Patient simulator to drive diagnostic thinking process and deep learning

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Abstract

Abstract

Background
The aim of this study was to evaluate clinical reasoning of the diagnostic thinking process among student nurses in pre-enrollment nursing programs in two different educational institutions using a patient simulator.

Method
This study adopted a quasi-experimental design. Problem behavior graphs (PBGs) were drawn to reflect the participants' clinical reasoning processes. Biggs' Study Process Questionnaire (SPQ) was used to evaluate their study approaches into six sub-scales.

Results
Forty-two subjects were randomly drawn from students of two pre-enrollment nursing programs: 21 from a college and 21 from a hospital-based nursing school. Subjects from the college had more data driven strategy (53%) in the problem behavior graphs (PBGs). They used more surface strategy than subjects from the nursing school (47%).

Conclusions
Results pinpoint data-driven strategy in nursing education helps to improve the current nursing education in Hong Kong. Only if the ability to master diagnostic thinking process from student nurses ensures patient safety in clinical environments.

Key words

Deep Learning, Nursing Education, Study Approach, Patient Simulator, Patient Safety, Diagnostic Thinking Process, Think Aloud

1. Background

Diagnostic reasoning is about evaluating patients' situations, seeing their needs and problems, establishing priorities in nursing, and finally making nursing decisions about the patient's care. It can also be described as a process whereby knowledge and experience are applied to clinical situations in order to develop nursing solutions (Thompson, Cullum, Mccaughan, Sheldon, and Raynor, 2004). This process that takes place when making judgments about clinical situations can also be named critical thinking, reflective reasoning, or decision-making.

One previous study found that, when facing unfamiliar or complex conditions in clinical situations, students typically used a hypothetico-deductive approach in their diagnostic reasoning. This approach involves systematically acquiring and validating cues through deliberate observations and measurements so that alternative hypotheses can be accepted, rejected or refined until a decision is reached (Thomas, Petty and Moore, 2013).

Since diagnostic reasoning is an evaluative process that leads to clinical nursing decisions, any mistakes made in diagnosis can severely affect the treatment process and even reverse the beneficial effects of other treatment modalities. Before making decisions, nurses need to evaluate both subjective factors (e.g., descriptions of symptoms by patients) and objective factors (e.g., laboratory data) to decide and perform patient care while simultaneously assessing the immediate and long-term effects of their care interventions. Data-driven strategy in diagnostic reasoning is normally compelled by data, rather than by intuition or personal experience. Because hospitals have a growing proportion of patients with complex health problems (Bright, Walker and Bion, 2004), they when used as clinical learning environments are growing more unpredictable in quality due to nursing shortages and reductions in patients' lengths of stay (Levett-Jones and Bourgeois, 2007). Hospitalized patients were more ill than before and they required more clinical nursing decisions and nursing care.

Diagnostic reasoning may lead to bias. This includes the tendency to unduly favor a hypothesis based on similar past experiences, to look for and/or overemphasize supporting evidence and ignore, rationalize, or fail to seek contradictory evidence, and to accept an hypothesis before adequate testing (Lawson and Daniel 2011). There are cognitive errors in clinical reasoning,

especially those associated with failures in perception and failed heuristics (Croskerry, 2003). A report from the New South Wales Health Patient Safety and Clinical Quality Programme (2006) identified poor clinical reasoning by graduate nurses as a contributing factor in adverse patient incidents (Arthur, Kable, and Levett-Jones, 2010). Hence, training in diagnostic reasoning is important for all nurses because it is a skill that must be developed through study and subsequent practice over time. Diagnostic reasoning is not, or seldom and certainly not comprehensively evaluated in nursing education, particularly in enrolled nurse training. Enrolled nurses' role in residential aged care is vital because residents receiving health care are increasingly frail and vulnerable with multiple chronic illnesses requiring complex medication and health care treatment regimes, and enrolled nurses are predominantly the health care in charge. Failure to take care of residents adequately in residential aged care settings not only leads to costly hospital admission but also to adverse health effects for residents.

