Self-Explanation Use in Nurse Practitioner

Student Diagnostic Reasoning

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THESIS

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This dissertation is dedicated to my family. To my children: may my example teach you that if you are willing to work hard, you can accomplish anything. To my husband: you have supported this dream without question through pregnancy and babies, sickness and injury, sheltering-in-place, and all of the other obstacles that life has thrown our way—thank you! To my parents: who instilled in me a love of learning and then provided the 8,000+ hours of babysitting to make it all possible.

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LIST OF ABBREVIATIONS

AACN	American Association of Colleges of Nursing
DNP	Doctor of Nursing Practice
FNP	Family Nurse Practitioner
ICC	Intraclass correlation coefficient
IRR	Inter-rater reliability
NONPF	National Organization of Nurse Practitioner Faculties
NP	Nurse Practitioner
PI	Principal Investigator
RN	Registered Nurse
U.S.	United States

SUMMARY

There is a major gap in educational best practices regarding how to scholastically foster diagnostic accuracy among nurse practitioner (NP) students. This research establishes foundational information that will lead to evidence-based educational interventions and curricular changes leveraging the technique of self-explanation to increase NP diagnostic accuracy. Self-explanation is defined as the purposeful technique of generating self-directed explanations to process novel information while problem-solving. Because different types of self-explanations enhance learning to varying degrees, identifying high-quality ways of self-explaining present among successful NP student diagnosticians is a critical step in advancing diagnostic reasoning education.

In this mixed-methods content analysis study, NP students were asked to solve written case studies while self-explaining out loud. Self-explanations were analyzed both qualitatively and quantitatively. The initial research question of this study was: How do NP students self-explain during diagnostic reasoning? Using iterative, qualitative analysis techniques, 17 categories of NP student diagnostician self-explanation emerged. Inference self-explanations include both clinical and biological foci. Non-inference self-explanations monitor students' understanding of clinical data and reflect shallow information processing.

Two research aims sought to explore qualitative findings quantitatively. Aim 1 was to compare differences between student expertise levels in terms of diagnostic accuracy scores and self-explanation scores. Expert students self-explain in qualitatively different ways than novice students, using more inference self-explanations (biological and clinical) and fewer non-inferences statements. Groups did not significantly differ in terms of diagnostic accuracy ($p <$ 0.1636). Aim 2 was to explore relationships between self-explanation scores and diagnostic accuracy levels. Clinical inference scores were not significantly associated with levels of diagnostic accuracy ($p < 0.39$). Biological inference scores were, however, significantly associated with diagnostic accuracy scores: $r(35) = 0.49$ ($p < 0.002$).

Collectively, these findings provide a solid framework for NP educators to support diagnostic accuracy among students via self-explanation. Prompted self-explanation interventions and curriculum changes integrating disease state courses and human sciences should encourage students to self-explain clinical features in terms of underlying biology. Cultivating the momentum created by this research will, ultimately, address a major issue in today's health care system by increasing accurate diagnoses and, hopefully, in turn fostering patient well-being.

I. INTRODUCTION

This dissertation is comprised of two manuscripts. The first manuscript establishes foundational information by addressing the research question: How do Nurse Practitioner (NP) students self-explain during diagnostic reasoning? The second manuscript builds upon the answer to this question by addressing the dual research aims of (a) exploring relationships between self-explanation scores and diagnostic accuracy levels, and (b) comparing differences between student expertise levels in terms of diagnostic accuracy scores and self-explanation scores.

Statement of Problem and Significance

Nurse practitioners are advanced practice registered nurses who have specialized knowledge and clinical practice competency. Nurse practitioners have either a master's or clinical doctorate degree, above and beyond their initial registered nurse (RN) preparation (American Association of Nurse Practitioners, 2019c). As licensed, independent providers, NPs practice autonomously and collaborate with other professionals in order to provide patient-centered, comprehensive care (American Association of Nurse Practitioners, 2019b). Accurately diagnosing patients is a critical component of NP clinical practice, with 61.1% of NPs stating that they diagnose and manage acute conditions in most patient encounters and 59.5% stating that they diagnose and manage chronic conditions in most patient encounters (American Association of Nurse Practitioners, 2018). The advanced practice nursing care that NPs provide is high-quality, cost-effective, and associated with positive health outcomes (Kuo et al., 2018; Kurtzman & Barnow, 2017; Morgan, 2019).

Diagnostic errors originating from a variety of providers are a major problem within our health care system. In the United States (U.S.), approximately 5% of adult outpatient health care visits result in diagnostic errors. Diagnostic errors play a key role in adverse hospital events (6-17%) and preventable patient deaths (10-15%), and often lead to disability and harm (Balogh, 2015; Sorinola et al., 2012). Alarmingly, diagnostic errors most often occur in patient encounters that involve disease processes that are frequently seen by providers: vascular events, infections, and cancers (Newman-Toker et al., 2019).

In 2015, the Institute of Medicine published a call-to-action, urging educators to improve the quality of diagnostic reasoning education for all providers, to lessen diagnostic errors and augment patient safety (Balogh, 2015). Mirroring this sentiment, both the National Organization of Nurse Practitioner Faculties (NONPF) and American Association of Colleges of Nursing (AACN) identify diagnostic reasoning as a core, entry-level NP clinical practice competency (American Association of Colleges of Nursing, 2017; National Organization of Nurse Practitioner Faculties, 2017). Despite this overwhelming need, evidence-based educational strategies to teach diagnostic reasoning are scarce and underdeveloped, and are insufficiently tied to diagnostic accuracy outcomes (Burt & Corbridge, 2018).

Self-explanation is a promising learning strategy emerging within medical education to strengthen diagnostic accuracy. Self-explanation is defined as the purposeful technique of generating self-directed explanations, in order to process novel information while problem-solving (Chi et al., 1989; Chi et al., 1994). The many different ways that people explain problem solving steps to themselves—the specific self-explanation content types—vary qualitatively, ranging from simply restating information to explanations above and beyond explicitly provided material. Self-explanation is a learner-centric phenomenon; explanations are generated by the learner, for the benefit of the learner (Chi et al., 1994). The self-explanation effect refers to the fact that self-explaining learners generally demonstrate improved problem-solving skills and deeper acquisition of declarative knowledge (Chi et al., 1989; Chi et al., 1994).

Critically, however, not all ways of self-explaining lead to equal problem-solving successes. Particular ways of self-explaining are more commonly spoken among more accurate problem-solvers in areas such as algebraic reasoning, computer programming, physics, and probability calculations (Chi et al., 1989; Neuman et al., 2000; Pirolli, 1994; Renkl, 1997). Extending the application of this trend, prompting students to self-explain in certain high-quality ways deepens learning and facilitates greater problem-solving accuracy in physics, argumentation, and mathematics (Nokes, 2011; Renkl et al., 1998; Schworm, 2007). The beneficial impact of encouraging specific ways of self-explaining is even more pronounced when self-explanation prompts are paired with some form of instructional assistance, providing constructive support to learners to process information in specific, high-quality ways (Berthold, 2009).

Self-explanation actively supports learning via two primary cognitive processes: knowledge integration and knowledge generalization (Rittle-Johnson & Loehr, 2017). Knowledge integration refers to the joining of new knowledge with other new or prior knowledge (Lombrozo, 2006). Self-explaining links prior knowledge to problem-solving steps, as well as to information contained in the problem text (Chi et al., 1989; Chi & VanLehn, 1991; Renkl, 1997). Within the realm of diagnostic reasoning, self-explanation encourages biomedical knowledge integration into clinical scenarios (Chamberland et al., 2013). As learners integrate new information, they are more apt to self-intuit learning miscomprehensions and are better able to picture the problem in their minds (Chi et al., 1989; Chi et al., 1994; Renkl, 1997). Self-explanation also works via knowledge generalization. Self-explaining focuses the learner's attention on deeper and more essential problem features, such as underlying principles (Rittle-Johnson, 2006). When knowledge is more closely tied to foundational features, it is more easily transferred to novel problems (Rittle-Johnson & Loehr, 2017). Through these mechanisms, self-explaining updates and revises individual memory knowledge structures (Chi, 2000). In summary, self-explanation encourages student-mediated cognitive processes vital to learning: knowledge integration and knowledge generalization.

There is growing evidence that enhancing the role of self-explanation in medical education yields positive learning outcomes. Experimental studies have established increases in diagnostic performance under certain conditions in which general, non-content-specific self-explanations are integrated into written case studies solved by medical students (Chamberland, Mamede, St-Onge, Setrakian, & Schmidt, 2015; Chamberland et al., 2011). Specifically, prompting medical students to self-explain in ways that justify their reasoning and relate their reasoning to that of a slightly senior medical provider increases diagnostic accuracy when compared to non-prompted students (Chamberland, Mamede, St-Onge, Setrakian, Bergeron, et al., 2015). On the other hand, specifically prompting medical students to self-explain errors in reasoning had no effect on diagnostic competence (Heitzmann et al., 2015). These mixed results may indicate that current medical education self-explanation interventions are underdeveloped. Prompts are neither tailored toward specific diagnostic reasoning-focused ways of self-explaining, nor tailored toward ways of self-explaining known to be associated with diagnostic accuracy. Thus, self-explanation's utility in improving diagnostic accuracy has yet to reach its fullest potential.

The research outlined in the following manuscripts advances NP education by identifying profession-specific, diagnostic reasoning-specific ways of self-explaining. Additionally, this research explores relationships between self-explanation scores and diagnostic accuracy levels and compares differences between student expertise levels in terms of diagnostic accuracy scores and self-explanation scores. Understanding how NP students self-explain is a crucial step in designing curricula and developing learning conditions that foster diagnostic accuracy. Fully maximized, evidence-based educational interventions may increase diagnostic accuracy and improve patient outcomes.

II. ARTICLE 1:

WAYS THAT NURSE PRACTITIONER STUDENTS SELF-EXPLAIN DURING DIAGNOSTIC REASONING

Nurse Practitioners (NPs) are licensed, independent clinicians with expertise in diagnosing and comprehensively treating health issues, as well as educating patients on disease prevention and health management (American Association of Nurse Practitioners, 2019c). Nurse practitioners practice autonomously and in collaboration with other health care providers to provide holistic advanced practice nursing care (American Association of Nurse Practitioners, 2019b). Over half of NP patient encounters include the diagnosis and management of acute and chronic conditions, and accurate diagnoses are critical during these encounters (American Association of Nurse Practitioners, 2018).

While NPs provide exceptional high-quality patient care, diagnostic errors—originating from all health care providers—is a major issue within our health care system (Kuo et al., 2018; Kurtzman & Barnow, 2017; Makary & Daniel, 2016). Each year in the U.S., diagnostic errors adversely impact an estimated 12 million people (Saber Tehrani et al., 2013). The effects of misdiagnoses can range from no harm to loss of life, with errors contributing to approximately 40,000 to 80,000 U.S. deaths annually (Balogh, 2015; Saber Tehrani et al., 2013). Accurate diagnoses are vital to high-quality health care, as they are the basis for timely and appropriate disease treatment that avoids harm and lessens preventable stressors (Balogh, 2015). An important step in mitigating the burden of diagnostic errors is to strengthen diagnostic reasoning in health care providers (Balogh, 2015).

Self-explanation has been used as a strategy to improve diagnostic accuracy among medical students and residents (Chamberland et al., 2013; Chamberland, Mamede, St-Onge, Setrakian, Bergeron, et al., 2015; Chamberland, Mamede, St-Onge, Setrakian, & Schmidt, 2015; Chamberland et al., 2011). Self-explanation is defined as the purposeful technique of generating self-directed explanations to process novel information while problem-solving (Chi et al., 1989). When students self-explain, they actively improve knowledge structures within their memories (Chi, 2000). Self-explanation supplements knowledge gaps, creates new links between information, and integrates new and prior knowledge together (Rittle-Johnson & Loehr, 2017). Improved knowledge structures enhance problem solving accuracy and deepen acquisition of declarative knowledge (Chi et al., 1989; Chi et al., 1994). Thus, encouraging learners to self-explain improves diagnostic performance (Chamberland et al., 2011).

When students self-explain, they make sense of information in a variety of unique ways. Information might be restated, or information might be synthesized into multidimensional thoughts (Chi et al., 1989). Students might expand problem conditions, identify goals, engage in anticipative reasoning, or paraphrase information (Chi et al., 1989; Renkl, 1997). Critically, certain ways of self-explaining enhance learning to varying degrees. Successful problem-solvers frequently use high quality self-explanations (Chi et al., 1989; Lehman et al., 1988; Neuman et al., 2000; Pirolli, 1994; Renkl, 1997). For example, a high-quality, principle-based physics explanation is, "…it equals the force, mass times acceleration" (Chi et al., 1989). The most successful self-explanation educational interventions are built upon foundational understanding of these high-quality self-explanation types. Specifically, purposeful prompting of students to self-explain in high-quality ways bolsters problem solving accuracy when compared to unprompted students (Berthold, 2009; Nokes, 2011; Renkl et al., 1998; Schworm, 2007).

While ways of self-explaining have been explored in non-medical fields, they did not involve diagnostic reasoning (Chi et al., 1989; Renkl, 1997). Diagnostic reasoning is a unique type of problem solving with vague, fluid starting points and final goals, as well as varying means of achieving definitive diagnoses (Gilhooly, 1990). While some research demonstrates greater diagnostic accuracy with explicit self-explanation prompts, other research fails to support this enhanced relationship (Chamberland, Mamede, St-Onge, Setrakian, Bergeron, et al., 2015; Heitzmann et al., 2015; Peixoto et al., 2017). Self-explanation prompts in these previous studies were not diagnostic reasoning-specific and they did not focus on self-explanation types associated with greater diagnostic accuracy.

