TEACHING STRATEGY 1

Cultivating Diagnostic Decision-Making With Problem-Based Learning: From Most Likely to Least Likely

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OUTCOMES

The goal of this problem-based learning (PBL) teaching/learning strategy is to cultivate nurse practitioner (NP) diagnostic reasoning. In this teaching strategy, adult-gerontology acute care nurse practitioner (AGACNP) students synthesize pertinent information from the patient's chief complaint, history, and physical exam to develop a differential diagnosis. Students rank-order the list of differential diagnoses from the most likely diagnostic hypothesis to the least likely hypothesis.

EVIDENCE BASE OF THE TEACHING STRATEGY

In 2000 To Err Is Human highlighted the preponderance of medical errors occurring in the United States (Kohn, Corrigan, & Donaldson, 2000). Although medical error is not captured as a cause of death by the Centers for Disease Control and Prevention, researchers from Johns Hopkins have examined medical death rates and estimate that medical errors may constitute the third leading cause of death in the United States (Makary & Daniel, 2016). The National Academies of Sciences, Engineering, and Medicine (Balogh, Miller, & Ball, 2015) report that diagnostic errors are a source of pervasive errors in healthcare and constitute at least 6% to 17% of adverse events in the hospital. Recent analysis of NPs' medical malpractice claims revealed that 42% of claims were attributable to errors in diagnosis (Sweeney, LeMahieu, & Fryer, 2017).

Diagnostic errors are defined as missed, delayed, or inaccurate diagnoses, and these errors have contributed to some of most serious *adverse events*. Formulating an accurate diagnosis is an important core, foundational competency for all NPs to ensure safe quality care (National Organization of Nurse Practitioner Faculties [NONPF], 2017). To improve healthcare providers' diagnostic reasoning acumen, the National Academies of Sciences, Engineering, and Medicine (Balogh et al., 2015) advocate using advances in the science of education, teamwork, and training in clinical reasoning. PBL is an innovative, evidence-based pedagogy that provides a critical learning environment for teams of students to work through authentic cases, providing multiple opportunities for students to develop and refine their diagnostic reasoning acumen over the course of the program.

PBL is an ideal pedagogy for clinical nurse educators to cultivate diagnostic reasoning. Barrows and Tamblyn (1980), a physician and a nurse, respectively, from McMaster University, developed PBL to provide opportunities for medical students, nursing students, and other healthcare students to acquire knowledge by working toward resolving a problem in a relevant context. PBL is premised on the social constructivist theory of learning, which posits that all

learners “construct” their knowledge in association with others (Bransford, Brown, & Cocking, 1999). Several important teaching and learning principles underlie the operationalization of PBL to learn diagnostic decision-making: (a) learning is inquiry-driven; (b) learning is self-directed; (c) learning is elevated when connections are formed among students, faculty, and content; and (d) learning is enhanced when contextualized and connected to practice (Gewurtz, Coman, Dhillon, Jung, & Solomon, 2016).

Although adoption of PBL has increased over the past 20 years, educational research documenting the effectiveness of PBL has lagged behind implementation. Science educators have promoted the use of empirically validated pedagogies to enhance student performance. Freeman et al. (2014) conducted a systematic review and meta-analysis of 225 studies comparing science, engineering, and mathematics educators who employed active learning strategies, such as PBL, in the classroom to educators who used a traditional lecture format and found that examination performance increased by half a grade and failure rates significantly decreased in active learning classrooms. Many studies have examined the effectiveness of PBL in medical education, but very few nursing educators have examined the effect of PBL on learning outcomes. Nursing researchers conducted a systematic review of eight pre-test, post-test studies comparing nontraditional, non-lecture-based pedagogies with traditional, lecture-based teaching and discovered that non-traditional methods were associated with a greater increase in critical thinking as measured by the California Critical Thinking Disposition Inventory (CCTDI) and California Critical Thinking Skills Test (CCTST); see Lee, Lee, Gong, Bae, and Choi (2016). Three of the eight studies employed PBL and one study used collaborative learning. Likewise, two separate systematic reviews of nursing students have found PBL was more effective for cognitive, affective, and psychomotor learning (Shin & Kim, 2013) and critical thinking (Kong, Qin, Zhou, Mou, & Gao, 2014).