Teaching factors contribute to the study approach adopted by students (Biggs, 1987; Cavanagh, Hagan and Ramgopal, 1994) whereas study approach in turn impacts the diagnostic reasoning process (Wong and Chung, 2002). Motive and strategy are the two components in Biggs' delineation of the study approach. Motive is the 'why' that a student wants to approach a task, and strategy is the 'how' that the student approaches the task. There are three common approaches to learning: surface, deep, and achieving. For the surface approach, a student seeks only to carry out the task, usually because of external positive and/or negative consequences. His or her motive to learn is only to complete the task. A typical style of this learning is rote learning. When learning by rote, students do not seek or see the interconnections between meanings and implications of what is learned. The deep approach, however, is based on internal motivation or curiosity. This approach invokes processes of a higher cognitive level than rote learning, for example, searching for analogies, relating to previous knowledge, and theorizing about what is learned. The third one is the achieving approach which is focused on some end products. In schools, students using the achieving approach seek to maximize the chances of obtaining high marks. In a word this learning is the means, not the end (Biggs, 1987). As in the surface approach, achievement is measured by some external scales.

Previous literature (Cavanagh, Hagan and Ramgopal, 1994; Wong and Chung, 2002) suggested that a number of factors influence the study approach a student will take, such as the quality of

teaching and/or students' workload. Good teaching can motivate students to take a deep approach while poor teaching in the widest sense can cause students to take a surface approach. Biggs defined good teaching as the encouragement of a deep approach to learning. Higher order objectives are also more likely to encourage students to take a deep approach to learning in the subject (Lubin, 2003). When workload is perceived to be heavy by students, they will often resort to a surface learning approach. No study further investigate is there any association between the types of clinical scenarios and the diagnostic processes.

In view of the above arguments and previous findings, this study was conducted with an aim to evaluate clinical reasoning for clinical decision-making in pre-enrollment nursing programs in two different educational institutions with a patient simulator.

2. Method

An experimental design with a random sequence of clinical scenarios was selected for this study to revealing participants' diagnostic thinking processes. The random sequence mimicked the complexity nurses faced in real-life. As for the evaluation of the study approach of the participants, Biggs' Study Process Questionnaire (SPQ) was used. SPQ has 42 items and it categorizes study approaches into six sub-scales: 1) surface motive, 2) deep motive, 3) achieving motive, 4) surface strategy, 5) deep strategy, and 6) achieving strategy. Each sub-scale contains seven items. The construct validity of the SPQ has been established in a large number of studies and summarized in the works of Biggs (1987), Salehi (2007), and Wong and Chung (2002).

The first scenario was a client with a known specific problem and the second was one with a non-specific problem. The third was an emergency case. Clinical data were entered into the Patient Simulation System (PSS) to ensure the validity of the simulated scenarios. In a past research the use of a patient simulator in testing the clinical performance of the health profession was documented with a high inter-rater reliability (kappa = 0.96) (Devitt et al., 1997). Patient simulators have been applied in health care education for a number of years (Arthur, Kable, and Levett-Jones, 2010). The PSS allows students to perform nursing procedures, e.g., listening to the patient simulator's heart and breath sounds, and feeling the pulsation of its carotid and radial arteries as if they were in a real clinical situation. They can also administer oxygen to the patient simulator, and the gas sensor in the patient simulator can then produce the relevant physiological

response which is shown on a computer screen. Patient simulator was used in the assessment of clinical reasoning because it permitted tracking in detail the interactions between students and the virtual patient (Courteille, Stockeld, Ponzer, and Fors, 2008).