Exploring the unique ways that providers self-explain during diagnostic reasoning is an important first step in leveraging self-explanation as an effective diagnostic accuracy learning strategy. In this qualitative study, we addressed this knowledge deficit by asking the research question: How do NP students self-explain during diagnostic reasoning? Understanding ways that NP students self-explain during diagnostic reasoning is an important step in developing self-explanation learning interventions to improve diagnostic accuracy and patient outcomes.

Methods

Ethical Approval

Research ethics approval was received from the University's Office for the Protection of Research Subjects, IRB # 2019-0668.

Participants

Participants included 37 Family NP (FNP) students enrolled in the Doctor of Nursing Practice (DNP) program at a large, Midwestern university. All participants were licensed registered nurses (RNs) enrolled in one of two graduate courses, occurring in years three and four of a four-year clinical doctorate program. Year-three participants (*n* = 18) were preclinical, and year-four participants (*n* = 19) were in their final clinical rotation. Using convenience sampling, the first author approached students in person during pre-scheduled class times in the fall 2019 and spring 2020 semesters. Participation was voluntary and did not affect course grades. Participants were reimbursed $60, based on the average regional wage of an experienced RN (State of Illinois, 2018).

Students were, on average, 30.4 years of age and had more than six years of clinical nursing employment experience. Most students identified as female and Caucasian and possessed a bachelor's degree in nursing. Students had a wide variety of significant nursing experiences, occurring in unique practice settings, with unique patient populations, and in unique specialty areas (Table I). No student had previous experience formally using self-explanation as a facilitative learning tool.

Table I
Student Characteristics

Characteristics	Number (%)
Expertise level	
Novice	18 (48.6)
Expert	19 (51.4)
Mean age, years (*SD*)	30.4 (6.5)
Mean years of nursing work experience, *n* (*SD*)	6.3 (2.7)
Gender identity	
Male	1 (2.7)
Female	36 (97.3)
Ethnicity	
Caucasian/White	23 (62.2)
Asian	9 (24.3)
Hispanic/Latino	3 (8.1)
Other	2 (5.4)
Highest degree of education	
Bachelor's degree	32 (86.5)
Master's degree	5 (13.5)
Highest degree of nursing-specific education	
Associate degree- nursing	1 (2.7)
Bachelor's degree- nursing	33 (89.2)
Master's degree- nursing	3 (8.1)
Most significant current (or past) nursing practice setting	
Hospital	29 (78.4)
Ambulatory Care	4 (10.8)
Other	4 (10.8)
Most significant current (or past) nursing patient population experience	
Adult	30 (81.1)
Pediatric/Adolescent	3 (8.1)
Newborn/Neonate	2 (5.4)
Other	2 (5.4)
Most significant current (or past) nursing specialty	
Critical care	10 (27.0)
Medical-surgical	8 (21.6)
Emergency/trauma	5 (13.5)
Oncology	3 (8.1)
Other	11 (29.7)
Previous experience with self-explanation as a learning tool	
Yes	0 (0)
No	37 (100)

Each student met one-on-one with the first author for a single 60-minute session. Before beginning, a waiver of written consent was presented to each student. A training period (introducing the concept and working through examples of self-explanation via narrated PowerPoint presentation) was followed by a practice vignette. Students were then asked to self-explain while solving case studies. Each case description was approximately 400 words and formatted identically to include the: chief complaint, history of present illness, past medical history, social history, family history, medications, physical examination, and diagnostic data. Topics were purposely chosen as didactically familiar yet clinically novel for this group of students. In other words, students had exposure to case study topics through coursework, but had not participated in any structured learning activities pertaining to specific diagnoses. Topics included chest pain (acute pericarditis), dizziness (benign positional paroxysmal vertigo), and abdominal pain (acute gallstone pancreatitis).

Design

Dual methodology content analyses were used to identify and describe categories of NP student diagnostician self-explanation (Elo, 2008). Content analyses result in objective, categorical descriptions of written, verbal, or visual communication-based phenomena (Elo, 2008). Using deductive methodology, a portion of data were classified into pre-existing, medically focused self-explanation categories (Chamberland et al., 2013; Muhoza-Butoke, 2018). Because many self-explanations lost substantial meaning when placed into categories, qualitative descriptive methodology was simultaneously and overarchingly employed. Qualitative, descriptive research provides low-inference interpretation, guided by the informational contents of the data (Sandelowski, 2000). While qualitative descriptive and deductive methodologies were used synergistically to explore the data, findings originating from qualitative descriptive analyses most thoroughly addressed the proposed research question of how NP students self-explain during diagnostic reasoning. This manuscript explores the answer to the research question by focusing more heavily on the qualitative descriptive portion of analyses.

Data Analysis

Qualitative descriptive data analysis was iterative. Idea units were selected as the analysis unit, defined as utterances representing fine-grained, singular ideas (Chi, 1997). Process coding facilitated first-cycle coding. Process coding applies gerunds (-ing verb forms) to data to indicate action. Because people are actively working toward goals when problem solving, action-oriented process coding is appropriate for problem solving data (Corbin, 2015; Saldana, 2016). Second-cycle pattern coding then facilitated the grouping of initial codes into common categories. Pattern coding condenses first-cycle coding into conceptually meaningful yet parsimonious categories (Miles, 2014; Saldana, 2016). Pattern coding corresponds well with content analysis methodology (Saldana, 2016). The first author unitized and analyzed all data, developing a comprehensive coding manual that included both descriptors and examples.

To increase the effectiveness by which the coding manual was applied, inter-coder reliability was established in a random sample of 12 case studies (10.8% of total data) by a second coder who was a DNP-prepared NP faculty member and was not affiliated with the FNP program. Through an iterative process of coding manual-based discussions and practice coding sessions, the codebook was refined, and the second coder was trained in the codebook's application. Percentage agreement was calculated, and inter-coder reliability was formally established with Cohen's kappa (Landis & Koch, 1977; Cohen, 1960).

Qualitative data were analyzed by the first author using NVivo 12 (Mac version 12.5.0) computer software (QSR International, Australia). Statistical analyses were performed by the first author using STATA software, version 14.6 (StataCorp LP, College Station, TX).

Results

Thirty-seven students self-explained three case studies each, producing a total of 6,332 pieces of data. Idea units were reduced to 178 open codes, then iteratively reduced to 25 first-level codes. Through second-level coding, 17 categories emerged describing the unique ways that NP student diagnosticians self-explain. Categories were further designated through taxonomical organization (Table II). Percentage agreement between coders was formally established at 75.32% and Cohen's kappa (1960) indicated substantial agreement (k = 0.6891, $p < 0.001$; Landis & Koch, 1977).

Table II
Taxonomy of Student Self-Explanations Types

	Inference self-explanations		**Non-inference utterances**	
	Clinical inferences	**Biological inferences**	**Monitoring statements**	**Other statements**
Taxonomy classification	*Explanations which frame information in terms of signs, symptoms, subjective patient information, or disease findings*	*Explanations which frame information in terms of mechanisms or deficits of the human body*	*Statements which self-monitor the status of the learner's own knowledge*	*Statements which fail to integrate more insightful meanings of data into problem solving processes*
Self-explanation categories	1. Principle-based reasoning 2. Classifying 3. Stratifying risk 4. Prioritizing 5. Ruling out organ system 6. Ruling out diagnosis 7. Connecting clinical information to organ system 8. Connecting clinical information to diagnosis	9. Biological inferences	10. Monitoring statements	11. Seeking information 12. Assuming and speculating 13. Surface-level awareness 14. Brainstorming without elaboration 15. Highlighting 16. Paraphrasing 17. Making an error

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Inference Self-Explanations

During diagnostic reasoning, NP students self-explain using inferences. Inferences are defined as explanations containing novel information, extending above and beyond the given material. In order for inferences to be substantive, they must be both insightful and meaningful in terms of solving the problem at hand (Chi, 2000; Chi et al., 1989). In this research, substance inferences were found to have one of two distinctive foci: clinical or biological information. Clinically focused self-explanations emphasize patient and disease attributes. Biologically focused self-explanations emphasize principles or mechanisms of underlying disease processes. Table III identifies and describes the types of inference self-explanations spoken by NP students during diagnostic reasoning.

Table III

Inference Categories of NP Student Diagnostic Reasoning Self-Explanation

Self-explanation category	Brief description	Example
1. Principle-based reasoning	Stating knowledge of or evaluating signs and symptoms in terms of specific disease presentations. Includes principle-based, declarative statements.	*"This nausea/vomiting is not typically characteristic of just an episode of reflux, especially since it's lasting 24 hours now, too"*
2. Classifying	Classifying and labeling clinical findings, signs, and symptoms. Descriptors are often precise, medically meaningful terminology.	*"She is having colicky pain"*
3. Stratifying risk	Using clinical information to stratify risk for specific diagnoses, diseases, or disease categories.	*"Not having regular exercise can increase your risk for heart issues"*
4. Prioritizing	Assigning levels of importance to clinical data. May be either positive or negative prioritization.	*"[The positional nature of her dizziness] seems like very important information that I would pay special attention to."*
5. Ruling out organ system	Using information to rule out the diagnostic involvement of a particular organ system. Organ system refers to anything less specific than an actual diagnosis.	*"Then the chest radiograph showing the—no infiltrations, no active disease so we can rule out respiratory issues."*
6. Ruling out diagnosis	Using information to rule out a specific diagnosis.	*"There's no erythema or pus in each ear, so it's not an ear infection."*
7. Connecting clinical information to organ system	Connecting signs, symptoms, diagnostic data, or other clinical information to an organ system. Organ system refers to anything less specific than an actual diagnosis.	*"Scleral icterus, yellow sclera, could be related to liver issues."*
8. Connecting clinical information to diagnosis	Connecting signs, symptoms, diagnostic data, or other clinical information to specific diagnoses.	*"Patient becomes dizzy and uncomfortable when trying to lay down during the exam, so — probably about 95% BPPV."*
9. Biological inferences	Emphasizes principles or mechanisms of underlying disease processes in terms of anatomy, physiology, or pathophysiology. Includes higher-level laboratory value interpretation, for example, connecting a laboratory value to its clinical significance.	*"If she has icterus and if those eyes are orange and everything, she's not getting rid of her bilirubin."*

Non-Inference Self-Explanations

Students also self-explain case studies using non-inferences. Non-inferences are defined as utterances lacking significant integration of new knowledge (Chi et al., 1989). Diagnostic reasoning non-inferences are categorized as either monitoring statements or other types of statements (Table IV). Monitoring statements monitor the status of self-knowledge by expressing understanding, communicating uncertainty, acknowledging knowledge deficits, or aiding a student in catching their own mistake. Other types of statements are defined as utterances that fail to integrate substantial new knowledge, representing more shallow information processing. Table IV identifies and describes the types of non-inferences spoken by NP students during diagnostic reasoning.

Table IV

Non-Inference Categories of NP Student Diagnostic Reasoning Self-Explanation

Self-explanation category	Brief description	Example
1. Monitoring statements	Statements monitoring the status of students' own knowledge. May be either positive or negative.	*"Reciprocal changes [on her EKG], I don't necessarily know what that means."*
2. Seeking information	Explanations seeking additional information beyond what is explicitly provided in the problem at hand.	"*128/68—it would be good to compare her baseline actually to see if this is a—what I would do is I would typically—if I were to suspect orthostatic issue—I would take it laying down, sitting, standing. That would really help me with the diagnosis."*
3. Assuming and speculating	Postulating information without due cause that cannot be logically deduced.	"*Maybe she's drinking more than she leads on. Maybe she's going back to being like her dad, as an alcoholic"*
4. Surface-level awareness	Shallow, surface-level awareness statements, lacking in-depth justification. Information may be dichotomized in terms of good vs. bad, interesting vs. boring, or worrisome vs. hopeful. Non-specific emotions, like concern or interest, are also included.	*"That's good she doesn't use marijuana, alcohol, or tobacco"*
5. Brainstorming without elaboration	Brainstorming diagnoses without concrete connections or explanations. This category also includes when students rule in or rule out a diagnosis, without justification.	*"Could be viral bacterial gastroenteritis, could be pancreatitis, could be any number of things"*
6. Highlighting	Without making connections or offering justifications, acknowledge information's presence, focusing in a certain diagnostic direction, or acknowledging familiarity.	*"Her mom had her gallbladder removed three years ago, so history of some type of gallbladder disorder in the family."*
7. Paraphrasing	Restating text or interpreting data on a basic level.	*"His current medication lists he's on hypertension medication, diabetes medication, and lipid medication."*
8. Making an error	Explanations containing any variety of errors, including but not limited to incorrectly interpreting data or incorrectly attributing clinical significance.	*"Raspy and scratchy sound with cardiac auscultation. Okay. Raspy and scratchy. That tells me there is some kind of a murmur going on there."*

Discussion

This research significantly extends the current understanding of self-explanation during diagnostic reasoning. Findings illuminate inference and non-inference types of self-explanations that NP diagnosticians use when clinically problem solving.

Inferences

Distinctive biological self-explanations illustrate the importance of this type of knowledge in beginner diagnosticians. The example "a raspy, scratching sound with cardiac auscultation, so maybe that has to do with physical structures rubbing or some sort," illustrates how biological knowledge causatively facilitates a student working toward a concrete diagnosis. A previously disparate physical exam finding, "a raspy scratching sound," is viewed in terms of its underlying anatomical explanation, "physical structures rubbing," thus, providing a vital, scaffolding link within the diagnostic reasoning process. The idea that biological information is a distinctive entity in beginner diagnosticians is supported by theories of medical expertise development (Charlin et al., 2000; Schmidt & Rikers, 2007; Van de Wiel, 2000). Because novice students lack extensive clinical and diagnostic experience, biological knowledge is critical to beginner reasoning, providing causative frameworks for students to make sense of immature clinical information (Boshuizen & Schmidt, 1992). While the student in the above example was not able to make the diagnosis from the patient's signs and symptoms alone, the student was able to successfully integrate a causative anatomical explanation, ultimately connecting this explanation to a common manifestation of the correct disease, acute pericarditis.

