecting on clinical encounters, revisiting diagnostic decisions, and deliberately recalibrating their thinking. Development occurred through repeated cycles of clinical experience, reflection, feedback, and refinement that gradually strengthened diagnostic fluency, confidence, and tolerance of uncertainty. These findings extend the MDR model (Beebe et al., 2024) by illustrating how metacognitive regulation develops progressively throughout NP education and functions as the mechanism through which experience is converted into diagnostic expertise.

DR Development is Shaped by Learners' Prior Experiences and Evolving Clinical Contexts

Rather than entering NP education as blank slates, participants brought diverse RN backgrounds that both facilitated and constrained their DR development. Prior clinical experiences supported pattern recognition and recognition of red flags, while simultaneously introducing potential limitations related to specialization, habituated thinking, diagnostic momentum, and cognitive bias. As learners progressed through NP education, their prior experiences interacted with increasingly complex clinical contexts, uncertainty, cognitive load, and evolving professional responsibilities. These findings suggest that DR development reflects a dynamic interaction between participants' previous experiences and the new cognitive and contextual demands encountered throughout NP education.

Intentional Educational Scaffolding is Essential for Developing DR

Participants consistently described DR development as requiring intentional educational support rather than emerging naturally through clinical exposure. Curriculum design, simulation, case-based learning, clinical practicum, preceptor questioning, feedback, peer learning, reflection, and graduated autonomy each contributed unique but complementary opportunities to develop DR. Learning was strengthened when reasoning processes were made explicit, and learners were challenged to articulate and justify their thinking in a psychologically safe environment. These findings suggest that effective DR depends on longitudinal educational scaffolding that deliberately integrates classroom, simulation, and clinical learning throughout NP education. Furthermore, many participants recommended significantly increasing NP program clinical practicum hours to better prepare them to meet the entry-level DR competencies. At the same time, participants recognized that expanding clinical practicum opportunities should be accompanied by efforts to address the financial and logistical challenges associated with unpaid clinical training. Future curriculum decisions should consider the quality, case mix, supervision, feedback, deliberate-practice opportunities, feasibility, and financial equity of clinical placements in addition to total hours.

Relationship of the Findings to the MDR Model

The integrated findings both support and extend the MDR model (Beebe et al., 2024). Consistent with the MDR model, participants experienced DR as an active metacognitive process involving ongoing monitoring and regulation of thinking through the integration of intuitive and analytical reasoning. These findings also refine the model by demonstrating that these metacognitive processes develop progressively through repeated cycles of clinical experience, feedback, reflection, and experiences of diagnostic uncertainty. Finally, this study extends the MDR model by identifying additional contextual influences on DR development, including

professional identity transformation, diagnostic accountability, prior RN experience, educational scaffolding, psychologically safe learning environments, and supportive relationships with preceptors and peers.

A Conceptual Model of DR Development in NP Education

The integrated findings suggest that DR development in NP education is an iterative, multidimensional process shaped by the interaction of prior RN experience, educational experiences, metacognitive regulation, and professional identity transformation. Building on these findings, an integrated conceptual model is proposed to illustrate how NP students progressively develop DR throughout their educational program (Figure 9.1).

Consistent with the Experiential Learning Theory (Kolb, 2015), the integrated model conceptualizes DR development as an iterative process in which experience, reflection, and application contribute to ongoing learning and refinement of reasoning. Through repeated cycles of five components, including knowledge acquisition, DR application, reflection, metacognitive calibration, and knowledge integration, NP students progressively refine their reasoning and readiness for independent NP diagnostic practice. These components are represented as a cycle rather than a linear sequence because students may move between them repeatedly as they encounter new clinical situations and progressively more complex diagnostic problems. The paragraph below will elaborate on each of these five components.

First, diagnostic knowledge development provided the foundation for building and refining the illness scripts. Students then apply this knowledge through DR in real or simulated clinical situations, followed by feedback and reflection on their reasoning processes, decisions, and outcomes. Metacognitive calibration involves recognizing potential cognitive biases and emotional influences. Students learn to regulate their thinking by recognizing when to trust their

intuition, when to question it, and when to switch from intuition to analytical reasoning. Lastly, through knowledge integration, students incorporate what they have learned from these experiences into their existing knowledge and reasoning processes. In this way, each cycle contributes to the ongoing refinement of DR, rather than representing a discrete stage that is completed before moving to the next.