As the simulation sessions were recorded, Problem Behavior Graphs (PBGs) were drawn to determine the participants' diagnostic thinking processes, with a high inter-rater reliability (kappa=0.82), indicating substantial agreement. A problem behavior graph is a method used to analyze and depict the thought processes made explicit when a participant thinks aloud as he or she solves a problem (Dawson and Medler, 2010). The "think aloud" method is an effective way to gain access to the cognitive processes nurses used in their clinical reasoning. Such cognitive processes are reflected as a collection of nodes that are linked together horizontally and vertically on a PBG. A horizontal link represents hypothesis-driven strategies used in decision-making. A hypothesis-driven strategy is employed when a participant formulates hypotheses and tests them by collecting data. A vertical link represents data-driven strategy in decision-making. In this case, a participant uses open-ended exploration of the data and draws conclusions accordingly. The time spent by a participant working on a problem is reflected in both the horizontal and vertical dimensions of the PBG.

3. Procedure

Ethics approval for the study was obtained from the Ethical Review Committee of the College. Prior to the start of the study, the researchers had obtained the participants' written consent. Afterwards, the participants were introduced to the various functions of the patient simulator, for familiarization with the environment of it to reduce likely anxieties. Then they were asked to complete the SPQ and finish the three simulated scenarios in a random sequence. When performing the set of specified tasks, the participants had to think aloud and the processes were videotaped. The participants had one minute to prepare for each scenario. They were informed about the background of the scenarios, including the name, age and medical history of the virtual patient and they were allowed five minutes to complete the tasks in each scenario. Upon completion of the tasks, they were interviewed and asked about their interpretation of the patient's condition, differential diagnosis, and the problems that the patient might have in each simulated scenario. In the process they could terminate a scenario at any time when they believed they had come to a diagnostic label. The simulation sessions were video recorded and

the PBGs were drawn to depict the thought processes made explicit by 'thinking aloud' during the diagnostic reasoning in the three simulated scenarios.

4. Results

A total of forty-two participants, two more than planned, were randomly drawn from students in the last year of the pre-enrollment nursing programs of two institutions: 21 from a hospital-based nursing school (8 male and 12 female) and another 21 from a college 7 male and 14 female). Table 1 shows the study approaches of the participants. The participants using the deep approach, whether they were from the hospital-based nursing school or the college, had higher mean scores in SPQ. All approaches were further analyzed according to their sub-scales and the respective mean scores were shown in Table 2 below.

Table 1. Pattern of study approaches of the subjects

	Mean score	
Approach	College	Nursing school
Surface	47.76	43.10
Deep	49.86	51.86
Achieving	43.71	43.33

Table 2: Pattern of study approaches (sub-scales) among the subjects

	Mean score		T-Test
	College	Nursing school	
Approach			
Surface motive	24.14 (n=21, SD=3.53)	22.19 (n=21, SD=4.29)	0.11
Deep motive	23.81 (n=21, SD=3.22)	25.76 (n=21, SD=3.08)	0.05
Achieving motive	22.05 (n=21, SD=3.75)	20.14 (n=21, SD=4.34	0.14
Surface strategy	23.62 (n=21, SD=2.78	20.90 (n=21, SD=3.21)	0.00
Deep strategy	26.05 (n=21, SD=3.67)	26.10 (n=21, SD=3.08)	0.96
Achieving strategy	21.67 (n=21, SD=3.67)	23.19 (n=21, SD=4.14)	0.21

There were statistically significant differences in the study approaches of deep motive and surface strategy between the two groups, p=0.05 and p=0.00 (p<0.05). The hospital-based nursing school students had higher scores in the deep motive approach. The mean scores in the sub-scales for the nursing school students were higher on deep motive, deep strategy and achieving strategy when compared with those for the college students, while the distribution of the scores in the sub-scales for the college participants was less dispersed.

The processes of the diagnostic reasoning were videotaped. Transcription and coding of data were carried out for analysis. Each diagnostic thinking process was divided into: 1) entry, 2) collect, 3) review, 4) interpret, 5) relate, 6) infer, 7) act, and 8) exit. These eight components represented the different internal knowledge states in clinical decision-making. The transcripts were segmented according to the meanings in relation to the eight components as the participants explored the scenarios. After segmentation, each new knowledge state was coded in ascending order and then each state of knowledge was plotted on the PBGs in sequence, with a time scale running horizontally and vertically (Figure 1 and 2).

