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Research Article

# Effectiveness of Simulation in Nursing Students' Critical Thinking Scores: A Pre-/Post-Test Study

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**KEYWORDS**
simulation;
critical thinking;
clinical reasoning;
nursing education;
nursing students

**Abstract**

**Background:** This study investigated how final-year undergraduate nursing students' critical thinking skills were impacted after attending a purposefully designed 15 hour program with nine hours of simulation-based learning activities aligned with a theoretical framework of clinical reasoning comprising the Clinical Reasoning Cycle and Debriefing for Meaningful Learning.

**Method:** A one-group pre-test post-test design was used. Fifty-six final semester undergraduate nursing students from five campuses of one Australian university participated in this study. Data were collected before and after the simulation program using the Health Sciences Reasoning Test.

**Results:** Analysis of data using paired sample t-tests demonstrated a positive change in critical thinking scores after completing the program (95% confidence interval 0.206-2.079). A total of 62.5% of participants achieved two scores higher after completing the simulation program.

**Conclusions:** Implementing a simulation program designed according to the Clinical Reasoning Cycle and using the Debriefing for Meaningful Learning model is associated with enhancing the critical thinking skills of nursing students.

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## Introduction

Clinical reasoning and critical thinking have been identified as competency deficient in many new graduate nurses (Herron, 2018; Theisen & Sandau, 2013). As a result enhancing critical thinking in undergraduate nursing education is a significant focus of contemporary nursing education research internationally (Alfaro-LeFevre, 2019; Carvalho et al., 2017; Levett-Jones, 2017). Developing critical thinking and clinical reasoning in undergraduate nursing students is important as these attributes are directly associated with enhanced problem-solving, fewer clinical errors, effective clinical judgement, and improved patient safety (Carvalho et al., 2017; Von Collin-Appling & Giuliano, 2017; Zuriguel Pérez et al., 2015). However, teaching critical thinking is challenging due to the complex and tacit nature of this skill (Bjørk, Berntsen, Brynildsen, & Hestetun, 2014; Peters, Halcomb, & McInnes, 2013; Wong and Kowitlawakul, 2020). Critical thinking in students is enhanced if cognitive and metacognitive processes are clearly explained to students and a structured and consistent approach is used (Delany & Golding, 2014; Deschênes et al., 2020; Lee et al., 2020). Educators need to be adequately equipped to convey and engage students in how to apply critical thinking to clinical practice and, in particular, inform students of the dynamic, complex and often subconscious processes involved (Ajjawi & Higgs, 2012; Smith, Loftus, & Levett-Jones, 2013; Wong and Kowitlawakul, 2020). Recommended strategies for teaching critical thinking include using frameworks to guide teaching, concept mapping, problem-based learning, guided reflective discussions of critical incidents, and simulation (Carvalho et al., 2017; LaMartina & Ward-Smith, 2014). Critical thinking in undergraduate nursing students can be improved by simulation-based learning (Blakeslee, 2020; Forneris et al., 2015; Niu et al., 2021). The effectiveness of simulation to enhance critical thinking is dependent on the ability of educators to make the otherwise invisible processes of critical thinking visible to students, and they are guided to get involved in these processes (Forneris et al., 2015; Lee et al., 2020; Zhang, Wang, Goh, Wu, & Mörelius, 2020). It is noteworthy that the phase of simulation, which is often the focus of engaging students in the processes of critical thinking, is the post-simulation debriefing. One model of debriefing specifically developed to enhance critical thinking in undergraduate nursing students is debriefing for meaningful learning© (DML) (Dreifuerst, 2012).