Findings also illustrated the multitude of different ways that NP students use clinical information during diagnostic reasoning. NP students apply clinical information to connect, prioritize, stratify risk, rule out, classify, and integrate principles. For example, one student leveraged the clinical information “GI upset, abdominal pain, nausea, vomiting” to both classify the patient’s complaint, “so this is acute epigastric pain,” and then connect symptoms to specific organ systems, “starting to think of differentials in the epigastric area. I wanna include pulmonary, cardiac, and abdominal areas.” Such a wide variety of clinically focused self-explanation types may have been acquired from the participants’ nursing backgrounds. On average, students had over six years of clinical nursing experiences. While new to the advanced-practice role, NP students are often experienced nurses who have cared for a wide variety of patients in a multitude of settings. One example of an explanation that incorporates past nursing experiences includes the statement, “I work in—on a surgical floor, and a lot of times, that [symptom is] from small bowel obstruction, so that’s what I’m thinking right now.” Nurse practitioner students who are experienced nurse clinicians often integrate past patient care experiences to apply clinical knowledge distinctly and effectively in a variety of unique ways during diagnostic reasoning.

The distinctive biological and clinical inference categories identified in this study are consistent with the conceptual framework of self-explanation, reinforcing self-explanation’s relevance to diagnostic reasoning (Chi et al., 1989). Clinical inferences refine diagnostic problem-solving conditions through classification and prioritization of patient data. Clinical and biological inferences explicate consequences through risk stratification and by ruling out organ systems or diagnoses. Clinical and biological inferences give meaning to clinical findings by connecting subjective and objective data to diagnoses and organ systems, by integrating underlying principles into reasoning processes, and by providing scaffolding links (Chi et al., 1989).

Non-Inferences

In addition to making inferences, NP students self-monitor during diagnostic reasoning. When NP students spontaneously apply monitoring statements, this supports self-explanation as a learning tool that actively improves diagnostic reasoning knowledge structures. In this study, a monitoring statement facilitated one student's realization that they were incorrectly interpreting a physical exam finding, allowing that student to redirect an incorrect line of thought. The student self-explained that, "Since her left tympanic membrane is pearly grey, that can be a concern with her dizziness… Well no, pearly grey is a normal [physical exam finding], so that's fine." The ability to self-intuit one's own comprehension is a vital first step for students in subsequently processing information differently, if needed, for problem solving successes (Chi, 2000). Monitoring statements help direct students' attention on the aspect of the problem that they need to most readily focus on, thus facilitating learning (Roy & Chi, 2005). Although monitoring statements are not substantive inferences, they are advantageous to learning. When NP students spontaneously apply monitoring statements, this further supports the idea that self-explanation is a learning tool that actively improves mental models of diagnostic reasoning-focused knowledge.

These findings also illustrated fine-grained non-inference self-explanation types. The structures and contents of the eight non-inference categories reflect shallow information processing and less mature knowledge structures. The statement "this EKG doesn't seem good" is a surface-level EKG interpretation, failing to connect the EKG pattern with the underlying etiology of pericardial inflammation. Such shallow information processing is consistent with previous research exploring patterns of self-explanation among less successful learners. Less successful students study information for shorter periods of time and often do not recognize the significance of information (Renkl, 1997). In addition, their self-explanations contain fewer idea components than those of successful learners, even though they may already know the materials as demonstrated by pre- and post-testing (Chi et al., 1989). Non-inference self-explanation categories complement previously identified self-explanation patterns of less successful learners, extending the current understanding of immature diagnostic knowledge structures.

Strengths

This study meaningfully extends and deepens the current foundational understanding of self-explanation use in NP diagnostic reasoning. The methodology is rigorous, credible, and meaningfully coherent, and results significantly contribute to current knowledge (Tracy, 2010). Multifaceted data sources and a variety of participants were purposely integrated into the study design to adequately represent the complexity of self-explanation during diagnostic reasoning. Specifically, data were elicited from three case studies varying in both topic and familiarity levels. Data were also collected from different student expertise levels to capture the greatest variety of self-explanation types. The first author was self-reflexive to her potential bias toward the conceptual framework of self-explanation. Thus, dual methodology analyses were purposely employed, taking place over multiple, iterative cycles informed by—but not limited to—the theoretical framework of self-explanation. Thick descriptions of each category of diagnostic reasoning self-explanation are substantiated through these ample and varied data (Geertz, 1973). In addition, multiple concrete examples exemplify each category. Codebook application was triangulated through the engagement of two data coders establishing substantial data classification agreement (Tracy, 2010).

Limitations

While considerable time and effort was taken in developing case studies, this paper-and-pencil learning format is not equivalent to real-life patient care. Although caution was taken during data collection to make students feel comfortable, some students expressed awkwardness when asked to self-explain out loud, potentially impacting findings. Lastly, English was not a native language for some of the students participating in this research, which may have affected their ability to self-explain English-written case studies.

Conclusions and Areas for Future Research

This dual methodology content analysis explored the understudied but promising use of self-explanation among NP students. Seventeen categories of NP student diagnostician self-explanation were identified and described. Inference self-explanations include both clinical and biological foci, a finding consistent with diagnostic expertise development theory. Non-inference self-explanations monitor students' understanding of clinical data and reflect shallow information processing.

Findings extend the current understanding of self-explanation use during diagnostic reasoning by affording a valuable glimpse into knowledge structures of beginner NP students. Future research should examine relationships between categories of self-explanation and markers of diagnostic success, a step in developing prompted self-explanation diagnostic accuracy learning interventions. In addition, future research should extend findings into realistic patient care settings. Health care simulation training sessions may provide an intermediary setting between the paper-and-pencil format used in this study and actual clinical settings. Leveraging study findings in order to foster diagnostic accuracy has the potential to improve diagnostic reasoning and in turn improve patient outcomes.

III. ARTICLE 2:

DIAGNOSTIC REASONING: RELATIONSHIPS AMONG EXPERTISE, ACCURACY, AND WAYS THAT NP STUDENTS SELF-EXPLAIN

Diagnostic errors are the most common cause of medical errors in the United States (U.S.), with an estimated 12 million people each year affected by their consequences (Newman-Toker et al., 2019; Saber Tehrani et al., 2013). In outpatient settings, one of every 20 adults are impacted by diagnostic mistakes (Singh et al., 2014). Of these primary care-based misdiagnoses, an estimated 33% result in serious, permanent damage or death (Singh et al., 2013). In order to deliver high-quality health care minimizing patient harm, it is imperative that providers accurately diagnose patients.

Diagnostic reasoning involves a complex interplay of many factors. While a strong knowledge base is foundational, clinical judgement lapses are a more frequent cause of diagnostic error (Sorinola et al., 2012). In fact, serious misdiagnosis-related harms are attributed to clinical judgement failures in over 85% of cases (Newman-Toker et al., 2019). The capacity to adeptly prioritize, compare, and contrast findings, and to reason diagnostically are examples of skills that providers must master in order to prevent misdiagnoses (Olson et al., 2019). For health care providers to diagnose more accurately, educators should employ multifocal strategies to improve diagnostic ability.

A promising learning condition emerging within medical education, known as self-explanation, offers a possible way forward. Self-explanation is the process of purposefully generating explanations of problem-solving steps for oneself, in attempts to make sense of new information. Self-explanation supports learning by restructuring memory-based knowledge representations (Chi, 2000; Chi et al., 1989). When information is restructured, prior knowledge links to problem solving steps and new information. Problem solving accuracy improves and knowledge acquisition increases (Chi et al., 1989; Chi & VanLehn, 1991; Chi et al., 1994; Renkl, 1997; Rittle-Johnson & Loehr, 2017).

While working through problems, learners may self-explain steps to themselves in a variety of ways, ranging from simply restating information to generating complex associations (Chi et al., 1989). Different ways of self-explaining enhance learning to varying degrees, as certain types of self-explanations are associated with greater problem-solving accuracy (Chi et al., 1989; Neuman et al., 2000; Pirolli, 1994; Renkl, 1997). Furthermore, encouraging students to self-explain in high-quality ways results in greater problem-solving accuracy when compared to the accuracy of uncoached students (Nokes, 2011; Renkl et al., 1998; Schworm, 2007).

Within medical education, learning interventions have yet to capitalize on high-quality diagnostic reasoning-specific ways of self-explaining. While some research demonstrates greater diagnostic accuracy with coached self-explanation prompts, other research refutes this relationship (Chamberland, Mamede, St-Onge, Setrakian, Bergeron, et al., 2015; Heitzmann et al., 2015; Peixoto et al., 2017). Critically, self-explanation prompts included in these studies are neither diagnostic reasoning-specific, nor built upon self-explanation types associated with greater diagnostic accuracy. Instructional interventions tailored to high-quality diagnostic reasoning-specific ways of self-explaining have the potential to maximize the impact of this way of learning on diagnostic accuracy.

While promising, self-explanation has not been used in nurse practitioner (NP) education (Burt & Corbridge, 2018). Nurse practitioners are registered nurses (RNs) with advanced, graduate-level education and clinical practice competencies. As licensed, independent providers, NPs practice autonomously and collaborate with other professionals in order to provide patient-centered care to diverse populations (American Association of Nurse Practitioners, 2019b). Accurately diagnosing patients is a critical component of NP clinical practice, with the diagnosis and management of diseases being the second most common type of care provided by NPs in the U.S. (American Association of Nurse Practitioners, 2018). The high-quality and cost-effective care that NPs provide their patients is associated with positive health outcomes (Kuo et al., 2018; Kurtzman & Barnow, 2017; Morgan, 2019). Consistent with other disciplines, however, the ability to accurately diagnose is a challenging skill to develop within NP education (Burt & Corbridge, 2018).

This study is a beginning step in laying the groundwork to incorporate self-explanation in NP program curricula to improve diagnostic accuracy in NPs. In a previous phase of research, unique ways that family nurse practitioner (FNP) students self-explain during diagnostic reasoning were identified and described (Burt, 2020). The purpose of the current study is twofold: (a) explore relationships between self-explanation scores and diagnostic accuracy levels, and (b) compare differences between student expertise levels in terms of diagnostic accuracy scores and self-explanation scores. Identifying high-quality diagnostic reasoning self-explanation types associated with diagnostic success may facilitate the future development of more refined self-explanation educational interventions, translating into more diagnostically competent NPs.

Methods

Ethical Approval

Research ethics approval was received from the University's Office for the Protection of Research Subjects, IRB # 2019-0668.

Participants

During the fall 2019 and spring 2020 semesters, a convenience sample of 37 RNs enrolled in the FNP option of the Doctor of Nursing Practice (DNP) program at a large Midwestern college of nursing were recruited by the first author during in-person class meetings. Voluntary study participation did not impact course grades, and participants were financially compensated ($60) for participation based on the hourly wage of an experienced RN (State of Illinois, 2018). Participants were enrolled in one of two graduate-level courses typically occurring in years three and four of this four-year DNP program. Year-three participants (n = 18) had not yet begun clinical rotations, and year-four participants (n = 19) were in their final clinical rotation before graduation.

Design

This study builds on a previous qualitative study in which NP students self-explained during the diagnostic reasoning process (Burt, 2020). Specifically, NP students were asked to self-explain out loud while diagnosing patients presented in three written case studies. Self-explanations were unitized into idea units, defined as utterances representing fine-grained, singular ideas (Chi, 1997). Self-explanations were then analyzed via qualitative methodology, using iterative first-level and second-level coding techniques. Data were reduced to 17 distinct categories of self-explanation types, as outlined in Table V. Categories were further organized into a taxonomy, reflecting inference (clinical and biological) and non-inference categories of self-explanation (Burt, 2020). In the current study, we (a) explored relationships between self-explanation scores and diagnostic accuracy levels, and (b) compared differences between student expertise levels in terms of diagnostic accuracy scores and self-explanation scores.

Table V

Taxonomy of NP Student Self-Explanation Types

Taxonomy of Self-Explanation Types		**Categories of NP Students Self-Explanation**	**Examples**
Inference-type self-explanations	Clinical inferences	1. Stratifying risk 2. Principle-based reasoning 3. Ruling out an organ system 4. Ruling out a diagnosis 5. Prioritizing information 6. Connecting clinical information to an organ system 7. Connecting clinical information to a diagnosis 8. Classifying information	*"It was a short period of time—only about a minute—and then seems to have resolved. Again, that wouldn't necessarily be consistent with a stroke."* *"Patient is moving uncomfortably on the exam table, so it's colicky pain."* *"There's no blood in her stool so that rules out some GI issues."* *"He has high blood pressure, diabetes, and dyslipidemia, which would put him at a greater risk for cardiac issues."* *"Okay again, it says if she looks down too quickly—so that [symptom] also sounds a little bit like vertigo doing fast moving things, especially if she's doing repeated motions."*
	Biological inferences	9. Biological inferences	*"The bilirubin tells me bile duct which if you have a clogged bile duct that could cause your liver enzymes to elevate"* *"A raspy, scratching sound with cardiac auscultation, so maybe that has to do with physical structures rubbing or some sort."* *"I wonder if this is the valve issue. Lower left sternal border. That is gonna be your pulmonary valve."* *"Lactic dehydrogenase is elevated, which tells me there's an inflammatory response."*
Non-inference statements	Monitoring statements	10. Monitoring the status of one's own knowledge	*"Her eye beats occur in the right side of direction which I'm sure that's significant for something, but I'm not sure at that time."* *"Since her left tympanic membrane is pearly grey, that can be a concern with her dizziness, so it can potentially be vertigo…Well no, pearly grey is normal, so that's fine."* "*That confirms what I'm saying."*
	Other statements	11. Making an error 12. Assuming and/or speculating information 13. Highlighting information without inferences 14. Brainstorming diagnoses without explanations 15. Expressing surface-level awareness 16. Seeking information beyond what is given 17. Paraphrasing information and low-level interpretation of data	*"I wonder if [these symptoms are] affecting her sleep patterns?"* *"This EKG doesn't sound good."* *"Maybe she's drinking more than she leads on. Maybe she's going back to being like her dad, maybe, as an alcoholic."* *"She sounds constipated."* *"Her glucose is slightly elevated"*

Procedure

Each participant engaged in a single, hour-long, one-on-one research session with the first author. Before beginning, a waiver of written consent was presented to each participant. Sessions were divided into three phases: (1) training, which included an overview of the concept of self-explanation using a narrated PowerPoint presentation; (2) practice, which facilitated student rehearsal of diagnostic reasoning focused self-explaining; and (3) data collection, during which students solved three written case studies while actively self-explaining.

