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Critical thinking skills in nursing students: comparison of simulation-based performance with metrics

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Abstract

Aim—This paper is a report of an examination of the relationship between metrics of critical thinking skills and performance in simulated clinical scenarios.

Background—Paper and pencil assessments are commonly used to assess critical thinking but may not reflect simulated performance.

Methods—In 2007, a convenience sample of 36 nursing students participated in measurement of critical thinking skills and simulation-based performance using videotaped vignettes, high-fidelity human simulation, the California Critical Thinking Disposition Inventory and California Critical

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Conflict of interest
No conflict of interest has been declared by the authors.

Author contributions
LJF, JOD, TGZ, JTS & LAH were responsible for the study conception and design. LJF & JOD performed the data collection. LJF, TGZ & JK performed the data analysis. LJF was responsible for the drafting of the manuscript. JOD, TGZ, AD, JK, JTS & LAH made critical revisions to the paper for important intellectual content. TGZ provided statistical expertize. LJF & LAH obtained funding. LJF, JOD & LAH provided administrative, technical or material support. JOD, TGZ, AD, JK, JTS & LAH supervised the study.

Thinking Skills Test. Simulation- based performance was rated as ‘meeting’ or ‘not meeting’ overall expectations. Test scores were categorized as strong, average, or weak.

Results—Most (75·0%) students did not meet overall performance expectations using videotaped vignettes or high-fidelity human simulation; most difficulty related to problem recognition and reporting findings to the physician. There was no difference between overall performance based on method of assessment ($P = 0{\cdot}277$). More students met subcategory expectations for initiating nursing interventions ($P \leq 0{\cdot}001$) using high-fidelity human simulation. The relationship between video-taped vignette performance and critical thinking disposition or skills scores was not statistically significant, except for problem recognition and overall critical thinking skills scores (Cramer’s $V = 0{\cdot}444$, $P = 0{\cdot}029$). There was a statistically significant relationship between overall high-fidelity human simulation performance and overall critical thinking disposition scores (Cramer’s $V = 0{\cdot}413$, $P = 0{\cdot}047$).

Conclusion—Students’ performance reflected difficulty meeting expectations in simulated clinical scenarios. High-fidelity human simulation performance appeared to approximate scores on metrics of critical thinking best. Further research is needed to determine if simulation-based performance correlates with critical thinking skills in the clinical setting.

Keywords

critical thinking; high fidelity human simulation; nursing students; simulation-based performance; videotaped vignettes

Introduction

Nurses must maintain a high level of vigilance and clinical judgment to detect early changes in patient status signalling the need for intervention (Buerhaus *et al.* 2005). This ability requires critical thinking, problem-solving and communication skills (NACNEP, 1996). In recent years (1995–2005), deficiencies in the transition to full-time practice, training, and competency assessment of healthcare providers have been identified as factors contributing to patient safety errors (JCAHO 2006).

Critical thinking is thought to be a key component of nursing practice, education and knowledge (Alfaro-LeFevre 2004), yet it is ambiguously and inconsistently defined and applied within the profession (Duchscher 2003). Furthermore, the relationship between critical thinking skill and simulated or actual clinical performance is unclear. Paper and pencil assessments of critical thinking pose important challenges (Duchscher 2003) as they represent an assessment of a nurse’s cognitive ability rather than actual clinical performance. Simulated methods, such as videotaped vignettes (VTV) and high-fidelity human simulation (HFHS), offer alternatives to paper and pencil examination. VTV is an assessment based on reflective, written responses elicited from watching a videotape of an actor portraying a patient in a clinical situation. The nurse observes the scenario and gives a written description of proposed actions and rationale (Performance Management Service, Inc. 2007). HFHS is an experiential action assessment method using a lifelike computerized mannequin that can be programmed to respond to real-world inputs. Both methods can be used to identify specific deficiencies and provide remediation to ensure safe practice.

To date, no researchers have evaluated the relationship between scores on standardized critical thinking tests and nurses' clinical performance using simulation-based performance methods such as VTV and HFHS. Furthermore, there is limited literature about areas of weakest performance. Such information is needed to direct efforts at improving education and practice.

Background

Critical thinking

Numerous scholars have attempted to define the essential attributes of critical thinking. The American Philosophical Association concluded that interpretation, analysis, evaluation, inference, explanation, and self-regulation were components (Facione 1990a,b). Watson and Glaser define critical thinking as the ability to recognize the existence of the problem, determine evidence in support of assertions, and apply attitudes and knowledge to logically determine a course of action (Watson & Glaser 1964, 1980). Paul (1993) suggested that critical thinking is characterized by a process of analyzing, synthesizing, and evaluating information collected through observation, reflection, experience, or communication that may lead to a particular belief or action. Others define critical thinking as reasonable and reflective thinking focused on deciding what to believe and do, including the ability to compare and contrast numerous decision alternatives (Landis & Michael 1981, Ennis & Millman 1985). Based on these definitions, critical thinking appears to have several key elements including an individual's ability to seek and comprehend relevant information and an association with knowledge, reasoning, cognitive skills, identification, and exploration of alternative frames of reference.

Nursing competency plays a vital role in assuring patient safety (IOM 2004). Sentinel events commonly occur in acute care settings where new graduate nurses begin professional careers (JCAHO 2006). The ability of new graduates to think critically and intervene effectively is essential. VTV and HFHS are simulation-based methods that can potentially assist in the evaluation and application of critical thinking skills. Given the known risks to patient safety, it is imperative that innovative teaching and evaluation methods be employed to support the development of critical thinking and improve performance outcomes.

Measurement of critical thinking in nursing students

The critical thinking skills of nursing students have been measured predominantly with commercially-developed instruments (Rane-Szostak & Robertson 1996). The California Critical Thinking Disposition Inventory (CCTDI), California Critical Thinking Skills Test (CCTST), and Watson-Glaser Critical Thinking Appraisal (WGCTA) are principally cited in the literature. However, the CCTDI and CCTST have been specifically developed and used with the nursing population.