Various research has focused on how simulation-based learning can lead to developing critical thinking in nursing students. However, their main focus has been the post-simulation debriefing or simulation itself, rather than the combination of both (Dreifuerst, 2012; Forneris et al., 2015). A review of the nursing education literature showed that since the inception of DML (Dreifuerst, 2012), four studies have investigated the effectiveness of this structured debriefing framework specifically in improving critical thinking skills in undergraduate nursing students (Catanzaro, 2016; Forneris et al., 2015; Weaver, 2014). The findings of studies investigating the effectiveness of DML (Dreifuerst, 2012) to enhance critical thinking and clinical reasoning differ as not all have shown significant positive impact associated with using DML. Furthermore, an analysis of these papers indicates the following important factors. First, the majority of studies are single site (Catanzaro, 2016; Knoesel, 2017; Mutlu, Yılmaz, & Dur, 2019). This necessitates conducting multisite research. Secondly, studies have explored students allocated to experimental and control groups (Dreifuerst, 2012; Weaver, 2015). However, they did not compare the same group before and after the simulation and debriefing. Third, students' critical thinking and clinical reasoning were measured by different tools, including the Health Science Reasoning Test© (HSRT) (Catanzaro, 2016; Forneris et al., 2015), Lasater Clinical Judgement Rubric (Mariani, Cantrell, Meakim, Prieto, & Dreifuerst, 2013), and Self-Confidence Scale (Weaver, 2014). Fourth, the student exposure to simulation and hence post-simulation debriefing using DML (Dreifuerst, 2012) varied from one (Catanzaro, 2016; Dreifuerst, 2012) to two (Mariani et al., 2013; Weaver, 2014) and three simulation experiences (Forneris et al., 2015). Fifth, whilst all studies indicated the selection or development of simulation scenarios was informed by curriculum content, no studies indicated whether the simulations were designed according to an instructional design framework and, more specifically, a theoretical framework of clinical reasoning (Watts et al., 2021). Hence, the priority is to evaluate the effectiveness of creative and purposefully designed teaching-learning activities, such as aligning simulation and debriefing with a common framework to enhance clinical reasoning skills.

As a result, we propose that a simulation experience that aligns the simulation scenario and the structured debriefing model is educationally sound and beneficial to student development of critical thinking. However, this has received little attention in the literature. This paper contributes to work exploring the enhancement of critical thinking in undergraduate nursing students by designing a simulation program that aligns simulation design and post-simulation debriefing with existing clinical reasoning frameworks.

## Theoretical Framework

The theoretical framework for this study was DML (Dreifuerst, 2012) aligned with the Clinical Reasoning Cycle (CRC) (Levett-Jones et al., 2010). Grounded in the perspectives of Donald Schön (1983), Dreifuerst's (2012) proposed method of DML engages students in the processes of analysis, evaluation, reflection, and anticipation and,

in doing so, guides students to progress 'beyond critical thinking toward the higher thinking skills of clinical reasoning' (p.327). The DML involves six phases: 'engage the participants; explore options by reflecting-in-action; explain decisions, actions and alternatives using deduction, induction and analysis; elaborate through analysis and inferential thinking; evaluate the experience through reflection-on-action; and extend through the processes of inferential and analytic thinking (i.e., reflection beyond-action)' (Dreifuerst, 2012, p. 327). It is believed that DML enhances critical thinking in nursing students (Arizo-Luque et al., 2022; Forneris et al., 2015). The CRC, on the other hand, represents the thinking strategies used by expert nurses in everyday practice situations (Levett-Jones et al., 2010). It is proposed that 'clinical reasoning is a dynamic process including eight phases: consider the patient situation; collect cues and information; process information; identify problems and issues; establish goals; take action; evaluate outcomes and reflect on the process and new learning' (Levett-Jones et al., 2010, p 517). By purposefully aligning the simulation's debriefing with DML and using clinical reasoning in the design of each simulation, the authors aimed to engage the students in a structured debriefing as they went through stages of clinical reasoning with students; as a result, enhancing critical thinking. This study aimed to investigate how third-year undergraduate nursing students' critical thinking skills were impacted after a curriculum redesign by introducing a 15 hour program with nine hours of simulation-based learning activities based on the CRC (Levett-Jones et al., 2010) and DML (Dreifuerst, 2012) frameworks.