This process is supported by classroom learning, simulation, clinical practicum, and self-directed learning, in collaboration with faculty/instructors, clinical preceptors, peers, and patients. The educational environment surrounds the iterative cycle in the model to illustrate that DR does not develop in isolation or solely through clinical exposure. Classroom and self-directed learning contribute to diagnostic knowledge development, while simulation and clinical practicum provide opportunities to apply and refine reasoning. Across these environments, faculty, instructors, and clinical preceptors can facilitate development through questioning, feedback, role modelling, and progressively increasing autonomy. Peers provide additional opportunities to articulate and compare reasoning approaches, while interactions with patients provide authentic clinical contexts in which students learn to gather and interpret information, manage uncertainty, and take increasing responsibility for diagnostic decisions. These educational experiences can therefore shape both the opportunities available for deliberate practice and the quality of reflection and feedback that follows those experiences.

Throughout this journey, NP students simultaneously undergo professional identity transformation while building on prior RN experience, which functions as a foundation and constraint for DR development. Prior RN experience is positioned beneath the educational environment because it represents the foundation that students bring into NP education. Existing clinical knowledge, pattern recognition, illness scripts, and relational expertise can facilitate DR

development and provide the base upon which new diagnostic knowledge is built. At the same time, prior experience may introduce established habits of thinking, cognitive biases, or diagnostic momentum that require recognition and recalibration as students assume the diagnostic responsibilities. The influence of prior RN experience is therefore dynamic rather than uniformly beneficial or limiting. Its contribution to DR development depends partly on how previous knowledge and ways of thinking are integrated, questioned, and refined through new educational and clinical experiences.

Professional identity transformation is represented as a parallel process that occurs alongside DR development. As students progress from experienced RNs to NP students, novice diagnosticians, and ultimately independent NPs, they are not simply acquiring additional knowledge and skills. They are also learning to assume greater diagnostic responsibility and accountability. Developing DR is therefore intertwined with becoming a diagnostician: students progressively shift from contributing nursing assessments within established care structures toward independently generating and evaluating differential diagnoses, making diagnostic decisions, and accepting responsibility for those decisions. The reciprocal relationship depicted between professional identity and the educational environment reflects how increasing diagnostic responsibility can shape students' engagement with learning experiences. Those experiences simultaneously contribute to their developing identity and confidence as diagnosticians.

The model ultimately conceptualizes readiness for independent NP diagnostic practice as a multidimensional outcome of this developmental process. Readiness involves the following: 1) diagnostic accountability, or accepting responsibility for diagnostic decisions as the most responsible provider. 2) adaptive DR, reflected in flexible and context-sensitive reasoning in complex situations. 3) diagnostic fluency, characterized by increasingly efficient, accurate, and

well-calibrated reasoning. 4) confident and appropriate management of clinical uncertainty, including the ability to navigate uncertainty while making safe clinical decisions. These outcomes should not be interpreted as a fixed end point at which DR development is complete. Rather, they represent increasing readiness for independent NP practice, with DR continuing to develop through experience, reflection, feedback, and ongoing learning after graduation.

In summary, this proposed conceptual model (Figure 9.1) illustrates DR development in NP education as the transformation of prior RN experience through repeated opportunities to acquire and apply diagnostic knowledge, reflect on performance, receive feedback, calibrate thinking, and integrate learning within educational and clinical environments. The model therefore moves beyond viewing DR development as the accumulation of knowledge or clinical hours, and instead emphasizes the interaction among experience, metacognitive regulation, educational support, and professional identity as NP students progress toward independent diagnostic practice.