The CCTDI assesses internal motivation toward critical thinking, for example, the disposition to use or not to use one's reasoning and reflective judgment when solving problems (Facione & Facione 2001). The CCTDI has been used to examine disposition of nursing students at the time of programme entry, exit, and various other times during the

programme (Colucciello 1997, Thompson & Rebeschi 1999). It has also been used to examine the relationships between critical thinking and the US National Council Licensure Examination© (NCLEX-RN) pass rates (Giddens & Gloeckner 2005, Stewart & Dempsey 2005), educational preparation (Shin *et al.* 2006), and alternative pedagogical strategies (Tiwari *et al.* 2006). Scores on the CCTDI have been reported to increase during the educational programme (Colucciello 1997, McCarthy *et al.* 1999, Thompson & Rebeschi 1999, Ip *et al.* 2000) and following curricular enhancements such as the use of problem-based learning techniques and videotaped clinical vignettes (Yeh & Chen 2005, Tiwari *et al.* 2006). However, findings of the relationship between CCTDI and NCLEX-RN scores have been equivocal. In one study (Giddens & Gloeckner 2005), students who passed NCLEX-RN were found to have statistically higher mean exit scores; however, Stewart and Dempsey (2005) found no relationship with NCLEX-RN pass rates.

The CCTST measures the ability of the participant to draw conclusions in the areas of analysis, inference, evaluation, deductive and inductive reasoning (Facione *et al.* 2002). The CCTST has been used to examine the critical thinking ability of students enrolled in baccalaureate programmes (Thompson & Rebeschi 1999, Beckie *et al.* 2001) and Registered Nurse to baccalaureate (RN-BSN) programmes (White & Gomez 2002), and to compare performance on the NCLEX-RN (Giddens & Gloeckner 2005). All but one of the these studies (Beckie *et al.* 2001) showed statistically significant improvement in scores as students progressed to their final year (Colucciello 1997, McCarthy *et al.* 1999, Thompson & Rebeschi 1999, Spelic *et al.* 2001) and higher scores for students who passed the NCLEX-RN© (Giddens & Gloeckner 2005). Curricular revisions and the addition of VTV as a teaching method did not improve CCTST scores (Beckie *et al.* 2001, Chau *et al.* 2001).

Simulation-based performance assessment

Several methods are currently used to test the application of critical thinking skills in a simulated setting. The most widely-published performance assessment tool that uses VTV is the Performance Based Development System (PBDS) (Performance Management Service, Inc. 2007).

The validity and reliability of the PBDS components have been reported (del Bueno 1990, 1994, 2001, 2005). Respondents are asked to view vignettes and describe in writing the actions they would take and their rationale. In 2001, del Bueno reported that 70% of 760 new nursing graduates completing the assessment did not consistently demonstrate the ability to recognize and safely manage patients with commonly-occurring problems. A subsequent larger study showed that up to 76% of 10,988 inexperienced nurses (<1 year experience) failed to meet expectations (del Bueno 2001). Fero *et al.* (2009) reported that 28·5% of 1211 new graduates and 21% of 933 experienced nurses did not meet expectations on the PBDS assessment. Baccalaureate and associate degree nurses were more likely to meet expectations as years of experience increased. A similar trend was not seen for diploma nurses (Fero *et al.* (2009). These results suggest that there are serious deficiencies in the critical thinking ability of new graduate and experienced nurses. Assessments such as the PBDS may facilitate identification of deficiencies and guide development of targeted orientation and remediation.

Few researchers have evaluated outcomes of using HFHS to educate nurses (Alinier *et al.* 2006) and only one study focused on new graduates. Trossman (2005) described the use of HFHS in the transition to full-time practice of new graduates and concluded that HFHS was helpful in recreating low occurrence, high risk situations and overcoming fears of being assertive (Trossman 2005). Nearly half of the educators and baccalaureate students reported that HFHS increased confidence, competency and perceived ability to practise in a real-world setting; the educators considered that skills gained through the HFHS experience would transfer to the clinical environment (Feingold *et al.* 2004). Nevertheless, results of three unpublished dissertations indicate no clear consensus (Wortock 2002, Schumacher 2004, Howard 2007). Wortock (2002) found no statistically significant difference in critical thinking scores when teaching methods included traditional, HFHS, web-based delivery, or web-based and HFHS in combination. Schumacher (2004) exposed students to classroom teaching, HFHS, or a combination of both. Findings indicated a statistically significant difference between critical thinking abilities ($P < 0{\cdot}002$) and learning outcomes ($P < 0{\cdot}001$), favouring simulation or a combination of classroom and simulation (Schumacher 2004). Howard (2007) compared HFHS to interactive case studies. A statistically significant difference was found in knowledge gained and critical thinking ability, with the HFHS group scoring statistically significantly ($P = 0{\cdot}051$) better than the case study group (Howard 2007). No studies were identified that explored the relationship between critical thinking scores using survey instruments and simulation-based performance.

Conceptual framework

The theoretical framework guiding this study was an adaptation of Argyris' and Schon's theories of Action Espoused, what people say they will do, and Theory-in-Use, what people actually do (Argyris & Schon 1974, Argyris 1980). In this study, three elements central to this theory were operationalized: (1) Governing values, that is, values people try to keep within acceptable limits, operationalized as sound clinical performance and judgment (i.e. critical thinking); (2) Action strategies, that is, plans or assessments used to keep governing values within acceptable limits, operationalized as applying critical thinking to accurately assess and plan care; and (3) Outcomes, that is, the intended or unintended consequences of the action, operationalized as critical thinking scores and simulation-based performance.

The study

Aim

The aim of the study was to examine the relationship between metrics of critical thinking skills and performance in simulated clinical scenarios. Specifically, we aimed to:

- Compare simulation-based performance scores for VTV and HFHS;
- Determine the relationship between critical thinking skills scores (CCTST, CCTDI) and simulation-based performance scores (VTV and HFHS).

Design

A quasi-experimental, cross-over design was employed. A within-subject method gave greater study power and reduced error variance associated with individual differences (Hulley *et al.* 2001). The data were collected in 2008.