## Materials and Methods

### Study Design

This study consisted of a one-group pre-test post-test design whereby participants' critical thinking skills were assessed before and after attending two lectures and nine hours of four different simulations designed according to the CRC (Levett-Jones et al., 2010) followed by DML (Dreifuerst, 2012). Ethical approval was granted by the Australian Catholic University Human Research Ethics Committee (2014 334N). Participants were informed that they were under no obligation to participate and that their participation was voluntary. Also, they were free to withdraw consent and discontinue participation in the research at any time of data collection without giving a reason. Furthermore, the participants were advised that refusal to participate or withdraw from the research would not adversely impact their course progress or future participation in any classes or units employing Simulation-Based Learning or assessment activities.

### Participants and Setting

All students enrolled in a capstone unit of study in the last semester of a three-year undergraduate nursing degree at an Australian university were invited to participate. The university has five campuses in five cities in Australia. The inclusion criterion was any student enrolled in the unit. This mandatory unit was redesigned to meet student and industry needs regarding students' preparedness for practice. There were no exclusion criteria for participation in this study. Based on a power analysis with $p < .05$, a power of .80, and a moderate effect size, at least 34 participants were needed. Fifty-six students from five campuses registered for the study and were included in the analysis of findings. All students gave informed consent and fully participated.

### Procedure

#### Aligning Clinical Reasoning and DML Models

The simulation program for this study comprised 15 hours of learning over two weeks: four hours of lectures introducing the simulation program, four simulations over nine hours, and a two-hour post-simulation lecture reflecting on the program. Simulation scenarios included: identification of deteriorating patient (manikin-based), challenging patient (simulated participant-based), refusal of treatment (video-based) and ward for a day (game-based). The first three scenarios started with a 20- minute briefing, 20-minute simulation, followed by a one-hour debriefing using DML, engaging all students in one group of 20 to 30 students (Dreifuerst, 2012) and was facilitated by two instructors (Table 1). The ward for a day scenario started with a 10-minute briefing, 80 minute simulation phase involving all students, followed by an 80-minute debriefing. Each simulation was designed according to the CRC (Levett-Jones et al., 2010) as the instructional design framework. Each post-simulation debriefing was facilitated using DML (Dreifuerst, 2012). All students were engaged in small groups in the pre-simulation brief and post-simulation debriefing sessions. For the game-based simulation, all students were engaged in scenarios in small groups. For manikin-based and challenging patient simulations, two students were engaged in each session, and the rest of the group (20-25 students) observed and took notes. All simulations were undertaken in a simulation environment. All facilitators for simulations had the same training prior to conducting the program. The simulation program's design has been detailed in another paper (Blakey, Guinea, & Saghafi, 2017).

#### Description of Instrument

The HSRT (Facione & Facione, 2006) - a validated tool developed by Insight Assessment in California- was used for data collection in this research. This tool measures the core reasoning and critical thinking skills needed in clin-

**Table 1** – Summary of the Simulation Program (Blakey et al., 2017, P. 31)

| | Simulation One | Simulation Two | Simulation Three | Simulation Four |
|---|---|---|---|---|
| Learning outcomes | Application of the CRC in the context of:<br>• Interprofessional communication according to ISBAR | Application of the CRC in the context of:<br>• Interpersonal skills<br>• Establishing rapport<br>• Maintaining dignity | Application of the CRC in the context of:<br>• Ethical decision-making | Application of the CRC in the context of:<br>• Patient allocation<br>• Prioritisation<br>• Delegation |
| Summary of simulation scenario | Fluids and electrolyte imbalance: Recognition and responding to a deteriorating patient. | The 'challenging' patient: Employing empathic interpersonal communication. | Refusal of treatment: Maintaining dignity. | 'Ward for a day': Prioritisation and delegation. |
| Simulation mode | Manikin-based | Simulated patient methodology | Video-based | Game-based |
| Duration | 2 hours | 2 hours | 2 hours | 3 hours |