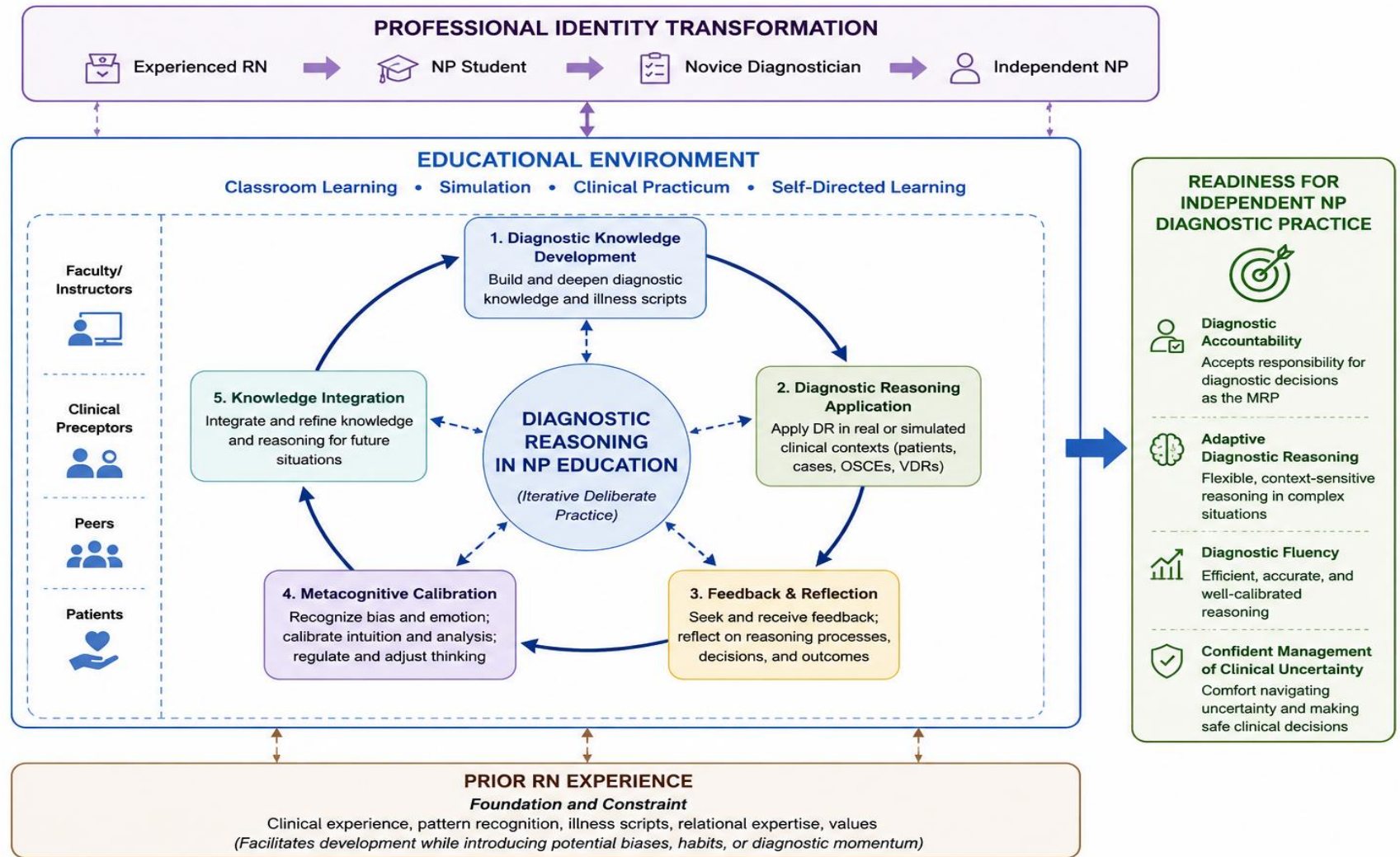


Figure 9.1 A Conceptual Model of Diagnostic Reasoning Development in NP Education

Note: Conceptual model content was developed by the author. Figure Credit: A. Pirani

Implications for NP Education

Curriculum Design

DR should be taught as a longitudinal thread woven throughout NP education rather than as an isolated topic or a competency expected to emerge naturally through clinical exposure. DR instruction should begin early in the curriculum and progressively increase in complexity, allowing learners to repeatedly integrate foundational knowledge with clinical application. Educational approaches that explicitly teach hypothesis generation, differential diagnosis, diagnostic test interpretation, cognitive bias, and management of clinical uncertainty may better prepare students for the diagnostic responsibilities of independent entry-level NP practice.

Recognizing NP students' Diverse RN Backgrounds

NP students enter NP programs with diverse RN experiences that shape how they approach DR. Rather than assuming prior RN experience uniformly facilitates learning, educators should recognize that different clinical backgrounds provide unique strengths while also introducing potential constraints, such as specialized illness scripts, habituated reasoning patterns, or uneven exposure to clinical presentations. Tailoring educational support to learners' prior experiences may facilitate the expansion of clinical reasoning developed through RN practice to encompass the DR responsibilities of the NP role.