Participants

A convenience sample of 36 nursing students prepared at the diploma (n = 14), associate (n = 12), or baccalaureate level (n = 10) and in their last term of academic preparation in the spring of 2007 were eligible for inclusion in the study. The study was conducted at a university located in Pennsylvania, United States of America. Diploma programmes offer hospital- based nursing preparation. Associate degree programmes are provided by a community college and are typically 2 years in length. Baccalaureate-prepared nurses have attended a 4-year programme offered by a college or university. Graduates are prepared to assume leadership roles in both inpatient and outpatient settings (All Star Directories, Inc. 2002–2008). All participants were English-speaking, and 18 years of age and older. Potential participants were excluded if they were enrolled in an RN completion or second degree programme, prepared as an emergency medical technician, paramedic, or Licensed Practical Nurse. Because the study was exploratory, sample size was not designed to test hypotheses. Sample size was calculated based on (1) recruitment feasibility and (2) the need to estimate effect sizes concerning the magnitude of relationships among study variables.

Instruments

The CCTDI is a 75-item Likert style attitudinal survey (Facione & Facione 2001). Total CCTDI scores range from 70 to 420. The instrument has seven subscales, each designed to measure a critical thinking habit of mind (Facione & Facione 2001). Each subscale score ranges from 10 to 60. Reliability has been established with a median alpha coefficient of 0·90 and subscale coefficients ranging from 0·71 to 0·80 (Facione & Facione 2001). A meta-study of baccalaureate nursing programmes using the CCTDI indicated sub-scales and overall scale scores correlate statistically significantly with the Academic Achievement Test (ACT) and Scholastic Aptitude Test (SAT) -Verbal assessment scores (Facione, 1997). For this study, total and subscores were categorized into weak, average, or strong critical thinking disposition as follows: <25th percentile (<300) = weak; 25th through 74th percentile (301–341) = average; >74th percentile (≥342) = strong.

The CCTST consists of 34-items that measure an individual's ability to draw conclusions in the areas of analysis, inference, evaluation, deductive, and inductive reasoning (Facione *et al.* 2002). Each item is assigned to one of three subscales; analysis, inference, or evaluation. Thirty of the 34 CCTST items are classified as either inductive or deductive reasoning. The reliability of the CCTST is 0·78–0·80 using the Kuder- Richardson-20 (Facione *et al.* 2002) and correlates positively to grade point average and SAT math and verbal scores (Adams *et al.* 1996, Facione *et al.* 2002). For the purpose of this study, scores and subscores were categorized into strong, average, and weak critical thinking skills as follows: 74th Percentile (≥22) = strong skills; 25th through 74th percentile (16– 21) = average, and<the 25th percentile (<16) = weak.

The VTV/HFHS Assessment Tool was a researcher-developed tool (LF) designed to assess simulation-based performance. Content validity was established from a literature review and input from nurse educators, administrators, clinicians, and simulation experts (n = 17). Inter-rater reliability was established using two independent raters. The tool provides an overall rating of knowledge and performance and six subcategory ratings, that is, recognize the clinical problem, report clinical data, initiate nursing interventions, anticipate medical orders, provide rationale to support decisions, and prioritize care (Table 1). Performance was rated as 'met' or 'did not meet expectations' for the six subcategories and overall performance. To obtain a rating of 'met expectations' for overall performance, students were required to meet expectations in any four of the six categories.

The testing scenario involved assessment and management of a patient with a pulmonary embolism. The scenario was written by a member of the research team (LF) and revised with input from educators and a statistician with expertize in use and assessment of VTV and HFHS. The scenario was pilot tested using five students (not included in the present study) to determine feasibility and clarity of instructions. No problems were identified.

Data collection

The study protocol was completed in one 8-hour session (Figure 1). In *Phase I*, each student completed a demographic profile, CCTDI, and CCTST. In *Phase II*, students were randomized into two groups. Group A received an orientation to VTV and instruction about assessment completion. Each was given a reference sheet containing prompts and examples on how to structure answers. Prior to the study scenario, Group A had the opportunity to participate in a practice VTV session. They viewed a VTV scenario of an actor portraying a patient having a blood transfusion reaction, and were given 10 minutes to complete the assessment individually and identify the patient problem, clinical data to report, nursing interventions they would initiate, anticipated medical orders, rationale for interventions, and the urgency with which they would treat the patient. Model answers were then shared with participants. Next, they were administered the VTV testing scenario, which depicted a postoperative patient experiencing shortness of breath, right-sided chest pain, elevated temperature, and altered blood gas values. Each participant was given 10 minutes to complete the assessment, with the same expectations as previously.

Group B participants received an orientation to HFHS and instructions about HFHS laboratory performance. They were given a reference sheet similar to that used in the VTV assessment to keep with them throughout the simulation. For practice, the group viewed a videotape of a HFHS scenario depicting a postoperative patient having a blood transfusion reaction. Expected performance was then reviewed. Next, they were given an individual orientation to the HFHS equipment and environment. A Laerdal SimMan (Laerdal Corporation, Stevangen, Norway) was used for both the orientation and testing scenario. An operator provided the patient and physician voice. Relevant vital signs were displayed on the monitor. After orientation, each participant entered the testing simulation room alone and was given a script including background information about the patient, as well as any data displayed on the bedside monitor. The HFHS case scenario recreated the same testing case presented in VTV. Students were given 10 minutes to manage the scenario and complete the

assessment. In *Phase III*, assignments were alternated. Group A participated in the same process to become familiar with HFHS and was tested using HFHS, and Group B participated in the same process to become familiar with VTV and was tested using VTV.

Inter-rater reliability was established by having two experienced VTV raters, blinded to group assignment, score participants' performance on the VTV simulation and two different HFHS raters, blinded to group assignment, scoring HFHS performance. Responses were rated by comparing the participants' answers to model answers. Raters determined whether the student met or did not meet expectations on the overall assessment and in each of the six subcategories.

Validity and reliability

Reliability and validity of the CCTDI and CCTST have been previously reported (Beckie *et al.* 2001, Stewart & Dempsey 2005, Shin *et al.* 2006). Measures to ensure reliability of VTV/HFHS ratings included use of expert raters blinded to group assignment and comparison to model answers.

Ethical considerations

Approval to conduct the study was obtained from a university institutional review board. Written informed consent was obtained from all participants.

