


# The Impact of High-Fidelity Simulation on Nursing Students' Flexible and Reflective Thinking in Higher Education

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## Abstract

This study evaluated the effect of high-fidelity simulation with both mannequins and live actors on flexible and reflective thinking of nursing students. Students enrolled in an undergraduate nursing program were recruited to participate in this study. Ninety students, all female, completed both pre- and post-surveys. The researchers conducted a paired samples *t*-test to determine if there is a statistically significant difference in students' level of flexible thinking before and after they experienced the high-fidelity simulation. Moreover, we conducted multivariate correlational analysis to examine the relationships between flexible thinking and reflective thinking. In general, statistical results in this study provide empirical support for the values of clinical simulation and debriefing on nursing students' flexible and reflective thinking. High-fidelity simulation can expose students to controlled and dynamic clinical environments, allowing them to attempt the transfer of theory to practice, learn from collaborative and active learning tasks, and be open-minded to multiple perspectives and in diverse situations. We conclude that critical reflection is an important piece of development in flexible thinking and reflective learning. During the time of post-simulation interactions, students are encouraged to reflect objectively on their performance in each scenario. The input from peers and instructors provides students with the opportunity to assess their personal ability to transfer theory to practice and evaluate if the theory design of the course is providing them with the needed information to care for the clients presented in the clinical simulation scenarios.

**Keywords:** *Flexible thinking; Reflective thinking; High-fidelity simulation; Nursing education*

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## Introduction

Nursing programs strive to develop critical thinking skills in nursing students. Nurses must have the ability to think critically and reason effectively in clinical situations. The skill of thinking critically can be developed through learning experiences, such as simulation, that allow students to think flexibly and reflect on their problem-solving ability. Barak and Levenberg (2016b) defined flexible thinking in learning as “a higher order thinking skill, comprised of open-mindedness as fundamental to the ability to adapt to changes in learning situations and to accept new or changing technologies” (p. 49). They found that flexibility is a higher-order thinking skill that requires training and development in technology-enhanced environments. Healthcare environments are becoming more technologically complicated with the advancement of new medical devices and the need to care for increasingly sick clients. Nurses are called to perform highly skilled and technical work. Care of the sick can involve multiple layers of technology, complicated pharmacological management, and high levels of monitoring by the nurse (Benner, 2010). Technology-enhanced and innovative learning environments are beneficial for students’ learning and academic success.

However, without well-designed instructions and learner-centered pedagogies, rapid change situations and technology adoption in learning can possibly decrease students’ confidence and motivation. Thus, Barak and Levenberg (2016a) believed flexible thinking can help students make decisions quickly and adjust learning strategies when the situation demands, especially when they are facing a dynamic problem-solving task. According to the researchers, such flexible thinking components include (1) acceptance of new or changing technologies, (2) open-mindedness to others’ ideas, and (3) adapting to changes in learning situations.

In addition, reflection is important for integrating information and transferring previous experience into constructed knowledge that can lead to deeper learning and to new integration by the learner. Reflective thinking can be taught if students are deeply involved in structured interventions and situated tasks with clear guidance provided. Researchers have studied reflective thinking extensively in a variety of educational disciplines (Chen et al., 2019; Hong & Choi, 2018; Yilmaz & Keser, 2016) and also in nursing programs (Siles-González & Solano-Ruiz, 2016; Zhang et al., 2017).

The process of learning to become a nurse involves behavior adaptation, integration of assimilation of knowledge and skills (Piaget, 1964), and a process of structured reflection (Kolb et al., 2001). In nursing education, integration of the debriefing process into simulation-based learning can promote communication, reflective thinking (Ali & Musallam, 2018), and decision-making skills (Andersen et al., 2018; Decker et al., 2015; Hayden et al., 2014). Such integration can enhance participant self-confidence to respond to realistic situations (Weaver, 2015) and provoke reflection on scenario content and actions taken from a critical perspective (Tutticci et al., 2017). Reflective thinking is recognized as an essential concept in affecting nursing students’ higher-order learning in simulation practice (Hwang et al., 2018; Lestander et al., 2016; Naber & Markley, 2017); however, the level of students’ reflective thinking and its relationship with flexible thinking remains unknown and understudied.

This study’s goal was to evaluate the effect of high-fidelity simulation (HFS) with both mannequins and live actors on nursing student’s flexible and reflective thinking. The researchers hypothesized that students’ abilities to think flexibly would increase after participating in a simulation activity.

## Background and Literature Review

The lack of the ability to think critically and demonstrate clinical reasoning has been identified as deficits in new nurses entering the profession (Benner, 2010). Employers expect nurses to enter the workforce prepared to care for sick clients and have the ability to navigate the unknown with more independence. Nursing programs are turning to simulation to create learning experiences that help students develop these skills. The adoption of HFS by nursing education programs has expanded over the past ten years (Myler & Seuryneck,