Case studies were randomly ordered and printed in paper booklets. Participants were instructed to progress through each case study while verbalizing self-explanations, arriving at one final diagnosis per case. In an effort to encourage consistent self-explaining, the text of each case study was physically segmented into chunks of text containing single ideas (Chi, 1997). In other words, case studies were typed with blank lines separating ideas. Students were asked to read each chunk of text silently and then verbalize their self-explanation of that specific text out loud, before moving on to the next text chunk. After self-explaining each case, participants wrote their final diagnosis in the paper booklet. If a participant paused longer than 10 seconds, the first author prompted “please continue self-explaining.” No feedback was given on the quality or content of self-explanations or diagnoses. Use of reference materials was not allowed. Verbalizations were digitally audio recorded and later transcribed for analysis. Upon conclusion, participants were handed an iPad to complete a demographic survey on the digital platform Qualtrics (Qualtrics, Provo, UT).

Case studies from internal medicine review books were adapted for use, so that each case conveyed standardized, thorough information (Appendices A-C) (Kanmen, 2013; Toy, 2013). Case descriptions (approximately 400 words) were presented in a uniform format (chief complaint, history of present illness, past medical history, social history, family history, medications, physical examination, and diagnostic data). Three NP faculty and three board-certified internal medicine and emergency medicine physicians gave feedback on adapted cases in terms of complexity, clarity, difficulty level, and clinical appropriateness. The cases were further revised based upon this feedback.

Case study diagnoses included acute gallstone pancreatitis (abdominal pain), acute pericarditis (chest pain), and benign positional paroxysmal vertigo (dizziness). Diagnoses were purposely chosen to be novel but non-obscure instances of diagnostic reasoning. Specifically, students had been previously exposed to these chief complaints in their didactic coursework but had not partaken in any planned simulations or written case studies of these diagnoses.

Inter-rater Reliability

In order to assess the degree by which coders consistently rated levels of diagnostic accuracy across subjects, inter-rater reliability (IRR) of diagnostic accuracy scoring was evaluated using a two-way mixed, absolute, single-measures intraclass correlation coefficient (ICC). The first author trained a second rater, who was a doctorally prepared NP (DNP) and university faculty member. Training included tool scoring explanation, examples, and discussion; training concluded with a short pilot test (Lombard, 2002). An acceptable level of agreement for the pilot test was established a priori, based on previous diagnostic accuracy research (ICC = 0.69; Chamberland et al., 2011); this level was well achieved: ICC = 0.90. IRR was then formally tested in a fully crossed design.

Measures

Diagnostic accuracy. As shown in Table VI, an accuracy score (0, 0.5, and 1) was assigned to each case study's diagnosis. An average diagnostic accuracy score was then calculated for the three case studies. The diagnostic accuracy score measure has adequate levels of construct validity and inter-rater reliability in previous diagnostic reasoning research (Chamberland et al., 2013; Chamberland, Mamede, St-Onge, Setrakian, Bergeron, et al., 2015; Chamberland, Mamede, St-Onge, Setrakian, & Schmidt, 2015; Chamberland et al., 2011; Mamede et al., 2012; Mamede et al., 2014; Peixoto et al., 2017).

Table VI
Diagnostic Accuracy Score

Numeric Score	Rating	Rating Rationale	Example Items
0	Completely incorrect	No correct components of diagnosis	Gastric ulcer
0.5	Partially correct	General category of disease correct; one component of the diagnosis correctly mentioned	Pancreatic inflammation
1	Completely correct	Specific, core diagnosis correct	Acute gallstone pancreatitis

Expertise level. Students were stratified into two groups: novice and expert. Novice students had not yet begun clinical rotations and were currently enrolled in their second of three disease management courses. Expert students were in their final clinical rotation before graduation and had completed three out of three disease management courses.

Self-explanation scores. Four scores were calculated based upon self-explanation content types: the non-inference score, the inference score, the clinical inference score, and the biological inference score.

Non-inference score. The non-inference score reflects the proportion of all non-inference self-explanations spoken, of any type. Non-inferences are defined as self-explanations which fail to integrate substantial, significant new information (Burt, 2020). For example, "that's good she doesn't use marijuana, alcohol, or tobacco" is a statement which reflects surface-level, non-inference awareness. The non-inference score is calculated by summing all non-inference statements and dividing this sum by the total number of idea units spoken.

Inference score. The inference score reflects the proportion of all inference self-explanations spoken. Inferences are defined as self-explanations integrating information above and beyond the material provided in the literal problem (Chi, 1997; Chi et al., 1989). The statement "her father passed away at 68 from a stroke, so given her Type 2 diabetes and her family history, she is at increased risk for stroke" is an example of an explanation that integrates new information in order to stratify risk. The inference score is calculated by summing all inference self-explanations (biological and clinical) and dividing the sum by the total number of idea units spoken.

Clinical inference score. The clinical inference score reflects the proportion of clinically focused, inference-type self-explanations spoken. For example, "this nausea/vomiting is not typically characteristic of just an episode of reflux, especially since it's lasting 24 hours now" is an inference that reflects clinical knowledge. The clinical inference score is calculated by summing all clinically focused inferences and dividing this sum by the total number of idea units spoken.

Biological inference score. The biological inference score reflects the proportion of biologically focused inference self-explanations spoken. The statement “if she has icterus and if those eyes are orange and everything, she’s not getting rid of her bilirubin” is an example of a biological inference. The biological inference score is calculated by summing all biological inferences and dividing this sum by the total number of idea units spoken.

Data Analysis

Descriptive and inferential statistical analyses were performed using STATA statistical software, version 14.6 (StataCorp LP, College Station, TX). Demographic characteristics were described. Associations between self-explanation scores and diagnostic accuracy scores were explored using correlations. Independent-samples *t* tests compared differences between student expertise levels in terms of diagnostic accuracy scores and self-explanation scores.

Results

Student Characteristics

Students ranged between 25-64 years of age, with a mean age of 30.4 years (Table VII). Students in both levels of expertise had approximately six years of clinical nursing employment experience. The majority of both expert and novice students identified as female and Caucasian and possessed a bachelor’s degree in nursing. Students in both levels of expertise had many unique, significant past and/or current nursing employment experiences described in terms of practice settings, patient populations, and specialty areas (Table VII).

Table VII
Demographic Characteristics

Characteristics	Total Sample	Expertise level Novice	Expert
Mean age (*SD*)	30.4 (6.5)	29.2 (3.2)	31.5 (8.5)
Mean years of nursing work experience (*SD*)	6.3 (2.7)	6.1 (3.3)	6.4 (2.1)
Gender identity, *n* (%)			
Male	1 (2.7)	0	1 (5.3)
Female	36 (97.3)	18 (100)	18 (94.7)
Ethnicity, *n* (%)			
Caucasian/White	23 (62.2)	9 (50)	14 (73.7)
Asian	9 (24.3)	6 (33.3)	3 (15.8)
Hispanic/Latino	3 (8.1)	2 (11.1)	1 (5.6)
Other	2 (5.4)	1 (5.6)	1 (5.6)
Highest degree of education, *n* (%)			
Bachelor's degree	32 (86.5)	15 (83.3)	17 (89.5)
Master's degree	5 (13.5)	3 (16.7)	2 (10.5)
Highest degree of nursing-specific education, *n* (%)			
Associate degree- nursing	1 (2.7)	0	1 (5.3)
Bachelor's degree- nursing	33 (89.2)	14 (77.8)	18 (94.7)
Master's degree- nursing	3 (8.1)	3 (16.7)	0
Most significant current (or past) nursing practice setting, *n* (%)			
Hospital	29 (78.4)	15 (83.3)	14 (73.7)
Ambulatory Care	4 (10.8)	2 (11.1)	2 (10.5)
Other	4 (10.8)	1 (5.6)	3 (15.8)
Most significant current (or past) nursing patient population experience, *n* (%)			
Adult	30 (81.1)	16 (88.9)	14 (73.7)
Pediatric/Adolescent	3 (8.1)	0	3 (15.8)
Newborn/Neonate	2 (5.4)	1 (5.6)	1 (5.26)
Other	2 (5.4)	1 (5.6)	1 (5.26)
Most significant current (or past) nursing specialty, *n* (%)			
Critical care	10 (27.0)	4 (22.2)	6 (31.6)
Medical-surgical	8 (21.6)	4 (22.2)	4 (21.2)
Emergency/trauma	5 (13.5)	1 (5.6)	4 (21.2)
Oncology	3 (8.1)	1 (5.6)	2 (10.5)
Other	11 (29.7)	8 (44.4)	3 (15.8)
Previous experience with self-explanation as a learning tool, *n* (%)			
Yes	0 (0)		
No	37 (100)		
Mean self-rated familiarity with chest pain (*SD*)	1.4 (0.6)	1.6 (0.7)	1.3 (0.48)
Mean self-rated familiarity with dizziness (*SD*)	5.4 (2.4)	5.4 (2.7)	5.4 (2.2)
Mean self-rated familiarity with abdominal pain (*SD*)	5.9 (1.7)	6.1 (1.7)	5.6 (1.7)

Diagnostic Accuracy Scoring

The ICC was 0.98 for diagnostic accuracy scoring. Students overall demonstrated low levels of diagnostic accuracy (Figure 1), with diagnostic accuracy scores ranging between 0 and 0.67 (Table VIII). Individual case studies differed in terms of diagnostic accuracy scores, with the vertigo case scoring the highest (*M* = 0.43) and the pericarditis case scoring the lowest (*M* = 0.11).

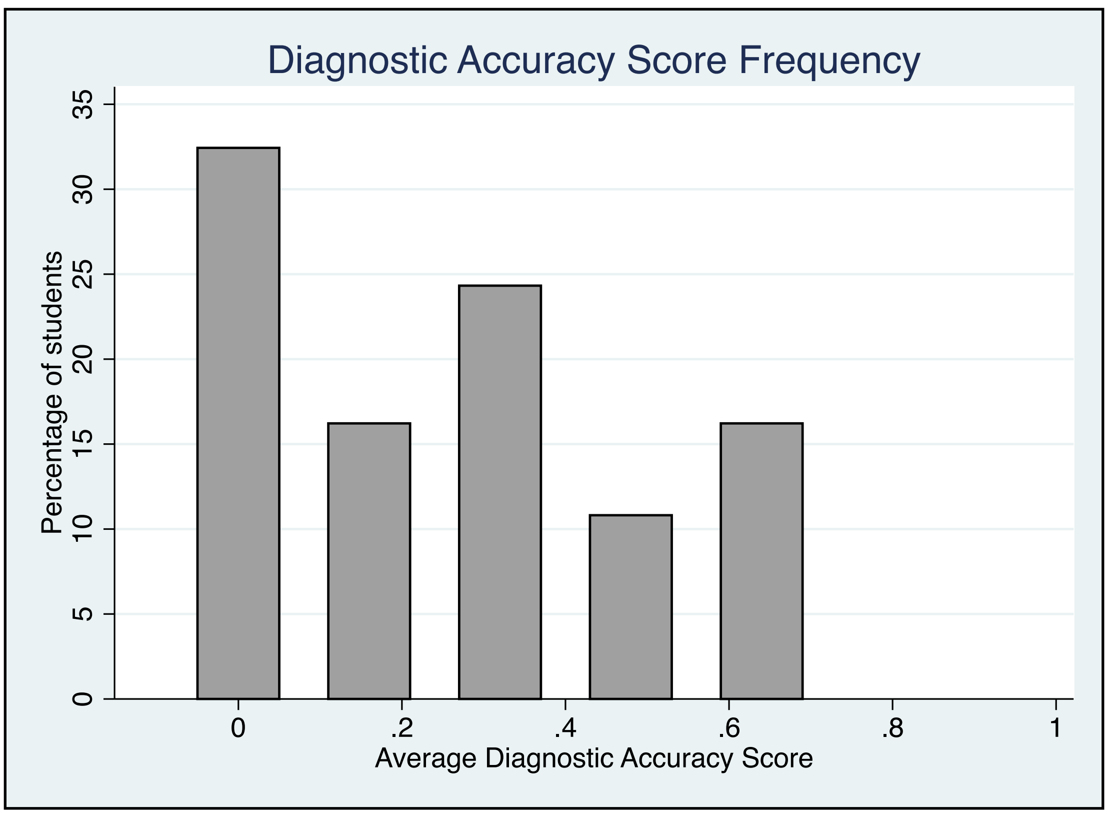

Figure 1. Average diagnostic accuracy scores.

Table VIII

Mean Diagnostic Accuracy and Self-Explanation Scores

	Total (n = 37)		
	Mean	Standard Deviation	Score Range
Diagnostic Accuracy Scores			
Average Diagnostic Accuracy	0.27	0.24	0 – 0.67
Vertigo case diagnostic accuracy	0.43	0.43	0 – 1.0
Pancreatitis case diagnostic accuracy	0.24	0.43	0 – 1.0
Pericarditis case diagnostic accuracy	0.11	0.29	0 – 1.0
Self-Explanation Scores			
Total inference	0.24	0.02	0.04 – 0.59
Clinical inference	0.20	0.11	0.03 – 0.54
Biological inference	0.04	0.06	0 – 0.28
Non-Inference	0.76	0.12	0.41 – 0.96

Self-Explanation Scores

Students most frequently applied non-inference statements, with scores ranging between 0.41 and 0.96 (Table VIII). The use of inference self-explanations varied widely, with this score ranging from 0.04 to 0.59. In terms of types of inferences spoken, students on average more frequently applied clinical inferences (*M* = 0.20) and less frequently applied biological inferences (*M* = 0.04).