Data analysis

Statistics were calculated using SPSS/PC+ software version 16.0 (SPSS Inc., Chicago, IL, USA). Descriptive data included age, race, gender, educational programme, internship/residency participation, nursing aide experience, and number of classes within their curriculum using HFHS. The Fleiss crossover binary response chi-square (Fleiss 1986) method was used to compare VTV and HFHS simulation performance scores. This method took into account the cross-over design of the study and tested for order effect. Cramer's V was used to test the relationship between critical thinking disposition and skills (CCTDI and CCTST scores) and simulation-based performance scores (VTV and HFHS). The level of statistical significance was set kat 0·05.

Results

A total of 36 nursing students participated in the study: 38·9% were diploma graduates, 33·3% associate degree graduates, and 27·8% baccalaureate graduates (Table 2). Although a sampling of each preparation level was obtained for comparative purposes, the sample was not adequate to conduct data analysis. The majority were between the ages of 20 and 30 years of age (63·9%) and female (83·3%). Five students (13·9%) reported having participated in an internship/ residency programme, 14 (38·9%) had nursing aide experience, and 24 (67·0%) had simulation experience prior to participation in the study.

Comparison of simulation-based performance

The majority of participants did not meet overall (four of six) expectations on the VTV (75·0%) or HFHS assessment (88·9%) (Table 3), and most were unable to identify essential

clinical data to report to the physician in either VTV (69·4%) or HFHS (75·0%). Primary deficiencies related to inability to anticipate appropriate medical orders (95%) and give a rationale for their decisions (100%). Nevertheless, almost half correctly recognized the clinical problem in VTV (63·9%) and HFHS (41·7%) and initiated appropriate nursing interventions (VTV = 38·9% and HFHS = 72·2%). Students performed well when asked to prioritize the patient condition as urgent (VTV = 97·2% and HFHS = 91·7%). Although some were unable to identify the clinical problem, they were able to identify it as serious and took immediate action by calling the physician.

There was no statistically significant difference between overall VTV and HSHS performance ($P = 0·277$). However, more students initiated nursing interventions in HFHS ($P \leq 0·001$). No statistically significant order effect was found for performance overall or any of the subcategories based on assessment delivery (Table 3).

Relationship between critical thinking scores and simulation-based performance

California Critical Thinking Disposition Inventory scores ranged from 267 to 384 (Table 4). Of the 36 participants, 25·0% had a strong critical thinking disposition, 55·6% were average, and 19·4% were considered weak. The highest mean score (50·33) was achieved for the inquisitiveness subscale. The lowest mean subscale score (41·75) was achieved for truth-seeking.

California Critical Thinking Skills Test scores ranged from 13 to 30. Of the 36 students, 30·6% had strong critical thinking skills, 41·7% were average, and 27·8% were considered weak. The highest mean subscale score (10·83) was achieved for inductive reasoning. The lowest mean score (4·94) was achieved on the analysis subscale.

There was no statistically significant relationship between overall VTV performance and CCTDI (Cramer's $V = 0·145$, $P = 0·683$) or CCTST (Cramer's $V = 0·235$, $P = 0·372$) scores. Analysis of VTV subcategories showed a relationship between problem recognition and overall CCTST scores (Cramer's $V = 0·444$, $P = 0·029$), indicating that students with strong critical thinking skills were more successful at synthesizing clinical data and accurately identifying the clinical problem. There was a statistically significant relationship (Cramer's $V = 0·413$, $P = 0·047$) between overall HFHS performance and CCTDI scores. Students with a strong critical thinking disposition met overall expectations on the HFHS assessment at a higher rate, which included the ability to identify the clinical problem, report essential data to the physician, initiate nursing interventions, and prioritize the care. Conversely, there was a negligible relationship between overall HFHS performance and CCTST scores (Cramer's $V = 0·155$, $P = 0·647$).

Discussion

Simulation-based performance assessment in the nursing population is limited. The literature lacks evidence which encompasses the full use of simulation evaluation, including critical thinking. No studies were identified in which the relationship between traditional measures of critical thinking and simulation-based performance was explored. Furthermore, no studies

were identified in which there was an attempt to determine if performance differences exist based on level of response.

Study limitations

The within-subject method provided greater study power and reduction in error variance associated with individual differences (Hulley *et al.* 2001) However, performance assessments were based on simulated vignettes; it is possible that actual performance may differ from both stated and observed actions in a simulated environment. Student experiences and clinical exposure during their educational tenure may have influenced willingness to volunteer for the study. Those students who agreed to participate may be different from those who did not (e.g. less confident or prepared). Students were required to perform alone in the HFHS scenario; this may have heightened anxiety and influenced performance. Although all types of RN students were represented, the sample was small and limits generalizability.

Critical thinking and simulation-based performance

Results of this study contribute to our understanding of both critical thinking and the transition of certain metrics to simulation-based performance by illuminating areas of potential deficiencies in nursing students. The results suggest that participants had difficulty meeting overall performance expectations with VTV and HFHS. The percentage who did not meet expectations fell within or above the range of previously published results using the PBDS assessment (del Bueno 2005): from a sample size of 10,988 inexperienced nurses (<1 year of experience) between 65% and 76% did not meet expectations on the PBDS. A study completed by Fero *et al.* (2009) showed that 28·5% of 1211 new graduates and 21·0% of 933 experienced nurses (≥1 year of experience) failed to perform to the expected level as measured by overall PBDS results. In the latter study, approximately 57% of nurses not meeting expectations were deficient in problem recognition, 62% did not anticipate medical orders, 65% did not report essential data to the physician, 67% did not differentiate urgency of the clinical situation, and 97% were not able to initiate independent nursing interventions (Fero *et al.* 2009).

Although a majority of our participants had learning needs with regard to identifying the problem, reporting clinical data, and anticipating orders, they performed well in initiating nursing interventions and prioritizing the patient. Nursing educators are frequently challenged by large clinical groups, resulting in limited time to focus on the use or application of knowledge and logical reasoning (del Bueno 2005). It is apparent that our students recognized that the situation in both VTV and HFHS was pressing and needed to be reported immediately; however, they struggled with what to report and anticipated treatment. They had more difficulty functioning independently when asked to synthesize the data presented to them in the HFHS environment. This may reflect their unfamiliarity with acting alone, rather than with supported clinical instruction. A majority of nursing programmes rely heavily on multiple-choice examinations in the classroom, and acute clinical situations are often managed by staff nurses due to urgency. This limits opportunities to critique practice and increase independent decision-making ability. Nursing students have limited opportunity to communicate with physicians as this role tends to be assumed by nursing staff to facilitate

taking verbal orders. Finally, these results may reflect a limitation in the tool used to assess both VTV and HFHS performance.