Figure 1: Excerpt from a horizontal reasoning pattern

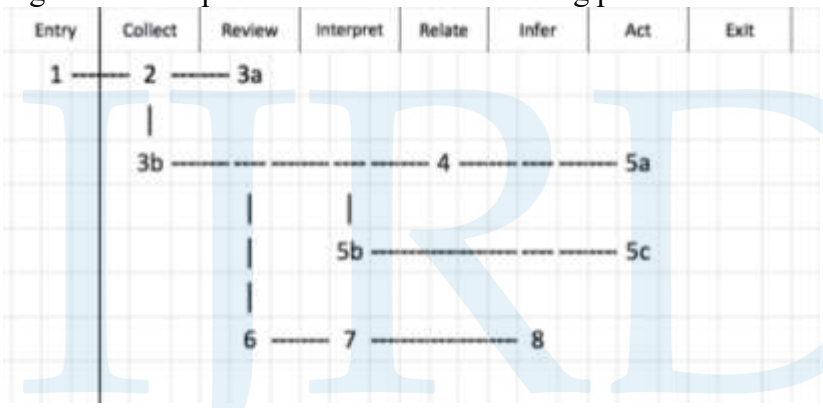
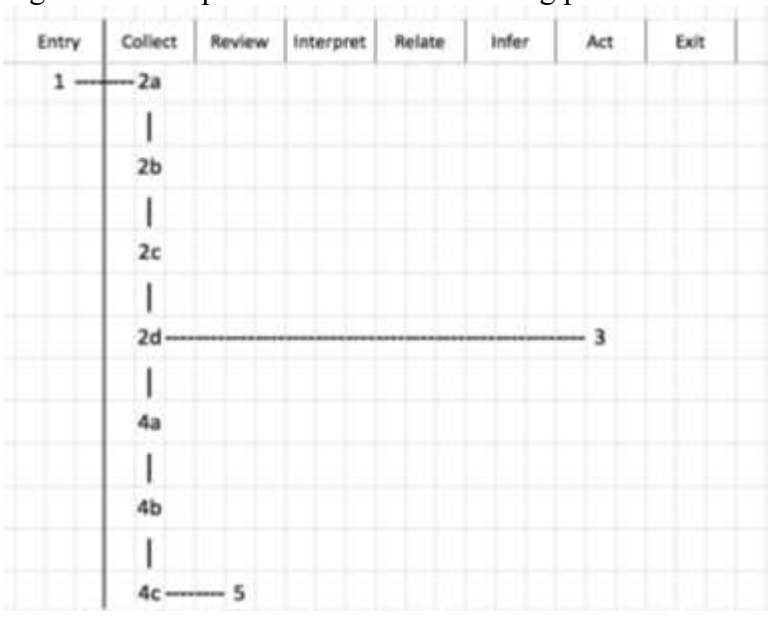