ical situations (Facione & Facione, 2006). The tool was originally called the 'California Critical Thinking Skills Test' and was based on a Delphi study by American Philosophical Association (Facione, 1990). The tool was then adapted to be used for health professionals. The tool's reliability is verified with Kuder Richardson Formula 20 coefficient (KR-20) ranging between 0.77 to 0.83 (Insight Assessment, 2015), and its validity is confirmed by previous studies (Hanlon et al., 2018; Huhn, Black, Jensen, & Deutsch, 2011). It consists of 33 multiple-choice questions from five critical thinking areas: analysis, inference, evaluation, induction, and deduction. The test takes approximately 50 minutes to complete (Facione & Facione, 2006). The tool is presented in various languages, and in this study, the original tool in English was used. Based on the answer sheet revived from the participants, the choice for each question is marked, and the score is calculated, which could sit in four categories: Not manifested, moderate, strong, and superior (Facione & Facione, 2006).

### Data Collection Procedure

The assessment tool was administered by a staff member who was not involved in the research project. All data collected were de-identified and allocated a number by a third party. Datasheets were stored securely in a locked filing cabinet at the chief investigator's office before being sent to the USA for data collation. Participants completed the HSRT at the introductory lecture and two weeks after the simulation program finished providing enough time between two occasions of completing the HSRT to reduce the chance of pretest familiarity bias.

## Analysis

Data were entered into an Excel database and analysed using SPSS Version 21.0. Descriptive statistics were used to calculate the differences between the critical thinking scores for the group and each participant before and after completing the program. Furthermore, paired sample t-tests were calculated.

## Results

Of the 1,298 students enrolled in the final year undergraduate nursing course, 56 students participated and completed the HSRT, a response rate of 4.31%. Most participants were female (86%), and more than half (59%) were in the age group of 20-25 years.

### HSRT Scores Prior to the Program

HSRT scores of third-year nursing students were analyzed before the program. The scores ranged from 11 (critical thinking not manifested) to 30 (superior level of performance), with a mean of 21.1 (strong level of performance) (Table 2). Five students obtained a total score of $<15$, indicating critical thinking abilities that are weak or not manifested at all (Insight Assessment, 2015, p.49).

### Changes in HSRT Scores After Attending the Program

Fifty-six students who completed the HSRT prior to attending the program were also asked to complete the same test after completing the program. A paired t-test provided

**Table 2** – Mean and Standard Deviations for Pre-/Post-program HSRT Scores- Comparisons of the HSRT Norms

| Score | Pre-program n = 56 | | HSRT Norms of Undergraduate USA Nursing Students* | | Post-program n = 56 | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | t | *p* |
| Total reasoning skills | 21.1 | 4.4 | 19.2 | 4.5 | 22.3 | 4.1 | t= 2.445 | .018 |

* HSRT norms of USA nursing students are only available for HSRT overall.

**Table 3** – Paired Samples Test

| | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | Lower | Upper | | | |
| Post-program score - Pre-program score | 1.14286 | 3.49768 | .46740 | .20617 | 2.07954 | 2.445 | 55 | .018 |

a comparison between the 56 pre- and post-program HSRT scores. Before the program, 28 participants or 50% had an overall critical thinking skills profile at the level of 'Strong' and above as defined by the Health Sciences Reasoning Test Performance Assessment Score. This was increased after the program to 71%. At an individual level, of the 56 participants, 62.5% achieved two scores higher after completing the program. Analysis of data demonstrated a positive change (t = 2.445, *p*-value = .018) in critical thinking scores after completing the program with a 95% confidence interval for mean difference [.206, 2.079] (Table 3).

The effect size was calculated: Cohen's $d = \frac{mean\ differnce}{standard\ deviaiton} = \frac{1.14}{3.49} = 0.32$). Considering the effectiveness of the program was evaluated in the same group of students, comparing individuals before and after the program and given the practical importance of critical thinking, this small change could be considered a significant improvement (Dankel and Loenneke, 2021).