Differences between Expertise Levels

Differences between expertise and mean self-explanation scores are shown in Table IX. On average, expert students voiced more inference self-explanations than novice students and fewer non-inference statements. Expert students used both more clinical inferences and biological inferences than novice students. Expertise group trends in self-explanation scores are illustrated in Figure 2. Diagnostic accuracy scores did not significantly differ between groups (Table IX).

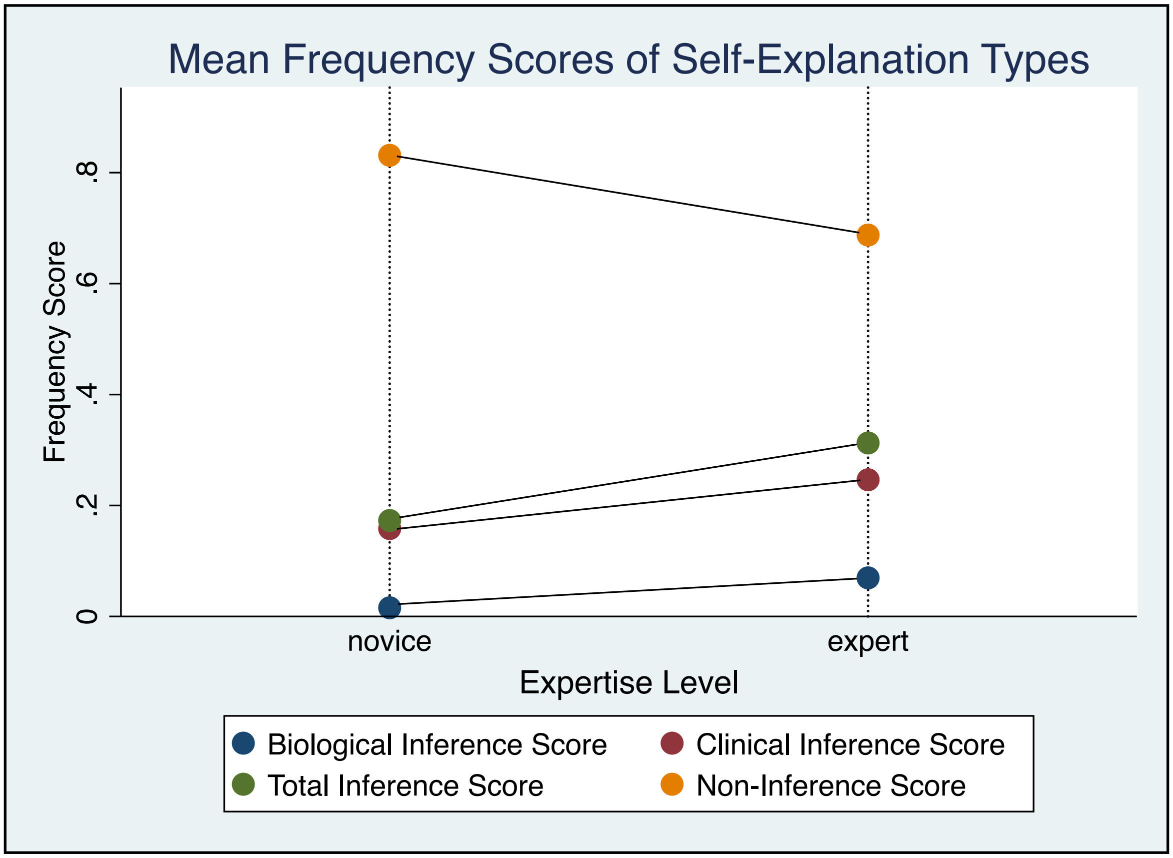

Figure 2. Self-explanation score trends, based on expertise level. This figure visually illustrates how self-explanation score trends differ between novice and expert students. Non-inference scores decrease with increasing expertise; inference scores, biological inference scores, and clinical inferences scores all increase with increasing expertise.

Table IX

Self-Explanation and Diagnostic Accuracy Scores, Compared in Terms of Expertise Level

	Novice		**Expert**		***t***	***p*-value**
N	18		19			
	Mean	Standard deviation	Mean	Standard deviation		
Self-Explanation Score						
Total inference	0.17	0.02	0.31	0.03	-4.13	0.0002
Clinical inference	0.16	0.07	0.25	0.13	-2.51	0.0165
Biological inference	0.02	0.01	0.07	0.07	-3.17	0.0031
Non-inference	0.83	0.63	0.69	0.79	4.25	0.0002
Diagnostic Accuracy Score	0.21	0.20	0.32	0.28	-1.42	0.1636

Relationships between Diagnostic Accuracy Scores and Self-Explanation Scores

Diagnostic accuracy scores were moderately associated with inference scores, $r(35) = 0.37$ ($p < 0.02$). A significant negative association was observed between diagnostic accuracy scores and non-inference scores: $r(35) = -0.36$ ($p < 0.03$). Diagnostic accuracy scores were significantly associated with biological inference scores: $r(35) = 0.49$ ($p < 0.002$). Diagnostic accuracy scores were not significantly associated with clinical inference scores: $r(35) = 0.14$ ($p < 0.39$).

Discussion

Results from this study extend the current understanding of how NP students self-explain when solving written case studies. Specifically, this study provides evidence that (1) expert students self-explain in different ways than novice students and (2) diagnostic accuracy is related to biological self-explanations.

Expertise

Expert students self-explained with approximately 11% more inference self-explanations than novice students, applying both clinically and biologically focused inferences more frequently than novices. On the other hand, novice students used significantly more non-inference, superficial statements. As an educational technique that supports learning by restructuring knowledge representations stored in memory, the contrasting self-explanation patterns observed in this study suggest that knowledge representations evolve with student experience.

This finding is consistent with the knowledge encapsulation theory of medical expertise development. This theory asserts that medical knowledge is structured, stored in memory, and applied to clinical problem solving differently based on provider expertise level (Schmidt et al., 1990; Schmidt & Rikers, 2007). Beginning students store knowledge in elaborate, unpracticed networks that have yet to be condensed and organized. Over time, repeated patient encounters help to unite and give depth to disparate facts. Eventually, the mental disease representations of experts become highly practiced, containing experientially gained patient characteristics, causal disease mechanisms, and in-depth knowledge (Boshuizen & Schmidt, 1992; Charlin et al., 2000; Schmidt & Rikers, 2007).

A key tenet of medical expertise development is that, as beginner students gain knowledge (before amassing years of provider-level clinical experiences), they begin to successfully frame diagnostic problems in terms of underlying biological processes. Boshuizen and Schmidt (1992) reported that the proportion of biologically focused spoken propositions almost doubles between second- and fourth-year medical students when solving written case studies (Boshuizen & Schmidt, 1992). The current study replicated this trend in NP students. While preclinical NP students used few biological self-explanations, more advanced NP students used a significantly higher proportion. As both NP and medical students progress in their programs of study, biological knowledge application increases in diagnostic reasoning.

On the other hand, clinical inference scores obtained in this study support the idea that NP students structure medical knowledge in terms of clinical findings. A possible explanation lies within the definition of an NP: an advanced practice registered nurse. While students in this study were new to the NP role, they had on average 6.3 years of clinical nursing experiences, most of which took place in hospital-type settings. From the onset of their graduate education, NP students possess nursing experiences that deepen their ability to clinically structure information. As students gain additional clinical experiences in their NP programs, this capacity significantly increases.

Diagnostic Accuracy

Diagnostic accuracy was significantly associated with biological inferences that students make while self-explaining, but accuracy was not associated with clinical inferences. These findings highlight the critical role that biological knowledge plays in the diagnostic processes of beginner diagnosticians. Because clinical knowledge is immature in beginner students, biological knowledge provides cohesive mental frameworks for novices to interpret challenging patient presentations. This finding is consistent with previous studies showing that biological knowledge supports diagnostic accuracy by providing students with meaningful causal relationships, linking disparate clinical findings to common root causes (Woods, 2007; Woods et al., 2005, 2007a, 2007b). For example, in a study by Woods, Brooks, and Norman (Woods et al., 2005) (2005), students learning underlying pathophysiological mechanisms responsible for signs and symptoms demonstrated greater diagnostic accuracy after a one-week delay, compared to students learning non-biological conditional disease probabilities. Because participants were medically naïve, the authors concluded that biological knowledge provided conceptual coherence to disease categories, whereas lists of signs and symptoms were more haphazard (Woods et al., 2005). The importance of biological knowledge's causal role in linking clinical features with diagnoses was also emphasized in an experiment in which students were taught artificial diseases with and without causal explanations. Students learning causal mechanisms, once again, better retained diagnostic accuracy over time (Woods et al., 2007a). This trend was replicated when students were asked to solve difficult-level cases embedded with novel terminology (Woods et al., 2007b).

In addition to being key to diagnostic accuracy, biological knowledge also plays a significant role in deeper, reflective diagnostic thinking. When medical students were asked to self-explain unfamiliar-topic case studies, they use more biologically focused self-explanations compared to when self-explaining familiar-topic case studies (Chamberland et al., 2013). As students attempt to make sense of challenging clinical findings, biological knowledge is more readily activated in cohesive, explanatory mental frameworks. Because case study topics in the current research were largely less familiar to students, it is plausible that biological knowledge's activation enabled students to make sense of unfamiliar signs and symptoms, assisting accuracy.

Limitations

Sampling occurred within one educational program, at one college of nursing, potentially decreasing the ability to generalize findings. The small sample size limited statistical power and advanced statistical analyses in some instances. Lastly, while many students successfully solved the case studies, there were lower-than-anticipated levels of diagnostic accuracy, limiting variability of this measure.

Strengths

The high response rate (54%) increases confidence in the quality and representativeness of the student sample. In order to increase the precision of data and decrease the dependence upon individual case study characteristics, average scores generated over the course of multiple case studies were used for analyses. In addition, a high degree of agreement was achieved between raters assigning diagnostic accuracy scores, indicating that this measure was a reliable reflection of the data, and not due to inadvertent measurement error (Cicchetti, 1994).

Summary and Areas for Future Research

This study provides foundational information linking ways of self-explaining to markers of diagnostic success, so that in the future self-explanation may be more robustly applied to teaching student NP's diagnostic accuracy. Engaging in self-explanation improves mental representations of knowledge, facilitating both learning of didactic information and solving of problems (Chi, 2000; Chi et al., 1989). Findings suggest that expert students self-explain in different ways than novice students, using more inference self-explanations and less non-inferences statements. Biologically focused self-explanations were associated with levels of diagnostic accuracy, highlighting the critical role that biological knowledge plays in both expertise development and diagnostic accuracy.

Findings of this study should guide the development of diagnostic accuracy interventions leveraging biologically focused self-explanations. Educational curricula should integrate anatomy, physiology, and pathophysiology into disease-state courses, supporting students to view patient presentations in terms of underlying biology from the onset of their education. Future research should explore the effectiveness of these interventions and curricular changes on diagnostic accuracy within actual clinical settings. Fostering the momentum created by this study will improve the ways we teach NP diagnostic accuracy in hopes of ultimately promoting patient well-being.

IV. DISCUSSION

Integrative Summary of Findings

Accurately diagnosing patients is a vital skill that nurse practitioners (NPs) must frequently and fluently execute in order to facilitate positive patient outcomes (American Association of Nurse Practitioners, 2019a). However, there is currently a major gap in educational best practices regarding how to foster diagnostic accuracy among NP students (Burt & Corbridge, 2018). The ramifications of this educational gap are demonstrated by the fact that misdiagnoses, originating from all provider types, remain the most common cause of medical error in the United States (U.S.) (Makary & Daniel, 2016). Diagnostic errors contribute to notable patient harm, preventable death, and disability (Balogh, 2015).

The purpose of this dissertation research was to explore self-explanation, a promising learning strategy that has the potential to foster more effective diagnostic accuracy among NP students. Self-explanation is defined as the purposeful technique of generating self-directed explanations to process novel information while problem-solving (Chi et al., 1989). When students self-explain, they actively improve knowledge structures within their memories. As a result, self-explanation facilitates both problem-solving accuracy and learning of didactic information (Chi, 2000; Chi et al., 1989; Chi et al., 1994). Critically, however, different ways of self-explaining enhance learning to varying degrees (Chi et al., 1989; Neuman et al., 2000; Pirolli, 1994; Renkl, 1997). High-quality ways that learners self-explain have yet to be explored among NP students. In order to leverage self-explanation in encouraging diagnostic accuracy most effectively, the research outlined in this dissertation addresses this knowledge deficit.

This mixed-methodology content analysis occurred in two phases. Phase one explored the research question: How do NP students self-explain during diagnostic reasoning? Using first-cycle process coding and second-cycle pattern coding, iterative qualitative analysis revealed 17 conceptually meaningful categories of NP diagnostician self-explanation. Individual categories are classified and described as either inference or non-inference types. Inferences are defined as explanations containing novel information, extending above and beyond the given material. Substantive inferences are both insightful and meaningful in terms of solving the diagnostic problem at hand. Inferences were found to have one of two distinct foci: clinical or biological knowledge. Clinical inferences emphasize patient and disease attributes. Biological inferences emphasize principles or mechanisms of underlying disease processes. On the other hand, non-inferences are defined as utterances lacking significant integration of new knowledge. Non-inferences are categorized as either monitoring statements or other types of statements. Monitoring statements reflect the status of students' self-knowledge. Other types of statements represent more shallow information processing.