Supporting Metacognitive Development

Metacognitive regulation emerged as a central mechanism underlying DR development. NP programs should therefore create regular opportunities for students to reflect on diagnostic decisions, recognize cognitive biases, calibrate intuitive and analytical reasoning, and learn from diagnostic uncertainty. Structured reflection, guided debriefing, clinical case reviews, and

feedback conversations may strengthen students' ability to monitor and refine their diagnostic thinking.

Classroom Teaching, Simulation, and Faculty Development

Participants consistently valued educational experiences that made DR visible, interactive, and clinically relevant. Case-based learning, simulation, virtual DR (VDR) activities, and structured classroom discussions provide opportunities for learners to articulate, justify, and refine their reasoning in psychologically safe environments before applying these skills in clinical practice. Simulation should extend beyond textbook presentations to include ambiguous clinical scenarios, multiple competing diagnoses, diagnostic errors, and uncertainty, followed by structured debriefing that promotes reflection and metacognitive calibration.

To effectively support these educational approaches, faculty development is equally important. Clinical expertise alone does not necessarily translate into effective DR teaching. Faculty members, instructors, and simulation facilitators involved in NP education may benefit from professional development opportunities that equip them to make DR explicit, model diagnostic thinking, facilitate reflective discussions, provide meaningful feedback, and create psychologically safe learning environments that foster DR development. Similar considerations apply to clinical preceptors, whose role in supporting DR development is discussed in the following section.

Clinical Practicum and Preceptor Development

Clinical practicums remain the cornerstone of DR development. Increasing NP program clinical hours may better prepare graduates to meet the entry-level DR competencies. However, clinical exposure alone is insufficient. The quality of clinical teaching, feedback, and learner engagement is equally important. Preceptors should be supported to model DR using think-aloud

strategies, encourage learners to justify their differential diagnoses, and provide graduated autonomy with timely feedback. Professional development initiatives that strengthen preceptors' understanding of how to teach DR may further enhance the consistency and quality of clinical learning experiences.

Assessment and Evaluation of DR

The findings suggest that merely assessing factual knowledge may not adequately capture the complexity of DR. Assessment strategies should increasingly evaluate NP students' DR processes in addition to diagnostic accuracy, with emphasis on how learners arrive at a diagnosis and justify excluding alternative diagnoses. Approaches such as think-aloud exercises, oral case presentations, direct clinical observation, and structured OSCEs that require students to explain and justify their diagnostic decisions may provide a more comprehensive evaluation of DR development. For instance, if a woman of childbearing age presents with right lower quadrant abdominal pain and an NP student's working diagnosis was appendicitis, the assessor or preceptor could further explore the student's DR by asking them to identify the pertinent positive and negative findings supporting appendicitis over alternative diagnoses such as ectopic pregnancy, ovarian torsion, or renal colic. Assignments that require students to reflect on, justify, and critique their own diagnostic decisions may also provide valuable opportunities to assess their DR development.

Implications for NP Clinical Practice

From a clinical perspective, improving DR during NP education is essential for reducing diagnostic errors and enhancing patient outcomes. Therefore, the implications of this research extend beyond education. Although this study focused on NP students, the findings have broader implications for clinical practice, particularly during the transition to independent NP practice.

DR is an evolving process requiring repeated clinical application, reflection, metacognitive calibration, and increasing comfort with diagnostic uncertainty. DR development continues beyond graduation as novice NPs assume greater diagnostic responsibilities and encounter increasingly complex clinical situations (Barnes, 2015). Structured orientation, mentorship, and transition-to-practice initiatives, including NP residency programs, may provide valuable opportunities to further strengthen DR (Barnes, 2015). Maintaining reflective practice, seeking feedback, recognizing cognitive biases, and engaging in ongoing professional development throughout NP practice may further support diagnostic accuracy and patient safety.

Implications for Future Research

This doctoral research provides a foundation for future studies examining the development of DR in NP education. Longitudinal research following learners from NP education into independent clinical practice would enhance understanding of how DR continues to evolve beyond graduation and identify factors that support the transition to independent practice. Future research should also evaluate the effectiveness of educational interventions designed to strengthen DR, including explicit metacognitive instruction, simulation-based learning, preceptor development, curriculum innovations, and educational strategies that help NP students effectively build on and leverage their prior RN experiences to develop DR. The conceptual model proposed in this dissertation provides a preliminary framework that warrants further empirical testing across diverse educational contexts and NP programs. Finally, incorporating the perspectives of NP educators, clinical preceptors, and practicing NPs would provide a more comprehensive understanding of how educational, clinical, and organizational factors collectively influence DR development.