Although no researchers have identified directly compared VTV and HFHS performance, several have investigated the relationship and effectiveness of alternative performance evaluation methods. The ability of VTV to enhance critical thinking ability, as measured by both the CCTST and the nursing knowledge test, was examined by Chau *et al.* (2001). Results indicated that CCTST scores increased slightly, but the difference was not statistically significant. Mean score on the nursing knowledge test did increase ($P = 0{\cdot}01$), indicating that VTV increased knowledge about the management of clinical situations (Chau *et al.* 2001). Rogers *et al.* (2001) evaluated medical students' learning using multiple-choice, structured clinical, and simulation examinations. Their results supported simulation as the superior evaluation tool, because unlike written examinations, the simulator gives an opportunity to evaluate both cognitive and psychomotor skills (Rogers *et al.* 2001). In a prospective, randomized trial, Steadman *et al.* (2006) sought to determine whether full-scale HFHS was superior to problem-based learning in the training of fourth-year medical students in acute care assessment and management skills. The simulation group performed statistically significantly better ($P < 0{\cdot}0001$) in the simulated assessment, leading the authors to conclude that the use of HFHS in the training of medical students in critical assessment is superior to problem-based learning. Other trials comparing HFHS to other innovative educational technologies have shown no difference between methods or that simulation was not as effective (Nyssen *et al.* 2002, Morgan & Cleave-Hogg 2005). In the present study, overall performance in both VTV and HFHS environments was similar, with the exception of a higher performance level in initiating independent nursing interventions via HFHS. Items in this subcategory are weighted heavily in psychomotor skill (lung sound assessment and placing a pulse oximeter/oxygen on the patient). These results may reflect the reality of the HFHS environment and the students' confidence in their skill set. However, when asked to combine cognitive and task-based skills, participants did not perform to the expected level. Although they were able to recognize the situation as urgent and that they needed to report it immediately, many struggled with reporting complete and accurate data to the physician. These results emphasize the importance of investigating alternative methods of promoting communication skills in the context of an urgent situation. HFHS offers this potential.

Results of scores on both the CCTDI and CCTST in the present study fell within or above those previously published in the nursing literature (Colucciello 1997, McCarthy *et al.* 1999, Thompson & Rebeschi 1999, Beckie *et al.* 2001, Giddens & Gloeckner 2005), suggesting that our participants reflect nursing students' critical thinking disposition and skills. We found no relationship between overall VTV and CCTDI or CCTST scores. However, there was a relationship between HFHS performance and overall CCTDI scores. Participants performing well in HFHS had higher CCTDI subcategory scores in analyticity and systematicity. The results suggest these students were more alert to potential problems, able to anticipate consequences, accept challenging situations, and organize their approach to care (Facione & Facione 2001). They appeared to perform better in situations that activated visual, auditory and tactile pathways and evoked a more engaged response. In contrast, those students performing well on the VTV assessment had greater strength in the truth-seeking

and inquisitiveness subcategories of the CCTDI, which indicates greater preference for intellectual curiosity, objectivity, and inquiry (Facione & Facione 2001). VTV testing was carried out using a written assessment, which may indicate that these students perform better when asked to reflect on the situation. The results suggest that students with a strong overall critical thinking disposition and a greater ability to analyze a situation systematically perform better when faced with a clinical scenario that more closely mimics reality, such as those created in HFHS.

Despite favourable reviews of simulation-based methods of critical thinking assessment, quantitative evidence supporting their effectiveness is still lacking (Steadman *et al.* 2006). It is still necessary to correlate simulation-based performance and actual clinical competency (Wong 2004). Several randomized clinical trials have demonstrated the effectiveness of simulation- based training in improving actual clinical performance on procedures, including laparoscopic cholecystectomy (Seymour *et al.* 2002, Grantcharov *et al.* 2003, Cosman *et al.* 2007), colonoscopy (Ahlberg *et al.* 2005), and catheter-based endovascular procedures (Chaer *et al.* 2006). However, these procedural skills may differ from those involved in carrying out the nursing process.

Implications for practice

As competency assessment methods evolve, nursing managers and educators need to prepare for the growing number of new graduate nurses, as they must be able to deliver effective and safe care as early as possible in their careers (Nursing Executive Center 2008). In a recent report published by the US Nursing Executive Center (2008), the authors argued that a broad analysis of new graduate practice is not helpful. Instead, they suggested a detailed evaluation of specific shortfalls that, in turn, help to close the gap in knowledge between academic preparation and practice. Specifically, they identified critical thinking as one of the top priorities.

Competencies include the ability to recognize changes in patient status, anticipate risk, interpret assessment data, facilitate decision-making, and to recognize when to ask for assistance (Nursing Executive Center 2008). The current study illuminated learning needs in the transition into fulltime practice. The results suggest that a clear relationship cannot be drawn between cognitive ability and its application to clinical performance. Although a majority of students had average and strong critical thinking disposition and skills scores, their simulated performance indicated weakness in interpretation of data and decision-making. Both VTV and HFHS appear to have potential utility in assessing achievement of this goal.

Conclusion

Nursing students' performance reflected difficulty meeting expectations when tested in simulated clinical scenarios. Overall performance in HFHS appeared to best approximate scores on the standardized measure of critical thinking disposition (CCTDI). Further research is needed to determine if simulation-based performance correlates with critical thinking skills in the clinical setting. This will allow both nursing educators and

administrators to determine the best, most-cost effective method of evaluating and preparing new graduates for clinical practice.

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References

Adams MH, Whitlow JF, Stover LM, Johnson KW. Critical thinking as an educational outcome: an evaluation of current tools of measurement. Nurse Educator. 1996; 21(3):23–32.

Ahlberg G, Hultcrantz R, Jaramillo E, Lindblom A, Arvidsson D. Virtual reality colonoscopy simulation: a compulsory practice for the future colonoscopist? Endoscopy 2005. 2005; 37:1198–1204.