Although advanced practice nursing educators have supported nontraditional teaching pedagogies to promote critical thinking and diagnostic reasoning, no studies have explored the impact of PBL compared with lecture to teach diagnostic decision-making to NPs.

DESCRIPTION OF THE TEACHING STRATEGY

Many human factors and cognitive biases influence our thinking and interfere with our ability to determine the best diagnosis. Seasoned healthcare practitioners and newly graduated NP students alike are vulnerable to a range of cognitive biases. For example, providers may be susceptible to one of the most significant biases known as *anchoring*, or focusing exclusively on one diagnosis without systematically exploring the possibility of other diagnoses. An incomplete search for the cause of a particular problem or diagnosis may lead to a *premature closing* of the case, potentially contributing to a missed diagnosis. Many practitioners adopt *shortcuts*, or heuristics, in the setting of time constraints, potentially excluding important diagnostic possibilities. Additionally, clinicians may be susceptible to the *availability bias*, or overestimating the likelihood of a familiar diagnosis and underestimating diagnoses that are less familiar. Newly graduated NPs may be particularly susceptible to these cognitive biases owing to their inexperience with a wide range of diagnostic patterns.

Experienced clinicians often resort to pattern recognition when formulating a diagnosis based on their experiences with previous patients who have displayed similar symptoms. Relying on pattern recognition may be an expeditious method for quickly diagnosing a problem for a seasoned NP, but it predisposes clinicians to a wide range of cognitive biases. If a provider is not experienced with a particular diagnosis, he or she may neglect to consider that diagnosis. NP students or newly graduated NPs are not able to draw on past experiences to identify different patterns and

will need to use “hypothetico-deductive” reasoning to generate a list of diagnostic possibilities, or a differential, ranging from the most likely diagnostic hypothesis to the least likely diagnostic hypothesis. Hypothetico-deductive reasoning is a logical and deliberate step-by-step process in which a diagnostic hypothesis is generated based on a set of facts or evidence and is most often used by clinicians when confronted with difficult diagnoses. Because of the incongruence between pattern recognition favored by clinicians and the hypothetico-deductive approach used by novice clinicians, it is critical for nursing educators to cultivate diagnostic reasoning in the classroom.

IMPLEMENTATION OF THE TEACHING STRATEGY

Teaching diagnostic reasoning begins in the first clinical course of the Adult-Gerontology Acute Care Nurse Practitioner Program, “Common Health Problems Across the Lifespan.” To help familiarize students with diagnostic decision-making, we introduce readings on diagnostic errors and differential diagnosis and lead students through an exercise in which they explore causes of abdominal pain according to the various locations of the pain and character of the pain. For example, “crampy” pain in the right upper quadrant may occur with disease of one of the underlying anatomical organs such as the biliary tree, resulting in the diagnostic possibility of cholecystitis, choledocholithiasis, or a hepatic abscess. Alternatively, “dull” pain associated with a cough may cause referred right upper quadrant pain from an adjacent organ, such as occurs with pneumonia.

Learners follow a PBL format, composed of a systematic, sequential process of problem-solving beginning with a problem analysis phase, followed by a self-directed learning or investigative phase and culminating in a group-reporting phase. Educators assume the role of facilitators, supporting students in their quest for additional knowledge to develop answers or solutions to a problem. Students in PBL classrooms are assigned to groups of five to eight learners who work together to analyze the case and determine the differential diagnosis and working diagnosis.