Strengths and Limitations

This doctoral research has several important strengths. It provides one of the first comprehensive qualitative examinations of how NP students develop DR throughout their educational program from the learners' perspectives. By interviewing 24 NP students from two Canadian universities, this study generated rich data on the cognitive, educational, and professional processes underlying DR development. The study findings have direct implications for NP education, curriculum design, clinical teaching, and faculty and preceptor development. Furthermore, this dissertation makes several original contributions to the literature. These include conceptualizing prior RN experience as a double-edged influence on DR development, highlighting the relational nature of DR, demonstrating the central role of metacognitive regulation in transforming clinical experience into DR learning, and proposing an integrated conceptual model that synthesizes the dynamic relationships among prior RN experience, educational scaffolding, professional identity transformation, and DR development. Finally, the three interconnected manuscripts move beyond describing isolated aspects of DR development to provide an integrated explanation of the process through which DR develops throughout NP education.

Several limitations should be considered when interpreting the findings. Participants were recruited from two Canadian universities. As such, the findings may not be transferable to NP programs with different admission requirements, curricula, or educational models. Participation was voluntary and may have resulted in self-selection bias, with students who were particularly interested in DR being more likely to participate. Additionally, participants were interviewed during the final semester of their NP education. Their accounts therefore represent retrospective reflections on DR development and may differ from learners' experiences earlier in the program.

The study relied on retrospective self-report and did not assess diagnostic performance, preceptor evaluations, or patient outcomes; therefore, perceived development cannot be interpreted as diagnostic competence or accuracy. Recruitment through educational programs and the researcher's NP educator role may also have influenced responses and interpretation.

Conclusion

This doctoral research sought to gain a comprehensive understanding of how NP students develop DR throughout their educational program in Canada. Overall, this doctoral research demonstrates that DR development is not an inevitable consequence of accumulating clinical experience. Rather, it is a dynamic, iterative, socially situated, and metacognitively regulated process through which NP students progressively build on and recalibrate their prior RN experiences within intentionally designed educational environments. As NP students engage in repeated cycles of knowledge acquisition, clinical application, reflection, feedback, and metacognitive calibration, they progressively develop the knowledge, skills, and professional identity required to assume diagnostic accountability and prepare for independent NP practice.

This dissertation contributes to the growing body of knowledge on DR in NP education by advancing a learner-centered understanding of how DR develops. Ultimately, strengthening DR education has the potential to better prepare future NPs to navigate diagnostic complexity with confidence. By making DR development more explicit, intentional, and evidence-informed, NP education can better equip graduates to provide safe, high-quality, and patient-centered care. It contributes to nursing knowledge by integrating three previously separated dimensions of NP diagnostic reasoning development: the influence of prior RN experience, the metacognitive regulation of reasoning under uncertainty, and the educational and relational conditions that learners perceived as supporting or constraining development. The preliminary conceptual model

positions diagnostic accountability and professional identity transformation alongside cognitive and metacognitive processes, offering a framework for future curriculum development and empirical testing.

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Appendix A: Recruitment Flyer

Calling Nurse Practitioner Students!

Participants Needed for PhD Research Study

Title of Study: Exploring the Development of Diagnostic Reasoning Skills Among Nurse Practitioner Students in Canada

- Are you interested in contributing to research on diagnostic reasoning in NP education? We're seeking NP students to participate in a **60–90 minutes virtual interview** as part of a study on diagnostic reasoning skills.

Eligibility:

- ✓ Must have completed at least **20 hours** of NP student clinical placement
- ✓ Participants will be selected on a **first-come, first-served** basis

Why Participate?

- 🎓 Help advance **NP education** and improve **healthcare quality**
- 💡 Share your **insights and experiences** in diagnostic reasoning

This study has received research ethics approval from University of Ottawa and University of Victoria.

Interested? Contact Sarah Pirani:

✉ Email: 📱 Cell:

Join us in shaping the future of NP education!