Phase two further analyzed data using associational and comparative quantitative analysis techniques. The research aims of phase two were twofold: (a) to explore relationships between self-explanation scores and diagnostic accuracy levels, and (b) to compare differences between student expertise levels in terms of diagnostic accuracy scores and self-explanation scores. Associations between the frequency scores of self-explanation types and diagnostic accuracy scores were explored using correlations. Findings showed that, in terms of diagnostic accuracy, the most strongly predictive way of self-explaining is inferring biologically ($r(35) = 0.49$, $p < 0.002$). The association between clinical inference frequencies and diagnostic accuracy scores did reach levels of significance ($r(35) = 0.14$, $p < 0.3$).

Independent-samples *t* tests were used to compare differences between student expertise levels in terms of diagnostic accuracy scores and self-explanation scores. Diagnostic accuracy scores did not significantly differ between groups ($t(35) = -1.42$, $p = 0.1236$). Expert students do, however, self-explain in qualitatively different ways than novice students. On average, expert students use significantly more inference self-explanations (expert: $M = 0.31$ vs. novice: $M = 0.17$, $t(35) = -4.13$, $p = 0.0002$), and less non-inference self-explanations (expert: $M = 0.69$ vs. novice $M = 0.83$, $t(35) = 4.25$, $p = 0.0002$), compared to novice students. This pattern held true for both biological and clinical inference types.

Findings from this study extend the current understanding of NP student diagnostician self-explanation use. Identifying and describing specific ways of NP student self-explanation, exploring relationships between ways of self-explaining and diagnostic accuracy, and comparing differences between student expertise levels in terms of diagnostic accuracy scores and self-explanation scores provides a framework to improve the way that educators teach diagnostic reasoning. Results should guide curricular changes and educational interventions that encourage students to connect clinical features to underlying biological etiologies and disease manifestations.

Future research should explore the effectiveness of curricular changes and self-explanation interventions in terms of diagnostic accuracy, accuracy retention, and knowledge transfer. In addition, future research should explore their impact upon diagnostic accuracy within actual clinical settings. Building on the momentum created by this research may improve how educators teach NP diagnostic reasoning, ultimately mitigating a major issue in today's health care system through promotion of accurate diagnoses and, in turn, patient well-being.

CITED LITERATURE

American Association of Colleges of Nursing. (2017). *Common Advanced Practice Registered Nurse Doctoral-Level Competencies*. http://www.aacnnursing.org/Portals/42/AcademicNursing/pdf/Common-APRN-Doctoral-Competencies.pdf

American Association of Nurse Practitioners. (2018). *The State of The Nurse Practitioner Profession*. https://storage.aanp.org/www/documents/research/2018-NP-Sample-Survey-Report.pdf

American Association of Nurse Practitioners. (2019a). *AANP Data Integrity: National NP Estimates.* https://storage.aanp.org/www/documents/research/2020-NP-Infographic-Final.pdf

American Association of Nurse Practitioners. (2019b). *Standards of Practice for Nurse Practitioners*. https://www.aanp.org/advocacy/advocacy-resource/position-statements/standards-of-practice-for-nurse-practitioners

American Association of Nurse Practitioners. (2019c). *What's a Nurse Practitioner (NP)?* https://www.aanp.org/about/all-about-nps/whats-a-nurse-practitioner

Balogh, E. P., Miller, B. T., Ball, J. R. (2015). *Improving Diagnosis in Healthcare*. T. N. A. Press. http://www.nationalacademies.org/hmd/Reports/2015/Improving-Diagnosis-in-Healthcare.aspx

Barnes, H., Richards, M. R., McHugh, M. D., Martsolf, G. (2018). Rural and nonrural primary care physician practices increasingly rely on nurse practitioners. *Health Affairs, 37*(6), 908-914. https://doi.org/10.1377/hlthaff.2017.1158

Berthold, K., Eysink, T. H. S., Renkl, A. (2009). Assiting self-explanation prompts are more effective than open prompts when learning with multiple representations. *Instructional Science, 37*, 345-363. https://doi.org/10.1007/s11251-008-9051-z

Boshuizen, H. P. A., & Schmidt, H. (1992). On the role of biomedical knowledge in clinical reasoning by experts, intermediates, and novices. *Cognitive Science, 16*, 153 - 184.

Burt, L., & Corbridge, S. (2018, Nov 2). Teaching diagnostic reasoning: a review of evidence-based interventions. *International Journal of Nursing Education Scholarship, 15*(1). https://doi.org/10.1515/ijnes-2018-0003

Burt, L., Corbridge, S., Finnegan, L., Clark, L., Schwartz, A., Corte, C., Quinn, L. (2020). Ways that nurse practitioner students self-explain during diagnostic reasoning. *submitted*.

Chamberland, M., Mamede, S., St-Onge, C., Rivard, M. A., Setrakian, J., Levesque, A., Lanthier, L., Schmidt, H. G., & Rikers, R. M. (2013). Students' self-explanations while solving unfamiliar cases: the role of biomedical knowledge. *Medical Education, 47*(11), 1109-1116. https://doi.org/10.1111/medu.12253

Chamberland, M., Mamede, S., St-Onge, C., Setrakian, J., Bergeron, L., & Schmidt, H. (2015). Self-explanation in learning clinical reasoning: the added value of examples and prompts. *Medical Education, 49*(2), 193-202. https://doi.org/10.1111/medu.12623

Chamberland, M., Mamede, S., St-Onge, C., Setrakian, J., & Schmidt, H. G. (2015). Does medical students' diagnostic performance improve by observing examples of self-explanation provided by peers or experts? *Advances in Health Sciences Education, 20*(4), 981-993. https://doi.org/10.1007/s10459-014-9576-7

Chamberland, M., Mamede, S. (2015). Self-explanation, an instructional strategy to foster clinical reasoning in medical students *Health Professions Education, 1*, 24-33.

Chamberland, M., St-Onge, C., Setrakian, J., Lanthier, L., Bergeron, L., Bourget, A., Mamede, S., Schmidt, H., & Rikers, R. (2011). The influence of medical students' self-explanations on diagnostic performance. *Medical Education, 45*(7), 688-695. https://doi.org/10.1111/j.1365-2923.2011.03933.x

Charlin, B., Tardif, J., & Boshuizen, H. P. (2000, Feb). Scripts and medical diagnostic knowledge: theory and applications for clinical reasoning instruction and research. *Academic Medicine, 75*(2), 182-190.

Chi, M. T. (1997). Quantifying qualitative analyses of verbal data: a practical guide. *Journal of the Learning Sciences, 6*(3), 271-315. https://doi.org/10.1207/s15327809jls0603_1

Chi, M. T. (2000). Self-explaining expository texts: the dual processes of generating inferences and repairing mental models. In R. Glaser (Ed.), *Advances in Instructional Psychology* (pp. 161-238). Lawrence Erlbaum Associates, Inc.

Chi, M. T., Bassok, M., Lewis, M. W., Reimann, P., & Glaser, R. (1989). Self-explanations: how students study and use examples in learning to solve problems. *Cognitive Science, 13*(2), 145-182. https://doi.org/http://dx.doi.org/10.1207/s15516709cog1302_1

Chi, M. T., & VanLehn, K. A. (1991). The content of physics self-explanations. *Journal of the Learning Sciences, 1*(1), 69-105. https://doi.org/http://dx.doi.org/10.1207/s15327809jls0101_4

Chi, M. T. H., de Leeuw, N., Chiu, M.-H., & LaVancher, C. (1994). Eliciting self-explanations improves understanding. *Cognitive Science, 18*(3), 439-477. http://proxy.cc.uic.edu/login?url=https://search.proquest.com/docview/618633865?accountid=14552

Cicchetti, D. V. (1994). Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. Psychological Assessment. *Psychological Assessment, 6*(4), 284-290. https://doi.org/doi:http://dx.doi.org.proxy.cc.uic.edu/10.1037/1040-3590.6.4.284

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement, 20*(1), 37–46. doi:10.1177/001316446002000104

Corbin, J., Strauss, A. (2015). *Basics of Qualitative Research* (4th ed.). SAGE.

Elo, S., Kyngas, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing, 62*(1), 107-115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Geertz, C. (1973). Thick description: Toward an interpretive theory of culture. In *The Interpretation of Cultures: Selected Essays*. Basic Books.

Gilhooly, K. J. (1990). Cognitive psychology and medical diagnosis. *Applied Cognitive Psychology, 4*, 261-272.

Heitzmann, N., Fischer, F., Kuhne-Eversmann, L., & Fischer, M. R. (2015, Oct). Enhancing diagnostic competence with self-explanation prompts and adaptable feedback. *Medical Education, 49*(10), 993-1003. https://doi.org/10.1111/medu.12778

Kanmen, D. L., Hingle, S. T. (2013). *Resident Readiness: Internal Medicine*. McGraw Hill Education

Kuo, Y. F., Adhikari, D., Eke, C. G., Goodwin, J. S., & Raji, M. A. (2018, Jan). Processes and outcomes of congestive heart failure care by different types of primary care models. *Journal of Cardiac Failure, 24*(1), 9-18. https://doi.org/10.1016/j.cardfail.2017.08.459

Kurtzman, E. T., & Barnow, B. S. (2017, Jun). A comparison of nurse practitioners, physician assistants, and primary care physicians' patterns of practice and quality of care in health centers. *Medical Care, 55*(6), 615-622. https://doi.org/10.1097/mlr.0000000000000689

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*(1), 159-174.

Lehman, D. R., Lempert, R. O., & Nisbett, R. E. (1988). The effects of graduate training on reasoning: Formal discipline and thinking about everyday-life events. *American Psychologist, 43*(6), 431-442. https://doi.org/http://dx.doi.org/10.1037/0003-066X.43.6.431

Lombard, M., Snyder-Duch, J., & Bracken, C. C. (2002). Content analysis in mass communication: assessment and reporting of intercoder reliability. *Human Communication Research, 28*(4), 587-604. https://doi.org/https://doi.org/10.1111/j.1468-2958.2002.tb00826.x

Lombrozo, T. (2006). The structure and function of explanations. *Trends in Cognitive Sciences, 10*(10), 646 - 470. https://doi.org/10.1016/j.tics.2006.08.004

Makary, M. A., & Daniel, M. (2016). Medical error-the third leading cause of death in the US. *BMJ, 353*, i2139. https://doi.org/10.1136/bmj.i2139

Mamede, S., van Gog, T., Moura, A. S., de Faria, R. M., Peixoto, J. M., Rikers, R. M., & Schmidt, H. G. (2012). Reflection as a strategy to foster medical students' acquisition of diagnostic competence. *Medical Education, 46*(5), 464-472. https://doi.org/10.1111/j.1365-2923.2012.04217.x

Mamede, S., van Gog, T., Sampaio, A. M., de Faria, R. M., Maria, J. P., & Schmidt, H. G. (2014). How can students' diagnostic competence benefit most from practice with clinical cases? The effects of structured reflection on future diagnosis of the same and novel diseases. *Academic Medicine, 89*(1), 121-127. https://doi.org/10.1097/acm.0000000000000076

Miles, M. B., Huberman, A. M., Saldana, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook* (3rd ed.). SAGE.

Morgan, P. A., Smith, V. A., Berkowitz, T. S. Z., Edelman, D., Van Houtven, C. H., Woolsen, S. L., Hendrix, C. C., Everett, C. M., White, B. S., Jackson, G. L. (2019). Impact of physicians, nurse practitioners, and physician assistants on utilization and costs for complex patients. *Health Affairs, 38*(6), 1028-1036. https://doi.org/10.1377/hlthaff.2019.00014

Muhoza-Butoke, C., St-Onge, C., Chamberland, M. (2018). Self-Explanation as a strategy for supporting the development of diagnostic reasoning in medical students: an exploratory study on knowledge development. *Health Professions Education, 4*, 78-85.