Figure 2: Excerpt from a vertical reasoning pattern



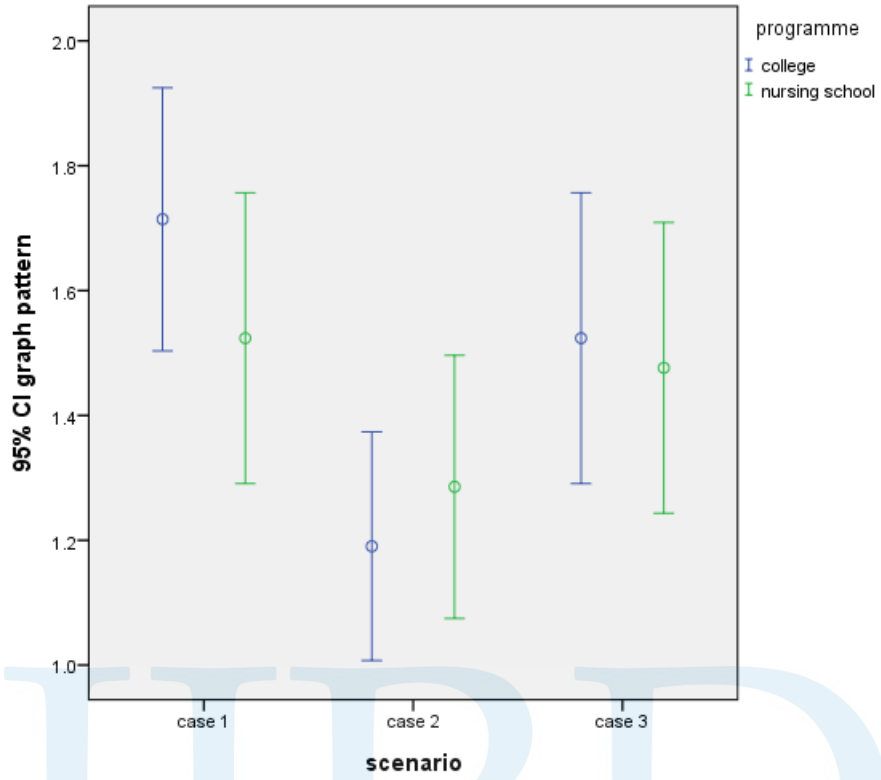
As shown in the figures, the participants from the college had more vertical patterns (data-driven strategy) (53%) in the PBGs than those from the nursing school (47%); whilst it was just the reverse for the horizontal patterns, with nursing school participants showing more horizontal patterns (53%) in the PBGs than the college participants (47%) (Table 3). Overall, there were more horizontal than vertical patterns in the PBGs. As for errors, one participant from the college had made an incorrect differential diagnosis in scenario 2 (a patient with a non-specific problem) and three from the nursing school had made incorrect differential diagnosis - two in scenario 1 (a patient with known specific problem) and one in scenario 2 (a patient with a non-specific problem).

Table 3: Summary of clinical reasoning patterns

Scenario	Programme	Horizontal pattern	Vertical pattern
One	College (n=21)	6 (28.58%)	15 (71.43%)
	Nursing school (n=21)	10 (47.62%)	11(52.38%)
Two	College (n=21)	17 (80.95%)	4 (19.05%)
	Nursing school (n=21)	15 (71.43%)	6 (28.57%)
Three	College (n=21)	10 (47.62%)	11 (52.38%)
	Nursing school (n=21)	11 (52.38%)	10 (47.62%)

There was a significant association between the types of scenarios and the diagnostic processes, $X^2 = 12.89$, $p = 0.00$ ($p < 0.05$) (Figure 3). More participants from college used vertical pattern (data-driven strategy in decision-making) in scenario 1 and 3. More participants from nursing schools use horizontal pattern (hypothesis-driven strategies in decision making) in scenario 2. There was an association between institutions and the study approaches, $X^2 = 33.91$, $p = 0.00$ ($p < 0.05$). College participants had higher scores in both surface strategy and surface motive. Hospital-based nursing school participants used achieving strategy more than college participants.

Figure 3: Comparison of means of case scenario and reasoning pattern



5. Discussion

Participants from the hospital-based nursing school used the achieving strategy as their study approach more, which showed they were more self-disciplined, neat and systematic. On the other hand, the college participants had higher scores in both surface strategy and surface motive. They were typical surface-achievers who often recited systematically selected details to obtain high grades and reproduced what they had learned from memory. Surface and deep study approaches are mutually exclusive, no student would maintain both approaches simultaneously; however each of them may be linked to an achieving approach (Biggs and Moore, 1993). The graduation credit requirements for the two institutions were different and the number of credits was higher in the program of the college. In the college, students' workload was perceived as heavy. It has been suggested that time pressure and stress from assignments may influence the type of learning approach a student develops (Maben, Latter, and Clark, 2006). In cases of extreme pressure, students will attempt to cope by adopting a surface approach to learning.