Alfaro-LeFevre, R. Critical Thinking and Clinical Judgment: A Practical Approach. 3. Saunders, St. Louis: 2004.

Alinier G, Hunt B, Gordon R, Harwood C. Effectiveness of intermediate-fidelity simulation training technology in undergraduate nursing education. Journal of Advanced Nursing. 2006; 54(3):359–369. [PubMed: 16629920]

All Star Directories, Inc. Your Guide to Nursing Education and Careers. 2002–2008. Retrieved from http://www.allnursing-schools.com on March 2008

Argyris, C. Inner Contradictions of Rigorous Research. Academic Press; New York: 1980.

Argyris, C., Schon, D. Theory in Practice: Increasing Professional Effectiveness. Jossey-Bass; San Francisco: 1974.

Beckie TM, Lowry LW, Barnett S. Assessing critical thinking in baccalaureate nursing students: a longitudinal study. Holistic Nursing Practice. 2001; 15(3):18–26. [PubMed: 12120107]

del Bueno D. Experience, education, and nurses' ability to make clinical judgments. Nursing and Health Care. 1990; 11(6):290–294. [PubMed: 2359541]

del Bueno D. Why can't new grads think like nurses? Nurse Educator. 1994; 19(4):9–11.

del Bueno D. Buyer beware: the cost of competence. Nursing Economics. 2001; 19(5):250–257.

del Bueno D. A crisis in critical thinking. Nursing Education Perspectives. 2005; 26(5):278–282. [PubMed: 16295306]

Buerhaus PI, Donelan K, Ulrich BT, Norman L, Williams M, Dittus R. Hospital RNs' and CNOs' perceptions of the impact of the nursing shortage on the quality of care. Nursing Economics. 2005; 23(5):214–221. [PubMed: 16315651]

Chaer RA, DeRubertis BG, Lin SC, Bush HL, Karwowski JK, Birk D, Morrissey NJ, Faries PL, McKinsey JF, Kent KC. Simulation improves resident performance in catheter-based intervention. Annals of Surgery. 2006; 244(3):343–352. [PubMed: 16926560]

Chau JP, Chang AM, Lee IF, Ip WY, Lee DT, Wootton Y. Effects of using videotaped vignettes on enhancing students' critical thinking ability in a baccalaureate nursing programme. Journal of Advanced Nursing. 2001; 36(1):112–119. [PubMed: 11555055]

Colucciello ML. Critical thinking skills and dispositions of baccalaureate nursing students–a conceptual model for evaluation. Journal of Professional Nursing. 1997; 13(4):236–245. [PubMed: 9239982]

Cosman PH, Hugh TJ, Shearer CJ, Merett ND, Biankin AV, Cartmill JA. Skills acquired on virtual reality laporoscopic simulators transfer into the operating room in a blinded, randomized, controlled trial. Medicine Meets Virtual Reality. 2007; 15:76–81.

Duchscher JE. Critical thinking: perceptions of newly graduated female baccalaureate nurses. Journal of Nursing Education. 2003; 42(1):14–27. [PubMed: 12555818]

Ennis, RJ., Millman, J. Cornell Tests of Critical Thinking. Midwest Publisher; Pacific Grove, CA: 1985.

Facione, PA. Critical Thinking: A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction. California Academic Press; Millbrae, CA: 1990a.

Facione, PA. Executive Summary of Critical Thinking: A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction, the ‘‘Delphi Report’’. California Academic Press; Millbrae, CA: 1990b.

Facione, NC. Critical Thinking Assessment in Nursing Education Programs: An Aggregate Data Analysis. California Academic Press; Millbrae, CA: 1997.

Facione, PA., Facione, NC. California Critical Thinking Disposition Inventory: Inventory Manual. California Academic Press; Millbrae, CA: 2001.

Facione, PA., Facione, NC., Blohm, SW., Giancarlo, CA. The California Critical Thinking Skills Test: Test Manual. California Academic Press; Milbrae, CA: 2002.

Feingold CE, Calaluce M, Kallen MA. Computerized patient model and simulated clinical experiences: evaluation with baccalaureate nursing students. Journal of Nursing Education. 2004; 43(4):156–163. [PubMed: 15098909]

Fero LJ, Witsberger CM, Wesmiller SW, Zullo TG, Hoffman LA. Critical thinking ability of new graduate and experienced nurses. Journal of Advanced Nursing. 2009; 65(1):139–148. [PubMed: 19032517]

Fleiss, JL. The Design and Analysis of Clinical Experiments. John Wiley & Sons, Inc; New York: 1986.

Giddens J, Gloeckner GW. The relationship of critical thinking to performance on the NCLEX-RN. Journal of Nursing Education. 2005; 44(2):85–89. [PubMed: 15719716]

Grantcharov TP, Kristiansen VB, Bendix J, Rosenberg J, Funch-Jensen P. Randomized clinical trial of virtual reality simulation for laparoscopic skills training. British Journal of Surgery. 2003; 91:146–150.

Howard, VM. Doctoral Dissertation. University of Pittsburgh; 2007. A comparison of educational strategies for the acquisition of medical-surgical nursing knowledge and critical thinking skills: human patient simulator vs. the interactive case study.

Hulley, SB., Cummings, SR., Browner, WS., Grady, D., Hearst, N., Newman, TB. Designing Clinical Research. 2. Lippincott Williams & Wilkins; Philadelphia: 2001.

Institute of Medicine. Insuring America’s Health: Principles and Recommendations. National Academy Press; Washington, DC: 2004.

Ip W, Lee D, Lee I, Chau J, Wootton Y, Chang A. Disposition toward critical thinking: a study of Chinese undergraduate nursing students. Journal of Advanced Nursing. 2000; 32(1):84–90. [PubMed: 10886438]

Joint Commission on Accreditation of Healthcare Organizations. Root Causes of Sentinel Events. 2006. Retrieved from http://www.jointcommission.org/SentinelEvents/Statistics/on 25 September 2006

Landis RE, Michael WB. The factorial validity of three measures of critical thinking within the context of Guilford’s Structure-of-Intellect Model for a sample of ninth grade students. Educational and Psychological Measurement. 1981; 41(4):1147–1166.