National Organization of Nurse Practitioner Faculties. (2017). *Nurse Practitioner Core Competencies Content* https://c.ymcdn.com/sites/www.nonpf.org/resource/resmgr/competencies/2017_NPCoreComps_with_Curric.pdf

Neuman, Y., Leibowitz, L., & Schwarz, B. (2000). Patterns of verbal mediation during problem solving: A sequential analysis of self-explanation. *Journal of Experimental Education, 68*(3), 197-213. https://doi.org/http://dx.doi.org/10.1080/00220970009600092

Newman-Toker, D. E., Schaffer, A. C., Yu-Moe, C. W., Nassery, N., Saber Tehrani, A. S., Clemens, G. D., Wang, Z., Zhu, Y., Fanai, M., & Siegal, D. (2019). Serious misdiagnosis-related harms in malpractice claims: The "Big Three" - vascular events, infections, and cancers. *Diagnosis (Berl), 6*(3), 227-240. https://doi.org/10.1515/dx-2019-0019

Nokes, T. J., Hausmann, R. G. M., VanLehn, K., & Gershman, S. (2011). Testing the instructional fit hypothesis: the case of self-explanation prompts. *Instructional Science, 39*(5), 645-666. https://doi.org/http://dx.doi.org.proxy.cc.uic.edu/10.1007/s11251-010-9151-4

Olson, A., Rencic, J., Cosby, K., Rusz, D., Papa, F., Croskerry, P., Zierler, B., Harkless, G., Giuliano, M. A., Schoenbaum, S., Colford, C., Cahill, M., Gerstner, L., Grice, G. R., & Graber, M. L. (2019). Competencies for improving diagnosis: an interprofessional framework for education and training in health care. *Diagnosis (Berl), 6*(4), 335-341. https://doi.org/10.1515/dx-2018-0107

Peixoto, J. M., Mamede, S., de Faria, R. M. D., Moura, A. S., Santos, S. M. E., & Schmidt, H. G. (2017). The effect of self-explanation of pathophysiological mechanisms of diseases on medical students' diagnostic performance. *Advances in Health Sciences Education, 22*(5), 1183-1197. https://doi.org/10.1007/s10459-017-9757-2

Pirolli, P., Recker, M. (1994). Learning strategies and transfer in the domain of programming. *Cognition and Instruction, 12*(3), 235-275. https://doi.org/10.1207/s1532690xci1203_2

QSR International. (1999). *NVivo Qualitative Data Analysis Software* [Software]. Available from https://qsrinternational.com/nvivo/nvivo-products/

Qualtrics. (2020). *Qualtrics XM Survey Design Software* [Software]. Provo, UT. Available from https://www.qualtrics.com/

Renkl, A. (1997). Learning from worked-out examples: A study on individual differences. *Cognitive Science, 21*(1), 1-29. https://doi.org/http://dx.doi.org/10.1016/S0364-0213(99)80017-2

Renkl, A., Stark, R., Gruber, H., & Mandl, H. (1998). Learning from worked-out examples: the effects of example variability and elicited self-explanations. *Contemporary Educational Psychology, 23*(1), 90-108. https://doi.org/10.1006/ceps.1997.0959

Rittle-Johnson, B. (2006). Promoting transfer: effects of self-explanation and direct instruction *Child Development, 77*(1), 1-15 https://doi.org/10.1111/j.1467-8624.2006.00852.x

Rittle-Johnson, B., & Loehr, A. M. (2017). Eliciting explanations: Constraints on when self-explanation aids learning. *Psychon Bull Rev, 24*(5), 1501-1510. https://doi.org/10.3758/s13423-016-1079-5

Roy, M., & Chi, M. T. H. (2005). The self-explanation principle in multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 271-286, Chapter xvi, 663 Pages). Cambridge University Press, New York, NY. https://doi.org/http://dx.doi.org/10.1017/CBO9780511816819.018

Saber Tehrani, A. S., Lee, H., Mathews, S. C., Shore, A., Makary, M. A., Pronovost, P. J., & Newman-Toker, D. E. (2013). 25-Year summary of US malpractice claims for diagnostic errors 1986-2010: an analysis from the National Practitioner Data Bank. *BMJ Qual Saf, 22*(8), 672-680. https://doi.org/10.1136/bmjqs-2012-001550

Saldana, J. (2016). *The Coding Manual for Qualitative Researchers* (3rd ed.). SAGE.

Sandelowski, M. (2000). Whatever happened to qualitative description? *Research in Nursing and Health, 23*, 334-340.

Schmidt, H. G., Norman, G. R., & Boshuizen, H. P. (1990, Oct). A cognitive perspective on medical expertise: theory and implication. *Academic Medicine, 65*(10), 611-621. https://doi.org/10.1097/00001888-199010000-00001

Schmidt, H. G., & Rikers, R. M. (2007, Dec). How expertise develops in medicine: knowledge encapsulation and illness script formation. *Medical Education, 41*(12), 1133-1139. https://doi.org/10.1111/j.1365-2923.2007.02915.x

Schworm, S., Renkl, A. (2007). Learning argumentation skills through the use of prompts for self-explaining examples. *Journal of Educational Psychology, 99*(2), 285-296. https://doi.org/http://dx.doi.org.proxy.cc.uic.edu/10.1037/0022-0663.99.2.285

Singh, H., Giardina, T. D., Meyer, A. N., Forjuoh, S. N., Reis, M. D., & Thomas, E. J. (2013). Types and origins of diagnostic errors in primary care settings. *JAMA Intern Med, 173*(6), 418-425. https://doi.org/10.1001/jamainternmed.2013.2777

Singh, H., Meyer, A. N., & Thomas, E. J. (2014). The frequency of diagnostic errors in outpatient care: estimations from three large observational studies involving US adult populations. *BMJ Qual Saf, 23*(9), 727-731. https://doi.org/10.1136/bmjqs-2013-002627

Sorinola, O. O., Weerasinghe, C., & Brown, R. (2012). Preventable hospital mortality: learning from retrospective case record review. *JRSM Short Rep, 3*(11), 77. https://doi.org/10.1258/shorts.2012.012077

StataCorp. (2015). *Stata Statistical Software: Release 14*. College Station, TX: StataCorp, LP.

State of Illinois. (2018). Occupational Emplyment Statistics: Wage Data, 2018 Edition. http://www.ides.illinois.gov/lmi/Occupational%20Employment%20Statistics%20OES%20Wage%20Inform/2018.pdf

Toy, E. C., Patlan, J. T. (2013). *Case Files for Internal Medicine* (4 ed.). McGraw Hill Education, Medical

Tracy, S. J. (2010). Qualitative quality: eight "big-tent" criteria for excellent qualitative research. *Qualitative Inquiry, 16*(10), 837-851. https://doi.org/10.1177/1077800410383121

Van de Wiel, M. W., Boshuizen, H.P.A., Schmidt, H. (2000). Knowledge restructuring in expertise development: Evidence from pathophysiological representations of clinical cases by students and physicians *European Journal of Cognitive Psychology, 12*(3), 323-355.

Woods, N. N. (2007). Science is fundamental: the role of biomedical knowledge in clinical reasoning. *Medical Education, 41*(12), 1173-1177. https://doi.org/10.1111/j.1365-2923.2007.02911.x

Woods, N. N., Brooks, L. R., & Norman, G. R. (2005). The value of basic science in clinical diagnosis: creating coherence among signs and symptoms. *Medical Education, 39*(1), 107-112. https://doi.org/10.1111/j.1365-2929.2004.02036.x

Woods, N. N., Brooks, L. R., & Norman, G. R. (2007a). It all make sense: biomedical knowledge, causal connections and memory in the novice diagnostician. *Advances in Health Sciences Education, 12*(4), 405-415. https://doi.org/10.1007/s10459-006-9055-x

Woods, N. N., Brooks, L. R., & Norman, G. R. (2007b). The role of biomedical knowledge in diagnosis of difficult clinical cases. *Advances in Health Sciences Education, 12*(4), 417-426. https://doi.org/10.1007/s10459-006-9054-y

Appendices

Appendix A

Acute Pancreatitis Case Study

Chief complaint:

42-year-old Caucasian female complaining of abdominal pain, nausea, and vomiting

History of present illness:

The patient complains of 24 hours of severe epigastric pain.

The pain radiates to her back.

The pain is steady in character.

She has also had several episodes of nausea and vomiting.

Her nausea and vomiting are worse with oral intake, so she has stopped eating and drinking.

In the past, she has experienced occasional post-prandial RUQ pain.

These episodes always resolved spontaneously within an hour or two.

This time, the pain is in a different position, is much more severe, and is not improving, so she sought medical attention.

Past medical history:

She denies any medical history

Social history:

She is married and has three children.

She drinks alcohol socially a few times a month.

She does not use any tobacco products.

Family history:

The patient's mother is age 78, she is alive and well.

Her mother's gallbladder was surgically removed 3 years ago.

Her father is deceased at age 60 due to alcoholic cirrhosis.

Medications:

She takes no medications.

She tried taking an antacid a few times for the pain, but it did not help at all.

Physical exam:

The patient is moving uncomfortably on the exam table.

Her skin is warm and diaphoretic.

Vitals signs are as follows: Blood pressure of 115/74, heart rate 104 beats per minute, temperature 37.9 degrees C, respiratory rate of 22 breaths per minute.

Her BMI is 18.5.

Her cardiac exam reveals normal S1 and S2, no murmurs or rubs noted.

Clear lung sounds auscultated bilaterally.

She has scleral icterus.

Her abdomen is soft and mildly distended.

Upon palpation, she has significant epigastric pain.

When you palpate her RUQ, she is able to breath adequately.

She does not have rebound tenderness or noted guarding.

Her pain improves slightly when she sits up and bends forward.

Her bowel sounds are hypoactive.

No masses or organomegaly are appreciated.

<u>Diagnostic data:</u>

Her stool is negative for occult blood

A plain film abdominal x-ray shows a non-specific gas pattern, without any gas in in the peritoneal cavity

Glucose level 110 mg/ dl

Lactate dehydrogenase level 310 IU/L (140-280)

Leukocyte count 16,500/mm^3 (4,300-10,800)

Total bilirubin 9.2 g/dl (0.1-1.2 mg/dl)

Alkaline phosphatase 285 IU/L (35-130)

AST 78 IU/L (14-50)

ALT 92 IU/L (5-40)

Lipase 1,024 IU/L (10-140 IU/L)

Case adapted from:
Toy, E.C. and Patlan, J.T. (2013). Case Files for Internal Medicine (4th ed). New York: McGraw Hill Education: Medical.

Appendix B

Acute pericarditis case study

Chief complaint:

A 40-year-old man presents with a two-day history of chest pain

History of present illness:

Yesterday, he woke up with chest pain.

He describes the pain as severe and sharp.

It is located substernal.

The pain is aggravated by cough and deep breathing.

The pain also worsens when lying down.

The pain improves when leaning forward.

He also has a one-week history of sore throat, runny nose, dry cough, and generalized body aches.

He denies dyspnea, orthopnea, paroxysmal nocturnal dyspnea, palpitations, or syncope.

He is physically active and, before getting sick, was training for a marathon.

Past medical history:

He has a history of hypertension, diabetes type 2, and dyslipidemia.

About 3 years ago, he had “a stent thing” placed in his heart.

Social history:

He drinks 1 glass of red wine on most nights.

No history of tobacco or illicit drug use.

Family history:

His dad died at age 85, from "old age."

His mother is alive at age 80. His mother has peripheral vascular disease.

Medications:

hydrochlorothiazide 12.5 mg daily, metformin 850 mg twice daily, lovastatin 20 mg every night

Physical exam:

He is grimacing and appears uncomfortable.

Vitals signs are as follows: Blood pressure of 118/67, heart rate 72, temperature 37.8 degrees C, respiratory rate of 21 breaths per minute.

Lung sounds clear bilaterally.

Abdomen soft, round, non-tender.

Cardiac auscultation reveals normal S1 and S2 heart tones. No S3 or S4 heart tones noted.

There is also a raspy, scratching sound with cardiac auscultation.

The sound is heard best with the stethoscope's diaphragm.

It is loudest over the lower left sternal border.

It is also louder when the patient is leaning forward.

Trace lower extremity peripheral edema noted bilaterally.

Diagnostic data:

WBC 6.8 K/uL (4.8-10.8)

RBC 5.0 M/uL (4.7-6.1)

Hgb 14.6 g/dl (12.6 – 17.4)

Troponin <0.01 ng/ml (<0.02)

Electrocardiogram with diffuse ST segment elevation without reciprocal changes. PR segment depression present in the limb leads.

Chest radiograph without infiltrates, no active disease

Case adapted from:
Klanmen, D.L. and Hingle, S.T. (2013). Resident Readiness: Internal Medicine. McGraw Hill Education.

Appendix C

Benign Paroxysmal Positional Vertigo Case Study

Chief complaint:

48-year-old African American female complaining of dizziness

History of present illness:

The patient complains of two weeks of intermittent dizziness.

When asked to describe what "dizzy" means to her, she relates a feeling of movement even though she is standing still.

The first time it happened, she also felt a little bit nauseated although she did not vomit.

In her job, she has to look down to fold clothes, and significant dizziness occurs if she looks down too quickly.

The dizziness only lasts about a minute.

The dizziness also occurs if she is laying down and rolls over in bed.

She denies chest pain, palpitations, headaches, numbness, and other focal neurological deficits.

Past medical history:

She reports Type 2 diabetes.

She also complains of seasonal allergies.

Social history:

She denies use of marijuana, alcohol, and tobacco.

Family history:

Her father passed away at age 68 from a stroke.

Mother is unknown

Medications:

She takes metformin 500 mg twice daily

Physical exam:

The patient appears comfortable.

Vitals signs are as follows: Blood pressure of 128/68, heart rate 82 beats per minute, temperature 37.4 degrees C, respiratory rate of 16 breathes per minute.

Her abdomen is soft, round, and non-tender.

She has normoactive bowel sounds.

Her cardiac exam reveals normal S1 and S2, no murmurs or rubs noted.

Clear lung sounds auscultated bilaterally.

Pupils are equal, round, and reactive to light and accommodation.

Extraocular movements are intact, without nystagmus.

Cranial nerves 2-12 are intact.

The patient's left tympanic membrane is pearly gray.

An intact cone of light is visible.

The right tympanic membrane is pearly gray.

It is slightly retracted.

An air-fluid level is noted.

There is no erythema or pus in either ear.

The patient becomes dizzy and uncomfortable when attempting to lay supine during the physical examination.

Diagnostic data:

EKG shows normal sinus rhythm

When the patient's head is placed in a right-sided 45-degree rotation and she lays down to a head hanging position, horizontal and rotational eye beats occur after a 5 second lag time.

The quickest eye beats occur in the right-sided direction.

When this maneuver is repeated with her head in a 45-degree left-sided rotation, eye beats are also quickest in the right-sided direction.

Glucose 132 mg/dl (74-106)

Potassium 4.0 mEq/L (3.5-5.0)

Sodium 136 mEq/L (132-146)

Case adapted from:
Toy, E.C. and Patlan, J.T. (2013). Case Files for Internal Medicine (4th ed). New York: McGraw Hill Education, Medical.