## Discussion

This study aimed to determine if attending a 15 hour program with nine hours of simulation activities designed according to CRC (Levett-Jones et al., 2010) and using DML (Dreifuerst, 2012) was effective in enhancing the critical thinking skills of final-year undergraduate nursing students. This study found that attending the program was associated with increased overall critical thinking scores. Students' critical thinking scores after attending the simulation program were higher than pre-program scores. This suggests that the simulation program resulted in a positive effect on the development of critical thinking skills. It is acknowledged that other variables could have contributed to this outcome.

The program included four simulations designed according to the CRC (Levett-Jones et al., 2010). In each experience, a different simulation modality was used (i.e., manikin, actor-based, video and game). DML (Dreifuerst, 2012) was employed as the debriefing model for each simulation.

Although the relationship between simulation and the development of clinical reasoning in undergraduate nursing students' skills has been supported in some studies, this is not a consistent finding (Cant & Cooper, 2017). Furthermore, the direct effect of debriefing using DML (Dreifuerst, 2012) when combined with simulation is not well studied (Forneris et al., 2015; Mariani et al., 2013; Turrise, Arms, Jones, & White, 2019). Only three studies have used validated assessment tools of HSRT and Lasater Clinical Judgement Rubric to evaluate critical thinking skills changes (Dreifurest, 2012; Forneris et al., 2015; Mariani et al., 2013). Aspects considered to have impacted the results are discussed below.

### Simulation Experience

In this study, purposeful simulation design in this program is considered to impact critical thinking scores positively. This finding is in contrast with some nursing specific studies demonstrating inconclusive results or no statistically significant difference in critical thinking skills following simulation (Adib-Hajbaghery & Sharifi, 2017). Most of these studies only offered one or two simulations except for Forneris et al. (2015), who offered three scenarios;

however, all scenarios featured the same simulated patient. Additionally, testing was completed in some studies up to three weeks post the simulations.

A second reason for the positive impact of simulation on the critical thinking scores of participants in this study could be that each simulation session started with a briefing where learning outcomes were presented to the students, followed by a debriefing. Research shows that, in fact, learning occurs during the debriefing stage (Levett-Jones & Lapkin, 2014) and setting learning outcomes before the simulation affects students' learning (Hall & Tori, 2017).

### Concentration of Simulation Experiences

Literature has demonstrated that a repeated, structured approach to clinical reasoning is required to aid in developing this skill; however, there is no recommendation on the necessary length of simulation (Levett-Jones et al., 2010). The simulation program focused on this study provided students with nine hours of simulation with four different scenarios over two weeks, with HSRT testing completed within the two weeks of completion of the program. Based on this difference, it is plausible to argue that the higher number of simulation hours, particularly debrief hours over a shorter period, will aid in developing clinical thinking skills in nursing students.

Studies that have explored the development of critical thinking, clinical reasoning, and clinical judgment with more than one scenario have run simulations over three weeks (Forneris et al., 2015), four weeks (Catanzaro, 2016), three months (Weaver, 2014) and up to two scenarios over half of a semester (Mariani et al., 2013). All studies had a maximum of three simulations during this period. The difference with our study is that the program offered a more concentrated approach with nine hours of simulation comprising four simulations over two weeks. As this study had statistically different pre-/post-program results, one contributing factor could be the concentration of the program, positively impacting students' clinical reasoning capacity. Whilst this concentrated simulation could be considered to impact clinical reasoning, Facione and Facione (2006) recommend that pre- and post-testing should not occur less than two weeks apart to ensure pre-testing does not impact post-testing results. Therefore, this is the minimum testing period.