McCarthy P, Schuster P, Zehr P, McDougal D. Evaluation of critical thinking in a baccalaureate nursing program. Journal of Nursing Education. 1999; 39(3):142–144.

Morgan PJ, Cleave-Hogg D. Simulation technology in training students, residents and faculty. Current Opinion in Anesthesiology. 2005; 18(2):199–203. [PubMed: 16534339]

National Advisory Council for Nursing Education and Practice. Report to the Secretary of the Department of Health and Human Services on the Basic Registered Nurse Workforce. Health Resources and Services Administration, Bureau of Health Professions, Division of Nursing; 1996. Retrieved from http://bhpr.hrsa.gov/nursing/nacnep.htm on 25 September 2006

Nursing Executive Center. Bridging the Preparation-Practice Gap: Volume 1: Quantifying New Graduate Nurse Improvement Needs. The Advisory Board Company; Washington, DC: 2008.

Nyssen AS, Larbuisson R, Janssens M. A comparison of the training value of two types of anesthesia simulators: Computer screen-based and mannequin-based simulators. Anesthesia and Analgesia. 2002; 94:1560–1565. [PubMed: 12032027]

Paul, RW. Critical Thinking: What Every Person Needs to Survive in a Rapidly Changing World. Foundation for Critical Thinking; Santa Rosa, CA: 1993.

Performance Management Service, Inc. What is PBDS?. 2007. Retrieved from http://www.pmsi-pbds.com on 12 July 2007

Rane-Szostak D, Robertson JF. Issues in measuring critical thinking: meeting the challenge. Journal of Nursing Education. 1996; 35(1):5–11. [PubMed: 8926519]

Rogers PL, Jacob H, Rashwan AS, Pinsky MR. Quantifying learning in medical students during a critical care medicine elective: A comparison of three evaluation instruments. Critical Care Medicine. 2001; 29(6):1268–1273. [PubMed: 11395619]

Schumacher, LB. Doctoral Dissertation. Duquesne University; 2004. The impact of utilizing high-fidelity computer simulation on critical thinking abilities and learning outcomes in undergraduate nursing students.

Seymour NE, Gallagher AG, Roman SA, O'Brien MK, Bansal VK, Andersen DK, Satava RM. Virtual reality training improves operating room performance: results of a randomized, double-blinded study. Annals of Surgery. 2002; 236(4):458–463. discussion 463–454. [PubMed: 12368674]

Shin K, Jung DY, Shin S, Kim MS. Critical thinking dispositions and skills of senior nursing students in associate, baccalaureate, and RN-to-BSN programs. Journal of Nursing Education. 2006; 45(6): 233–237. [PubMed: 16780012]

Spelic S, Parsons M, Hercinger M, Andrews A, Parks J, Norris J. Evaluation of critical thinking outcomes of a BSN program. Holistic Nursing Practice. 2001; 15(3):27–34. [PubMed: 12120108]

Steadman RH, Coates WC, Huang YM, Matevosian R, Larmon BR, McCullough L, Ariel D. Simulation-based training is superior to problem-based learning for the acquisition of critical assessment and management skills. Critical Care Medicine. 2006; 34(1):151–157. [PubMed: 16374169]

Stewart S, Dempsey LF. A longitudinal study of baccalaureate nursing students' critical thinking dispositions. Journal of Nursing Education. 2005; 44(2):81–84. [PubMed: 15719715]

Thompson C, Rebeschi LM. Critical thinking skills of baccalaureate nursing students at program entry and exit. Nursing and Health Care Perspectives. 1999; 20(5):248–252. [PubMed: 10754847]

Tiwari A, Lai P, So M, Yuen K. A comparison of the effects of problem-based learning and lecturing on the development of students' critical thinking. Medical Education. 2006; 40(6):547– 554. [PubMed: 16700770]

Trossman S. Bold new world: technology should ease nurses' jobs, not create a greater workload. American Journal of Nursing. 2005; 105(5):75–77.

Watson, G., Glaser, EM. Critical Thinking Appraisal Manual. Harcourt, Brace & World; New York: 1964.

Watson, G., Glaser, EM. Critical Thinking Appraisal Manual. Harcourt, Brace, Jovanovich; New York: 1980.

White MJ, Gomez G. Outcomes of critical thinking and professional attitudes in RN/BSN completion programs. Nurse Educator. 2002; 27(2):71–72. [PubMed: 11984392]

Wong AK. Full scale computer simulators in anesthesia training and evaluation. Canadian Journal of Anesthesia. 2004; 51(5):455–464. [PubMed: 15128631]

Wortock, JM. Doctoral Dissertation. University of South Florida; 2002. Brain-based learning principles applied to the teaching of basic cardiac code to associate degree nursing students using the human patient simulator.

Yeh M, Chen H. Effects of an educational program with interactive videodisc systems in improving critical thinking dispositions for RN-BSN students in Taiwan. International Journal of Nursing Studies. 2005; 42:333–340. [PubMed: 15708020]

What is already known about this topic

- Nursing competency plays a vital role in promoting patient safety, and critical thinking is thought to be a key component of nursing practice.
- Deficiencies in critical thinking ability have been identified in new graduate nurses, including the inability to successfully recognize and safely manage patients with commonly-occurring problems or complications.
- The relationship between critical thinking scores on standardized tests and performance in simulated clinical scenarios, including the use of videotaped vignettes and high-fidelity human simulation, has not been explored.

What this paper adds

- The majority of nursing students were unable to perform to the expected level with regard to synthesizing clinical information and reporting clinical findings in simulated clinical scenarios.
- There was no statistically significant difference in overall student performance based on the simulated method of assessing performance using videotaped vignettes or high-fidelity human simulation.
- Students with a strong critical thinking disposition scores were more likely to meet performance expectations when assessed using high-fidelity human simulation.

Implications for practice and/or policy

- Simulation-based performance using videotaped vignettes and high-fidelity human simulation can assist in identifying students' proficiency in problem recognition, reporting essential data, initiating appropriate nursing interventions, anticipating medical orders, providing rationale, and prioritizing.
- Innovative teaching and evaluation methods, including the use of simulation-based performance assessment, may support the development of critical thinking skills and thus improve performance outcomes.
- Further study is needed to determine the role of simulation-based performance methods in assessing critical thinking and predicting clinical performance.