Students in this class are asked to imagine they work at “Acute Care General Hospital” and every 2 weeks, they are consulted on a different, progressively challenging case. Working in teams, NP students collaborate on the initial analysis of a patient case scenario, evaluating the history, the physical exam, and preliminary diagnostic tests, if available. Once students have discussed some of their preliminary conceptions of the pertinent positives and pertinent negatives in class, they begin their investigation and analysis of the case over the course of the week on a discussion board. The case analysis begins by asking students to define unknown terms, explore background factors, and examine some of their initial assumptions. For example, in the workup of a 67-year-old African American female patient who presents with a right upper quadrant abdominal pain, students explore the significance of the patient’s ethnicity, gender, comorbidities, and age. Subsequently, they delve into the pathophysiology, the epidemiology, and the diagnostic criteria of a differential or possible diagnosis that may explain the patient’s symptoms. Diagnostic reasoning requires students to gather pertinent information from the chief complaint, history, and physical exam and synthesize that information to systematically explore different diagnostic possibilities. Each student in the group generates a different diagnostic possibility with supportive evidence for the possible diagnosis along with refuting evidence, or evidence that may not support the differential.

When students return to the classroom the following week, they begin the reporting phase during the initial “Teaching Rounds” part of the class. Each student in a group takes 3 minutes to report to their group on their investigation of the background factors, leading to one possible differential. Using cognitive tools such as diagrams, concept maps, or drawings, they describe the pathophysiology and diagnostic criteria of the purported diagnostic possibility along with

evidence for their hypothesis. The group examines both supportive and refuting evidence of each diagnostic hypothesis that may or may not correlate with the constellation of signs and symptoms. Students rank-order the differential and assign probabilities to each of the possible differentials according to the level of supportive evidence and their confidence in the diagnosis. At times, groups use a flip chart to display the order of their differentials, from most likely to least likely.

Once the groups have formulated their list of differentials, we open up the class for a discussion, exploring areas of agreement and disagreement. Students request additional laboratories or diagnostic exams to confirm or refute the top diagnosis or diagnoses. Generating a differential diagnosis is an iterative process, and as additional information is acquired, the order of the differential could and should evolve. By constructing a list of hypotheses or differentials, the likelihood of missing a diagnosis is reduced.

The second week of the case involves the foreground phase or the phase in which students will explore the diagnostic workup and treatment of the hypothetical patient. Students explore the sensitivity, specificity, and the risks and benefits of the diagnostic test. They will describe the specifics of the test and the information necessary to obtain informed consent, if applicable. Results of the tests are provided by the faculty to help students confirm the diagnosis. Once a working diagnosis is achieved, students will determine how best to manage the patient's top working diagnosis. Treatment considerations include evidence-based pharmacotherapy approaches, dietary and activity recommendations, and psychosocial and behavioral interventions.

METHODS TO EVALUATE THE EFFECTIVENESS OF THE TEACHING STRATEGY

As a group, students track their diagnostic accuracy in each clinical class. In Common Health for adult-gerontological students, tracking begins after the midterm with 6 weeks left in the semester. Each case scenario is explored over the course of 2 weeks, meaning that there are three differential assignments for three cases. After the class debrief, groups grade their diagnostic acumen according to a "Diagnostic Differential Rubric." The rubric details how points are assigned for diagnostic accuracy:

- 1 point = constructing a differential, without ranking the order of the differential
- 2 points = the actual diagnosis is one of the seven differentials generated by the group
- 3 points = the actual diagnosis is in the top three differentials generated by the group
- 4 points = the actual diagnosis is the top differential generated by the group

NP students will continue to monitor their diagnostic accuracy over the subsequent three clinical courses in the curriculum. At the end of the program, NP graduates have a record of their diagnostic acumen in the program, consistent with the required transparency and feedback recommended by the practice guidelines. After the completion of the case, students individually reflect on the diagnostic decision-making process for the week with a 2-minute reflection period.