VITA

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EDUCATION

Current — PhD candidate, Nursing Science, University of Illinois at Chicago, Chicago, IL
Dissertation Title: *Self-Explanation Use in Nurse Practitioner Student Diagnostic Reasoning*
Committee Members: Susan Corbridge (advisor), Lorna Finnegan, Alan Schwartz, Laurie Quinn, Colleen Corte, Lou Clark
GPA: 4.0

2010 — Master of Science, Primary Care Nurse Practitioner, University of Illinois at Chicago, Chicago, IL

2005 — Bachelor of Science in Nursing, Georgetown University, Washington, DC

CERTIFICATIONS AND LICENSURE

State of Illinois Registered Professional Nurse: Current
Board-Certified Adult Nurse Practitioner, American Nurses Credentialing Center: Current
State of Illinois Advanced Practice Nurse, Certified Nurse Practitioner: Current
State of Illinois Controlled Substance License: Current
DEA License and Registration: Current
American Heart Association CPR for the Professional and ACLS Provider: Current
Trauma Nursing Core Course Certified Provider: 04/2006 to 04/2010

EMPLOYMENT

Academic Positions

2020-Present — Program Director, Adult-Gerontology Primary Care Nurse Practitioner Program (AG-PCNP), Department of Biobehavioral Nursing Science, University of Illinois at Chicago College of Nursing, Chicago, Illinois

2018-Present — Teaching Associate, BSN Program, Department of Biobehavioral Health Science, University of Illinois at Chicago College of Nursing, Chicago, Illinois

2016-2018	Program Coordinator, Adult-Gerontology Primary Care Nurse Practitioner Program (AG-PCNP), Department of Biobehavioral Health Science, University of Illinois at Chicago College of Nursing, Chicago, Illinois
2011-2018	Clinical Instructor/Teaching Associate, Adult-Primary Care Nurse Practitioner Program, Department of Biobehavioral Health Science, University of Illinois at Chicago College of Nursing, Chicago, Illinois

Clinical Positions

2014 - present	Nurse Practitioner, Emergency Department Observation Unit, University of Illinois Medical Center, Department of Emergency Medicine, Chicago, IL
2013 - 2014	Nurse Practitioner, Maxwell Street Immediate Care Clinic, University of Illinois Medical Center, Department of Emergency Medicine, Chicago, IL
2010 - 2011	Nurse Practitioner, Solid Organ Transplant Department, Northwestern Memorial Hospital, Chicago, IL
2006 - 2008	Nurse Transplant Coordinator, Solid Organ Transplant Department, Northwestern Memorial Hospital, Chicago, IL
2005 - 2006	Registered Nurse, Trauma/Surgical Intensive Care Unit, Loyola University Health System, Maywood, IL

<u>HONORS AND RECOGNITIONS</u>

2016	Daisy Foundation Faculty Award Honoring Extraordinary Nursing Faculty, University of Illinois at Chicago College of Nursing
2010	Outstanding Master's Student Award recognizing clinical and academic excellence, Department of Biobehavioral Health Science, University of Illinois at Chicago College of Nursing

<u>FUNDING</u>

Intramural

2019	***Awarded***: Sigma Theta Tau International Honor Society of Nursing, Alpha Lambda Chapter Research Award ($500) *Self-Explanation Use in Nurse Practitioner Student Diagnostic Reasoning* Role: Principal Investigator

Extramural

2019	***Awarded***: American Association of Nurse Practitioners (AANP) Professional Funding Grant

($5,000)
Self-Explanation Use in Nurse Practitioner Student Diagnostic Reasoning
Role: Principal Investigator

RESEARCH

2020- Ongoing

Student Perceptions of Telehealth-focused Learning (Principle Investigator)

A mixed-methods study exploring NP student perceptions of curricular changes integrating Telehealth-focused learning into a clinical course

Specific aims: (1) describe NP student perceptions of a multi-modality, telehealth-focused clinical course; (2) determine the impact of telehealth-focused simulation experiences on NP student learning satisfaction; (3) determine the impact of telehealth-focused simulation experiences on NP student learning confidence

2019 - Ongoing

Self-Explanation Use in Nurse Practitioner Student Diagnostic Reasoning (Principle Investigator)

PhD Dissertation Research at the University of Illinois College of Nursing: A mixed methods content analysis, addressing diagnostic reasoning education in Nurse Practitioner students

Specific aims: (1) qualitatively describe the ways that student nurse practitioners self-explain problem solving steps while partaking in diagnostic reasoning of written case studies; (2) quantify and explore the relationships between types of self-explanations, diagnostic accuracy, and student expertise level

2019 – Ongoing

Nurse Practitioner Preceptor Perception of Support (Co-Investigator)

Member of the Faculty and Preceptor Development Committee (National Organization of Nurse Practitioner Faculties (NONPF)) work-group, facilitating a state-wide survey and needs assessment addressing support of NP preceptors

Specific aims: (1) quantify the current, perceived level of precepting support among NP preceptors in the state of Illinois; (2) identify specific support gaps, so as to facilitate implementation of targeted support from program faculty

2019 - Ongoing

First Death: High Fidelity Hybrid Simulation (Co-Investigator)

(In kind) Member of the “First Death” research group at the at the University of Illinois College of Medicine, Simulation and Integrative Learning Institute (SAIL), Department of Medical Education: A mixed-methods, single group pre-post intervention study utilizing high-fidelity, hybrid simulation and grounded theory component data analysis

Specific aims: (1) explore the inner journey of pre-clinical medical students experiencing a structured, hybrid-simulation of death; (2) explore the inner journey of educators, clinicians, and actors facilitating a high fidelity, hybrid simulation death

PUBLICATIONS (*denotes peer-reviewed)

***Burt, L.** & Corbridge, S. (2018). Teaching Diagnostic Reasoning: A Review of Evidenced-Based Interventions. International Journal of Nursing Education Scholarship. 15(1), 1 – 14. https://DOI.org/10.1515/ijnes-2018-0003

*O'Dell, A., **Burt, L**., Diegel-Vacek, L., Corbridge, S**.** (2018). COPD Guideline Update. American Journal of Nursing. September, 118(9), 36–47. http://dx.doi.org/10.1097/01.NAJ.0000544950.73334.58

***Burt, L.,** & Corbridge, S. (2013). COPD Exacerbations: Evidence-based guidelines for assessment and management. *American Journal of Nursing, 113*(2):34-43. http://dx.doi.org/10.1097/01.NAJ.0000426688.96330.60

INVITED PRESENTATIONS

International

2020 **Burt., L.,** Clark, L., Park, C., Blackie, M., Yingling, S., Park, Y.S., & Kiser, B. (2020, January). *First death: The inner journey of learners in a patient death hybrid-simulation.* Professor Rounds Abstract Poster Presentation, delivered at the 20th International Meeting on Simulation in Healthcare (IMSH 2020), San Diego, CA.

National

2020 **Burt, L**. & Corbridge, S. (Invited 2020, June; conference cancelled due to pandemic precautions). *Accurate diagnoses, positive outcomes: Maximizing nurse practitioner diagnostic accuracy*. 60-minute podium presentation, to be delivered at the 2020 American Association of Nurse Practitioners (AANP) annual conference, New Orleans, LA.

2020 Park, C., Clark, L., Blackie, M., **Burt, L**., Yingling, S., Park, Y.S., & Kiser, B (invited 2020, June; conference cancelled due to pandemic precautions). *First death: A mixed methods approach to simulation innovation and research*. 60-minute innovation and discussion presentation, to be delivered at the 2020 Association of Standardized Patient Educators (ASPE) Conference, Portland, OR.

2019 Corbridge, S. & **Burt, L.** (2019, June). *Interpreting Pulmonary Function Tests.* Learning Workshop, presented at the 2019 American Association of Nurse Practitioners (AANP) annual conference, Indianapolis, IN.

2018 **Burt, L**. (2018, April). *Diagnostic reasoning: Evidenced-based educational interventions*. Podium presentation, delivered at the 44th annual conference of the National Organization of Nurse Practitioner Faculties (NONPF), Indianapolis, IN.

PROFESSIONAL ACTIVITIES AND SERVICE

Professional Organizational Committees

2018-Present **Member,** Faculty and Preceptor Development Committee, National Organization of Nurse Practitioner Faculties (NONPF)

Professional Service

2019 **Abstract Reviewer**, National Organization of Nurse Practitioner Faculties (NONPF) 46^{t} Annual NONPF Conference, Chicago, IL

Professional Organizational Membership

National Organization of Nurse Practitioner Faculties (NONPF)
American Association of Nurse Practitioners (AANP)
Society to Improve Diagnosis in Medicine (SIDM)
Society for Simulation in Healthcare (SSH)
Sigma Theta Tau Nursing Honor Society, Alpha Lambda Chapter

Manuscript Reviews

2020 – ongoing Invited reviewer for *Nursing Education in Practice*

2018 - 2019 Invited reviewer for *International Journal for Nursing Education*

ACADEMIC SERVICE – UNIVERSITY OF ILLINOIS AT CHICAGO

Administrative Appointments

2020 – Present Program Director, Adult-Gerontology Primary Care Nurse Practitioner Program (AG-PCNP), Department of Biobehavioral Nursing Science, University of Illinois at Chicago College of Nursing, Chicago, Illinois

Leadership and oversight of this program in the Chicago, Peoria, Urbana, Quad Cities, Springfield and Rockford campuses, including mentoring of Clinical Instructors in AG-PCNP program in all regional sites

2002 - 2014 Program Coordinator, UIC College of Nursing Adult-Gerontology Primary Care Nurse Practitioner (AG-PCNP) Program

Leadership and oversight of this program in the Chicago, Peoria, Urbana, Quad Cities, Springfield and Rockford campuses, including mentoring of Clinical Instructors in AG-PCNP program in all regional sites

Department of Biobehavioral Health Science Committees
*elected

2012 – 2019 *Peer Review Committee

TEACHING – UNIVERSITY OF ILLINOIS AT CHICAGO

Interprofessional Collaboration

2019 - current Participant in the “First Death” Simulation Experience for 275-300 second year medical students at the University of Illinois (Graham Clinical Performance Center). Assumed role of “Embedded Participant” during high fidelity simulation, facilitating medical student participation and achievement of pre-defined learning outcomes (40 hours per year)

Course Development

2020 Developed course content on telehealth-focused advanced practice nursing care, including multiple telehealth-focused high-fidelity standardized patient simulation experiences; two lectures; and student assessments (NURS 539)

2019 Developed course content on nursing research and scholarly publications, including lecture and evaluation materials, to be integrated into a senior-level BSN nursing course (NURS 387)

2018 Developed an evidenced-based remediation program to be integrated as needed into Adult-Gerontology Primary Care Nurse Practitioner courses (in NURS 539, NURS 540, NURS 541)

2017 Developed multiple high fidelity simulation scenarios to be integrated into Adult-Gerontology Primary Care Nurse Practitioner courses (in NURS 539, NURS 540, NURS 541)

2016 Developed and integrated case-based learning into Adult-Gerontology Primary Care Nurse Practitioner courses (in NURS 539, NURS 540, NURS 541

Courses Taught

Course	Role	Years	Enrollment
NURS 539: Nurse Practitioner Practicum 1, Management of Health and Illness in Adults	Course Coordinator	2020	6
NURS 387: Senior Seminar	Course Co-Coordinator	2019-2020	85 - 87
NURS 377: Integrative Practice Experience	Course Co-Coordinator	2018-2019	108
NURS 532: Comprehensive Health Assessment for Advanced Nursing Practice	Course Faculty (Lab and Didactic Instructor)	2011 - 2016	30 - 50
NUPR 541: Nurse Practitioner Practicum 3, Management of Health and Illness in Adults	Course Coordinator	2016 - 2018	1 - 12
NUPR 540: Nurse Practitioner Practicum 2, Management of Health and Illness in Adults	Course Coordinator	2016 - 2018	1 - 12
NUPR 539: Nurse Practitioner Practicum 1, Management of Health and Illness in Adults	Course Coordinator	2016 - 2018	1 - 12
NUPR 541: Nurse Practitioner Practicum 3, Management of Health and Illness in Adults	Course Faculty	2011 - 2016	4 - 16
NUPR 540: Nurse Practitioner Practicum 2, Management of Health and Illness in Adults	Course Faculty	2011 - 2016	4 - 16
NUPR 539: Nurse Practitioner Practicum 1, Management of Health and Illness in Adults	Course Faculty	2011 - 2016	4 - 16

Guest Lectures at the University of Illinois

2014 - present NURS 533: Applied Pharmacology
Prescribing in the Elderly: Renal Considerations (1 hour)

2010 NURS 535: Advanced Pathophysiology Across the Lifespan
Diabetic Kidney Disease: Pathophysiology and Clinical Implications (1 hour)

Advising

2018 – current Currently advises 7 Graduate Entry Master of Science – Advanced Generalist Nursing Students

2016 - 2018 Advisor to 5 master's level Adult-Gerontology Primary Care Nurse Practitioner Students

2012 - 2016 Advisor to 12 Adult-Gerontology Primary Care and Acute Care Nurse Practitioner Students

Additional teaching experience

2014 – current	Clinical Preceptor for Nurse Practitioner students, Emergency Department Observation Unit, University of Illinois Medical Center, Department of Emergency Medicine, Chicago, IL

VOLUNTEER EXPERIENCE AND PUBLIC SERVICE

2020 – Present	Member of Medical Advisory Committee, Unity Preschool, Evanston, IL
	Provides advanced practice nursing guidance and leadership in regards to nursing best practices and school operations during world-wide pandemic
2018 – 2019	Kindergarten Room Parent, Orrington Elementary School, Evanston, IL
2017 – 2018	Preschool Room Parent, Unity Preschool, Evanston, IL
2011 – 2012	Volunteer Nurse Practitioner, Adult Primary Care, CommunityHealth, Chicago, IL
	Provided medical care to low-income adults without health insurance living in the Chicago-land area
2006	Health Education Instructor, Interfaith House, Chicago, IL
	Developed and taught health education classes to homeless individuals in medical recovery
2002 – 2005	Certified Emergency Medical Technician (EMT)-B, Georgetown Emergency Response Medical System, Washington, DC
2004 – 2005	Director of Ongoing Education, Georgetown Emergency Response Medical System, Washington, DC
	Responsible for maintaining clinical competency of volunteer Emergency Medical Technicians (Basic) via on-going educational opportunities such as workshops, lectures, and simulations