Appendix B: Consent Form

Title of the study: Exploring the development of diagnostic reasoning skills among nurse practitioner students in Canada

Sarah Pirani, NP, MSc, DNP, PhD(c)
School of Nursing, University of Ottawa

PhD Supervisor:
Dr. Jane Tyerman RN, PhD, CCSNE
Associate Professor, School of Nursing
Faculty of Health Sciences, University of Ottawa

Invitation to Participate: You are invited to participate in the above mentioned research study conducted by *Sarah Pirani for her Doctoral Thesis, supervised by Dr. Jane Tyerman.*

Purpose of the Study: The purpose of the study is to explore the development of diagnostic reasoning skills among nurse practitioner students in Canada.

Participation: Your participation will consist of a one-time interview, which will last about 60-90 minutes. The interview will focus on your experience of developing diagnostic reasoning skills as a student in the NP program. If you agree to participate, after selecting the “Yes, I agree to participate in this study” option at the end of this form, there will be a demographic questionnaire for you to complete, which may take approximately five minutes. You will also be asked if you would consent to audio recording.

Risks: Your participation in this study will entail that you share your experience with developing diagnostic reasoning skills. You have the option to refuse to answer any questions or withdraw from the study at any time. There will not be any negative consequences if you decide to withdraw from the study. Your identity will not be revealed.

Benefits: Your participation in this study will provide essential information on how NP students develop diagnostic reasoning skills during their NP program. It will contribute to the future of NP education, such as designing more effective, student-centered teaching and learning strategies to support NP students learn diagnostic reasoning.

Confidentiality and Privacy: The information you will share during the interview will remain strictly confidential. The contents will be used only for the purpose of this research and your identity will be protected. Anonymity will be protected by using pseudonyms or participant numbers.

Conservation of Data: The data collected, including audio recordings, transcripts, researchers' notes, consent forms, etc. will be kept in a secure manner. It will be kept in a password protected computer, with backup on a secure OneDrive cloud storage. Only members of the research team will have access to this data. It will be kept for the duration of 5 years.

Please be advised that this research study includes data storage in the U.S.A (e.g. SurveyMonkey). As such, there is a possibility that information about you that is gathered for this research study may be accessed without your knowledge or consent by the U.S. government, in compliance with the U.S. Freedom Act.

Compensation: As a token of appreciation, a \$50 Amazon gift card will be emailed to you after your interview participation. Participants who withdraw from the study will still be entitled to their full compensation.

Voluntary Participation: You are under no obligation to participate and if you choose to participate, you can withdraw from the study at any time and/or refuse to answer any questions, without suffering any negative consequences. If you choose to withdraw, all data gathered until the time of withdrawal will be removed from the dataset and not used in the study.

If you have any questions about the study, you may contact the researcher or her supervisor. If you have any questions regarding the ethical conduct of this study, you may contact the Office of Research Ethics and Integrity via email (ethics@uottawa.ca) or telephone (613-562-5800 ext 5387). Additionally, I am also a faculty member in the School of Nursing at University of Victoria and the study has received research ethics approval at the University of Victoria (ethics@uvic.ca 250-472-4545).

It is recommended that you retain a copy of this consent form for your records.

By clicking the box below, I indicate my consent to participate in the study:

- ☐ Yes, I AGREE to participate in the study.
- ☐ No, I DECLINE to participate in the study.

Consent to audio recording of the interview:

- ☐ Yes
- ☐ No

Appendix C

Demographic Information Questionnaire for NP Student Participants

Thank you for participating in this study on exploring the development of diagnostic reasoning skills among nurse practitioner students in Canada. If you could please complete this brief demographic questionnaire at least one day before the scheduled interview, that would be greatly appreciated. It may take approximately five minutes to complete this questionnaire. Your responses will remain confidential and will be used for this research purpose only.

Questions:

1. What is your age?
 - _____
2. What is your gender?
 - _____
3. How many years of RN work experience did you have before entering the NP program?
 - _____
4. In which healthcare settings have you worked as an RN? (Select all that apply)
 - Hospital - Emergency Department
 - Hospital - Intensive Care Unit
 - Hospital - Medical/Surgical Unit
 - Hospital – Pediatrics
 - Hospital - Obstetrics/Gynecology
 - Community Health Center
 - Primary Care Clinic
 - Long-term Care Facility

- Home Health Care
- Mental Health Facility
- Other (please specify): [Text box]

5. What is your primary area of RN specialization? (choose one)

- Hospital - Emergency Department
- Hospital - Intensive Care Unit
- Hospital - Medical/Surgical Unit
- Hospital – Pediatrics
- Hospital - Obstetrics/Gynecology
- Community Health Center
- Primary Care Clinic
- Long-term Care Facility
- Home Health Care
- Mental Health Facility
- Other (please specify): [Text box]