RESOURCES NEEDED TO IMPLEMENT THE TEACHING STRATEGY

Diagnostic reasoning and accuracy require collaboration, communication, and consultation to reduce the number of diagnostic errors. PBL with its emphasis on learning in groups provides a natural learning environment that helps set the stage for students to practice the art and science

of formulating a differential diagnosis, or a working diagnosis, promoting safe, quality care in practice. Most experts recommend facilitators for each small group.

LIMITATIONS OF THE TEACHING STRATEGY

Limitations of this type of learning may include a lack of resources needed to hire additional facilitators to help with each small group. In that case, educators may spend additional, individual time with each group and then open up the discussion for all groups in the classroom to report/discuss their significant findings.

Educators may lack the knowledge and skills to employ PBL in the classroom. Multiple resources, including books, journals, and videos, are available to help educators learn how to implement PBL in the classroom.

Additionally, because there is a lack of evidence documenting the effectiveness of PBL for learning diagnostic reasoning skills, researchers are encouraged to use validated tools such as the critical thinking inventories to measure critical reasoning skills when using PBL to teach students how to formulate differential diagnoses.

SAMPLE EDUCATIONAL MATERIALS

As the NP in the ED, you are called to evaluate Mrs. S. in Room 2A. Mrs. Sally S. is a 42-year-old, Hispanic woman who presents to the ED after experiencing intermittent right upper quadrant pain for the past 2 weeks. She describes the pain as severe and intense and occurring primarily after eating. The pain lasts for about 1 to 3 hours after eating.

Mrs. S.'s past medical history includes hypertension, hypercholesterolemia, obesity, and type 2 diabetes mellitus. She has not had any surgeries in the past. She is allergic to penicillin and reports experiencing hives with penicillin.

Presently, Mrs. S. takes the following medications: metformin 500 mg by mouth BID, HCTZ 25 mg twice per day, and an oral contraceptive, Ortho Tri-Cyclen Lo.

Mrs. S. admits to smoking half a pack of cigarettes per day for the past 20 years. She admits to drinking three to five glasses of wine per week. She is divorced and has three children.

Upon physical exam, Mrs. S. is 5'5" tall and weighs 186 pounds. Her vital signs are blood pressure 150/80 mm Hg; pulse of 110 beats per minute, and a respiratory rate of 22 breaths per minute. Her oxygen saturation on room air is 94%. Physical exam is notable for dry skin and tenting. Her neurological exam is within normal limits, with normal cranial nerve function. Her chest exam reveals S₁, S₂ heart sounds with no rubs, murmurs, or gallops. Pulses are intact throughout, but diminished. Her lung sounds reveal diminished breath sounds in the right lower lobe, otherwise normal. Her abdominal exam reveals a large, protuberant, abdomen, with tenderness over the right upper quadrant, positive Murphy's sign, and positive, but diminished bowel sounds. The patient is able to move all extremities, but sensation is diminished in the plantar aspect of bilateral feet.

Week #1

Phase I: Introduction of the case in class. Ask students to:

- a. Identify all unknown terms.
- b. List pertinent positives and pertinent negatives and how they may relate to the patient's presentation. For example, students will define a "Murphy's sign" or "tenting."

Phase II: Self-directed learning phase/investigative phase conducted by groups on the discussion board. Students will:

- a. Explore the relevant comorbidities and explain how they relate to the patient's presentation.
- b. Explain the mechanism of action of all of the patient's pharmacotherapies and detail how the medication may relate to the patient's presentation.
- c. Explore possible diagnostic hypotheses to explain the patient's symptoms. Describe the symptoms, history, and/or physical assessment data that may support the differential or refute the differential. Consider how likely the diagnostic hypothesis might be.

Phase III: Reporting phase begins with teaching rounds in small groups. Students rank-order the possible differentials, with supportive/refuting evidence. Students will make connections among the chief complaint, history, comorbidities, and physical exam.