Comparing the reasoning patterns of the two groups of participants, more than half of the college

participants adopted the data-driven approach (vertical). They used open-ended exploration of data to create linkages between clinical data to arrive at conclusions. Many studies suggested that the use of data-driven strategies is an important aspect of complex learning (Patel, Arocha, Chaudhari, Karliin and Briedis, 2005; Schaaf, 2015). In contrast, more that half of the hospital-based nursing school adopted the hypothesis-driven strategy (horizontal) for decision-making. Results were different from Wong's study (2002) that not all hospital based nursing students adopted hypothesis-driven strategy for decision-making. They formulated hypotheses and tested them by collecting data, analyzing data, and forming conclusions.

A point worth to note is that the differences between the two groups may be due to their different nursing curricula and/or teaching methods. Table 4 below shows the details of the nursing curricula in the two Enrolled Nurse programs.

Table 4: Enrolled Nurse curricula between college and hospital-based nursing school

	College	Hospital-based
Academic qualification	Higher Diploma	Diploma
Qualification of teachers	Master degree	Master degree
Year of study	2	2
Number of clinical practicum weeks	38	50
Number of students	150	100

It was found that there was an association between the types of clinical scenarios and the nature of the diagnostic thinking processes. In scenario 2 (patient with non-specific problem), most of the participants adopted a hypothesis-driven strategy (horizontal) for decision-making. Three participants from the hospital-based nursing school had misdiagnosed three cases (two scenario 1 cases - patient with a known specific problem, and one scenario 2 case - a patient with a non-specific problem). One participant from the college had made one misdiagnosis in scenario 2. The misdiagnosis occurred because of these participants' failure to generate and test alternatives. Participants have more misdiagnosis in scenario with non-specific problem. It is crucial to design relevant and authentic scenarios to assess students' progress in learning diagnostic reasoning skills. With different scenarios, students can be encouraged to read about patients' problems that promote diagnostic reasoning and to avoid rote learning or memorization without context. The results of this study suggested that a scenario-based teaching approach can strengthen the nursing students' diagnostic reasoning ability, thus preparing them to become

competent nurse and ensuring a high quality of patient care and patient safety in both hospital and residential aged care settings.

The findings of this study have also highlighted variations in decision strategies among the students from the two learning environments despite the same set of scenarios were administered to them. A variety of methods for teaching and assessing clinical decision-making were needed. In particular, the use of patient simulation with authentic scenarios allowed the students unlimited practices and encouraged them to generate and test alternatives to minimize misdiagnosis (Berragan, 2011; Bland, Topping, and Wood. 2010). In this study, both participants were weak in patients with non-specific problem, more training and practice on non-specific cases were needed. The use of patient simulation is useful in teaching and learning activities because it can compare students, and teachers can track exactly where and how students go wrong (Wiseman and Horton, 2011; Hope, Garside, and Prescott, 2010). Simulation can be repeated as often as needed and teachers can control the variables to simplify or complicate the process before students confront real situations. Teachers can point out diagnostically meaningful data and identify irrelevant findings to students and this approach provides a positive impact on learning motivation (Oh, Jeon and Koh, 2015).

6. Conclusion

This study was to evaluate the depth of clinical reasoning for decision-making of student nurses pursuing Enrolled Nurse programs in two different educational institutions using a patient simulator. Diagnostic reasoning is an essential part of the nurse training and practices. The students from the hospital-based nursing school adopted the achieving strategy more often than the students from the college whereas the college students scored higher in the surface strategy and the surface motive, revealing their different study approaches. On the other hand, more than half of the college students adopted the data-driven strategy, but the students from the hospital-based nursing school adopted the hypothesis-driven strategy more often in their diagnostic reasoning. It is noteworthy that the differences between the two groups may be due to the different curricula design of the programs in the institutions. We would suggest revisiting the current nursing education in Hong Kong and investigating into the teaching methods and students' workload, especially for the local Enrolled Nurse programs with the goal of fostering a

deep learning approach and an effective reasoning and thinking process. Only if diagnostic reasoning is mastered well will nursing programs be able to prepare students to be competent health care practitioners that ensure patient safety in clinical settings.

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