6. In which year of the NP program are you currently enrolled? Are you a full-time or part-time NP student?

- First year, full-time
- Second year, full-time
- First year, part-time
- Second year, part-time
- Third year, part-time
- Other (please specify): [Text box]

7. Have you completed any additional certifications or specialized training as an RN? If yes, in which area?
8. What is your highest level of education completed prior to entering the NP program?
- Bachelor's degree in Nursing
 - Master's degree in Nursing
 - Other (please specify): [Text box]
9. In which province or territory are you currently studying?
- [Text box]
10. How many clinical hours have you completed so far in your NP program? [Text box]
11. What clinical settings did you complete your clinical hours, as an NP student? (Select all that apply)
- Primary Care/Family Health Clinic
 - Urgent Care Center
 - Emergency Room
 - Inpatient Acute Care Hospital
 - Mental Health and Psychiatry Outpatient
 - Mental Health and Psychiatry Inpatient
 - Other [Text box]

Thank you for completing this demographic questionnaire. Your responses will provide invaluable context for our research on diagnostic reasoning in NP education.

Appendix D

Interview Guide

Thank you for consenting to participate in my study. My name is Sarah Pirani, and I am a nursing PhD student at the University of Ottawa and a faculty member in the School of Nursing at the University of Victoria. The purpose of this study is to explore the development of diagnostic reasoning skills among NP students in Canada. This interview will take about 60 to 90 minutes. We'll use a few questions to guide us through the interview.

1. To begin, how would you define diagnostic reasoning in your own words? What does it mean to you as a nurse practitioner student?
2. Can you describe a specific learning experience during your NP education where you applied DR? What factors contributed to your success during this experience?
3. How do you think your previous nursing experience has influenced your ability to develop DR skills as an NP student? Can you provide examples of how your past experiences have helped or hindered your learning of DR?
4. What challenges have you encountered in developing DR skills, and how did you address them? What resources and support were most helpful? What types of support or resources were least helpful?
5. Do you incorporate a reflective process in your DR approach? If so, can you describe a time when this approach significantly affected your diagnostic decision-making?
6. When diagnosing a patient, how do you balance your gut feelings or instincts with a more deliberate, step-by-step analysis? Can you describe a situation where you relied more heavily on either your intuition or a methodical approach? What was the outcome of that situation?

7. Are you aware of any cognitive biases or emotional factors that influence your diagnostic reasoning? Can you describe a situation where such factors affected your diagnostic decision-making?
8. Can you explain how instructors and preceptors have supported you in developing DR skills? What specific teaching strategies or feedback have been most beneficial to you? What teaching strategies or forms of feedback were least helpful?
9. What roles do peer interactions and discussions play in developing your DR skills? Can you provide an example of a peer interaction that significantly influenced your understanding or approach to DR?
10. How has your NP program's curriculum supported or hindered your development of diagnostic reasoning? Are there specific courses, learning activities, or formats that helped you most? Why?
11. Looking back to the start of your NP program, how do you think your diagnostic reasoning has evolved? Can you describe a moment when you realized that your DR skills had improved? What factors do you think contributed to that growth?
12. Future Needs and Recommendations: What additional support, resources, or changes in your NP program do you think would better support the development of diagnostic reasoning skills among NP students?
13. If you could give advice to incoming NP students about developing DR skills, what would it be?

Appendix E: Access Permissions

Manuscript #1 (Chapter 6) was published in Nurse Education Today. Because it's an open access journal and I am the author, they do not require permission to include in my thesis. Please see screenshot below:

The screenshot shows the Elsevier RightsLink interface for the article "Diagnostic reasoning in the RN-to-NP transition: An interpretive description study" by Sarah Pirani, Jane Tyerman, Michelle Lalonde, and Erin Ziegler, published in Nurse Education Today in November 2026. The interface includes a "Quick Price Estimate" section with a text box explaining the service and a "Please note" section regarding author rights. Below these are several dropdown menus for selecting reuse options, author status, translation status, circulation, format, and currency. A green "PRICE Pending" button is visible at the bottom right.

Diagnostic reasoning in the RN-to-NP transition: An interpretive description study
 Author: Sarah Pirani, Jane Tyerman, Michelle Lalonde, Erin Ziegler
 Publication: Nurse Education Today
 Publisher: Elsevier
 Date: November 2026
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