- a. Begin the class with teaching rounds. Each student is expected to present the outcomes of his or her investigation over the course of the week. This could include a possible differential, such as cholecystitis, with the pathophysiology, diagnostic criteria, and the evidence for and against this possibility.
- b. Groups rank-order the differentials. Using a flip chart, students detail their differential diagnosis with supportive or refuting evidence.

In the aforementioned case, students will develop multiple connections among the patient's presenting signs, symptoms, history, comorbidities, and medications to support the diagnostic differential.

- Pertinent positives may include the age, patient's history of obesity, a calculated body mass index (BMI) of 30 (obese), and gender. In this case, multiple factors may contribute to an increased risk of cholecystitis due to a combination of obesity, fertility, and female gender.
- The patient's comorbidity of diabetes contributes to an increased risk of infections and increased severity of presentations.
- Sally S.'s medications may increase the risk of cholecystitis and choledocholithiasis. Oral contraceptives increase estrogen and may increase the risk of biliary tract disorders.
- Oral contraceptives, smoking, and diabetes may increase the risk of serious cardiovascular disease. Knowing this, students will calculate the patient's risk of atherosclerotic heart disease using one of several cardiovascular risk calculators.
- Students will generate a list of possible diagnoses by synthesizing pertinent historical data, physical exam data, and presenting signs and symptoms. For example,
 - cholecystitis—supportive/refuting evidence
 - choledocholithiasis—supportive/refuting evidence
 - cholangitis—supportive/refuting evidence
 - pneumonia—supportive/refuting evidence
 - myocardial infarction—cannot miss

REFERENCES

- Balogh, E. P., Miller, B. T., & Ball, J. R (Eds.). (2015). *Improving diagnosis in health care*. Washington, DC: National Academies Press.
- Barrows, H., & Tamblyn, R. (Eds.). (1980). *Problem-based learning: An approach to medical education*. New York, NY: Springer Publishing Company.
- Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academies Press.
- Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, 111(23), 8410–8415. doi:10.1073/pnas.1319030111
- Gewurtz, R. E., Coman, L., Dhillon, S., Jung, B., & Solomon, P. (2016). Problem-based learning and theories of teaching and learning in health professional education. *Journal of Perspectives in Applied Academic Practice*, 4(1), 59–70. doi:10.14297/jpaap.v4i1.194
- Kohn, L. T., Corrigan, J., & Donaldson, M. S. (Eds.). (2000). *To err is human: Building a safer health system*. Washington, DC: National Academies Press.
- Kong, L., Qin, B., Zhou, Y., Mou, S., & Gao, H. M. (2014). The effectiveness of problem-based learning on development of nursing students' critical thinking: A systematic review and meta-analysis. *International Journal of Nursing Studies*, 51(3), 458–469. doi:10.1016/j.ijnurstu.2013.06.009
- Lee, J., Lee, Y., Gong, S., Bae, J., & Choi, M. (2016). A meta-analysis of the effects of non-traditional teaching methods on the critical thinking abilities of nursing students. *BMC Medical Education*, 16(1), 1–9. doi:10.1186/s12909-016-0761-7
- Makary, M. A., & Daniel, M. (2016). Medical error—The third leading cause of death in the US. *BMJ*, 353(2139), 1–5. doi:10.1136/bmj.i2139
- National Organization of Nurse Practitioner Faculties. (2017). *Common advance practice registered nurse doctoral-level competencies*. Retrieved from <https://cdn.ymaws.com/www.nonpf.org/resource/resmgr/competencies/common-aprn-doctoral-compete.pdf>
- Shin, I., & Kim, J. (2013). The effect of problem-based learning in nursing education: A meta-analysis. *Advances in Health Science Education*, 18(5), 1103–1120. doi:10.1007/s10459-012-9436-2
- Sweeney, C. F., LeMahieu, A., & Fryer, G. E. (2017). Nurse practitioner malpractice data: Informing nursing education. *Journal of Professional Nursing*, 33(4), 271–275. doi:10.1016/j.profnurs.2017.01.002