### Debriefing Based on a Theoretical Model and CRC

Debriefing in this program was conducted immediately after each scenario, and the DML (Dreifuerst, 2012) model was used to structure the debriefing. Also, the facilitators implemented the clinical reasoning model to direct students as the debriefing progressed. The significance of double-loop visual learning advocated by Dreifuerst (2012) and a key characteristic of DML (Dreifuerst, 2012) cannot be disregarded as a useful approach in enhancing critical thinking skills among the participants (Argyris, 1977). During the debriefing, critical reflection at a higher level is achieved when students start to detect errors and challenge their own or other opinions (double-loop learning) (Cleary, Horsfall, Happell, & Hunt, 2013). Whilst it has been demonstrated that simulation has been as successful in improving critical thinking of undergraduate nursing students, the focus of these studies has been the post-simulation debriefing (Dreifuerst, 2012; Forneris et al., 2015). No studies have been identified that explored scenario design using a clinical reasoning framework as an instructional design approach. This study differentiates itself by exploring the combination of simulation design using the CRC (Levett-Jones et al., 2010) as a structured design framework and a specific post-simulation debriefing demonstrated to improve clinical reasoning (Dreifuerst, 2012; Forneris et al., 2015).

Furthermore, having two facilitators conducting debriefing was also essential as one facilitator concentrated on guiding the discussion, and one took notes and put them on the board. This assisted with visual learning opportunities and enhanced double-loop learning. It is important to remember that the debriefing facilitators were trained and instructed on how to run the debriefing using a structured framework (i.e., DML).

Under the Healthcare Simulation Standards of Best Practice ™ (Watts et al., 2021), simulations must be purposefully designed to meet the required learning outcomes. For all simulations developed as part of this project, the learning outcomes were to apply a clinical reasoning framework that follows the CRC steps (Levett-Jones et al., 2010). To achieve this, all simulations in this program were developed using the CRC as a framework aligned with DML (Dreifuerst, 2012). Using the CRC as an instructional design model, students become familiar with this desired thought process in simulation and understand how to apply clinical reasoning in everyday clinical situations. The assumption is that clinical reasoning is more easily applied by students when engaging in clinical placement. As previous studies only explored the debriefing model, this study could indicate that the purposeful design of nursing simulation experiences according to established clinical reasoning frameworks combined with a debriefing model can significantly enhance critical thinking.

## Study Limitations and Areas for Further Research

A limitation of this study was the low response rate (4.31%), and a larger sample size would have increased the strength and generalisability of the findings. The response rate might be explained by the circumstances in which students attended the program: an intensive on-campus program over two weeks when no other classes were running. Participation in this study required sitting in an assess-

ment twice, each one hour in duration. Additional time on campus may have proved a disincentive and may have negatively influenced participation in the study. Secondly, students' perceptions of the HSRT as a 'test' may also have negatively impacted participation. In the future, combining an observational study may strengthen the results regarding enhancing critical thinking among participants. Further, a repeated HSRT test three months post-intervention to investigate further changes in critical thinking scores would provide insight into longer-term changes in critical thinking scores.

## Conclusions

This study reported the impact of multi-modality simulations followed by a structured model of debriefing on undergraduate nursing students' critical thinking scores across multiple sites. An improvement in critical thinking scores after completing the program indicates that implementing aligned models of clinical reasoning and DML (Dreifuerst, 2012) through simulation in the undergraduate nursing curriculum is associated with improving critical thinking scores among undergraduate nursing students. Furthermore, the CRC provided an instructional design framework and a cognitive aid required for simulation. This contributes to the body of knowledge supporting the use of simulation and debriefing in teaching practice, especially in nursing.

## Declaration of Competing Interest

None.

## CRediT authorship contribution statement

**Farida Saghafi:** Conceptualisation, Methodology, Formal analysis, Investigation, Project administration, Writing – original draft, Writing – review & editing, Funding acquisition. **Nicole Blakey:** Conceptualisation, Investigation, Writing – original draft, Writing – review & editing, Funding acquisition. **Stephen Guinea:** Conceptualisation, Methodology, Writing – original draft, Writing – review & editing, Funding acquisition. **Tracy Levett-Jones:** Writing – review & editing.

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