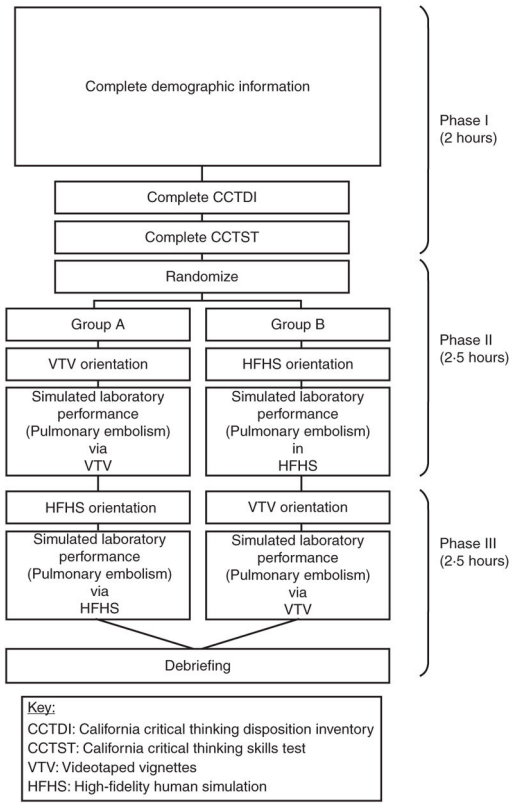

Figure 1.
Study protocol.

Table 1

Videotaped vignette/high-fidelity human simulation assessment tool

Category	Expected subcategory actions (met expectations)
Recognizes clinical problem	Recognizes that the patient is experiencing a pulmonary embolism or pneumothorax.
Reports essential clinical data	Reports that the patient is complaining of chest pain, shortness of breath, and/or compromised respiratory status
	Reports all vital signs
	Reports previously obtained arterial blood gas values
Initiates nursing interventions	Reassures the patient
	Completes a lung sound assessment
	Places a pulse oximeter and oxygen on the patient
Anticipates medical orders	Anticipates an order for a Chest X-ray or Computerized Tomography Scan
	Anticipates an order for an additional arterial blood gas
	Anticipates an order to draw a prothrombin time/partial phromboplastin time
Provides rationale to support decisions	States appropriate rationale for each category
Prioritizes	Notifies the physician immediately of the clinical situation

Subject met expectations if:

Overall = carried out all actions listed in any four of the six categories;

Subcategory = carried out all actions in the subcategory.

Table 2

Participant demographics (n = 36)

Variables	Number (% of total)
Age (years)	
20–23	13 (36·1)
24–30	10 (27·8)
31–54	13 (36·1)
Race	
White	33 (91·7)
African-American	2 (5·6)
Asian	1 (2·8)
Gender, female	30 (83·3)
Educational programme	
Diploma	14 (38·9)
Associate	12 (33·3)
Baccalaureate	10 (27·8)
Internship/residency participation (yes)	5 (13·9)
Nursing aide experience (yes)	14 (38·9)
Number of classes using simulation(yes)	
0 Classes	12 (33·3)
1–2 Classes	14 (38·9)
3–5 Classes	10 (27·8)

Table 3

Comparison of simulation-based performance ($n = 36$)

VTV/HFHS assessment categories	Sample not meeting VTV expectations, *n* (%)	Sample not meeting HFHS expectations, *n* (%)	Results of method comparison (*P*-value)	Assessment delivery order effect (*P*-value)
Overall assessment rating	27 (75·0)	32 (88·9)	0·277	0·731
Recognizes clinical problem	13 (36·1)	21 (58·3)	0·083	0·051
Reports essential clinical data	25 (69·4)	27 (75·0)	1·000	0·354
Initiates nursing interventions	22 (61·1)	10 (27·8)	≤0·001	0·545
Anticipates medical orders	36 (100·0)	35 (97·2)	*	*
Provides decision rationale	36 (100·0)	36 (100·0)	*	*
Prioritizes	1 (2·8)	3 (8·3)	*	*

* Unable to calculate due to the lack of variability in the results.

VTV, videotaped vignette; HFHS, high-fidelity human simulation.

Table 4

Critical thinking disposition and skills scores

		Critical thinking disposition/ skills, *n* (%)		
Measure	**Mean (SD)**	**Weak**	**Average**	**Strong**
CCTDI				
Truth-seeking	41·75 (5·89)	4 (11·1)	15 (41·7)	17 (47·2)
Open-mindedness	45·81 (5·17)	5 (13·9)	20 (55·6)	11 (30·6)
Analyticity	46·08 (5·83)	7 (19·4)	14 (38·9)	15 (41·7)
Systematicity	44·86 (6·08)	9 (25·0)	17 (47·2)	10 (27·8)
Self-confidence	46·33 (7·29)	7 (19·4)	18 (50·0)	11 (30·6)
Inquisitiveness	50·33 (6·36)	9 (25·0)	15 (41·7)	12 (33·3)
Maturity	49·33 (4·53)	6 (16·7)	18 (50·0)	12 (33·3)
Total CCTDI score	324·5 (28·3)	7 (19·4)	20 (55·6)	9 (25·0)
CCTST				
Analysis	4·94 (1·41)	6 (16·7)	14 (38·9)	16 (44·4)
Inference	9·64 (2·56)	9 (25·0)	14 (38·9)	13 (36·1)
Evaluation	5·08 (2·01)	9 (25·0)	15 (41·7)	12 (33·3)
Induction	10·83 (2·48)	8 (22·2)	12 (33·3)	16 (44·4)
Deduction	8·83 (3·20)	10 (27·8)	16 (44·4)	10 (27·8)
Total CCTST score	19·67 (4·65)	10 (27·8)	15 (41·7)	11 (30·6)

CCTDI minimum score achievable = 70, maximum score achievable = 420.

CCTST minimum score achievable = 0, maximum score achievable = 34.

<25th percentile of scores = weak critical thinking disposition/skills.

≥25th to 74th percentile of scores = average critical thinking disposition/ skills.

≥75th percentile of scores = strong critical thinking disposition/skills.