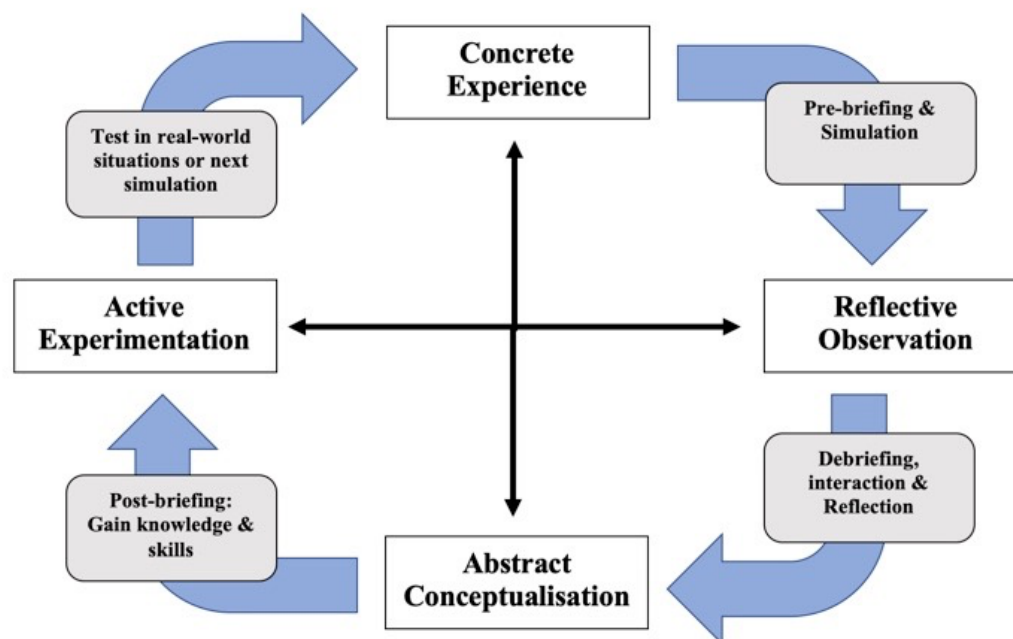
2016). Simulation provides a safe environment for nursing students to practice skills and clinical reasoning without harming patients. Currently, simulation is used as a pedagogical method to expose students to controlled clinical environments, allowing them to attempt the transfer of theory to practice in an environment without risking patient safety. A benefit of simulation is that students can reflect on their performance and receive immediate feedback from peers and faculty (Rhodes et al., 2016). In addition, the use of simulation promotes teamwork, improves communication, and allows students to demonstrate and practice needed clinical skills as well as clinical reasoning. Clinical reasoning is one of the most important aspects of a clinician's skill set and it is powerful in determining the outcome of patient care. Simmons (2010) referred to clinical reasoning as "a complex cognitive process that uses formal and informal thinking strategies to gather and analyze patient information, evaluate the significance of this information and weigh alternative actions" (p. 1155).

In the 21st-century learning environment, students act differently when they face rapidly changing situations and unfamiliar problems (National Education Association, 2012). Some students can reliably adjust to many different circumstances by effectively using all their acquired skills to learn new knowledge, while others might refuse to make their first move to adapt to changes. Thus, to process information and restructure knowledge received from different media and resources, adapt to various roles in diverse learning tasks, and make alternative decisions to fit the particular needs of a given circumstance, students have to be open-minded and flexible in thinking.

Debriefing is used at the end of each simulation to allow students to reflect on their experience and confer with peers and faculty in a "think aloud" forum where students and faculty reflect the synthesis of evidence-based practice to improve patient outcomes and identify practice issues. Debriefing can be defined as a "structured and guided-reflection process in which students actively appraise their cognitive, affective, and psychomotor performance within the context of clinical judgment skill development" (Sabei & Lasater, 2016, p. 46). Debriefing is determined as an essential component of simulation-based learning (Dreifuerst, 2012; Neill & Wotton, 2011) and is vital for the development of clinical reasoning and reflective practice (Lasater, 2011) in nursing education. Practices and debriefings in simulation are designed as a pedagogical method to allow students to transfer theory to practice in a safe, judgment-free environment. Previous research suggests that debriefing can be time-consuming and often lasts longer than the actual simulation as this is where the higher-order thinking occurs (Mariani et al., 2014). The debriefing period allows students to process what they did well in the simulation, consider how they could have performed better, and think about the possible outcomes of a simulation with prompting by trained instructors.

## **Theoretical Framework**

Kolb (1984) defined learning as "the process whereby knowledge is created through the transformation of experience" (p. 38) from the experiential perspective. Kolb's experiential learning theory (ELT) consists of four phases in the learning cycle that include (a) concrete experience—where the learner participates in an authentic learning experience such as simulation, (b) reflective observation—where the learner consistently and interactively reflects on the experience such as post-simulation debriefings, (c) abstract conceptualization—where the learner distills perceptions from reflections and gains new knowledge and skills, and (d) active experimentation—where the learner applies and tests new ideas in an experience or practice (see Figure 1). Kolb suggested that for students to learn, they must go through all four phases and complete another learning cycle to build up layers of knowledge or to learn new ones.

**Figure 1.** *Experiential Learning*

*Note.* Adapted from “Experiential Learning: Experience as the Source of Learning and Development,” by D. A. Kolb, (1984) ©Prentice-Hall.

Moreover, experiential learning is defined by Benner (1984) as “posing and testing questions in real situations that deviate from expectations based upon theory and principles” (p. 187). Simulation provides the opportunity for experiential learning that can develop critical thinking by engaging students in actions and thinking processes. Benner (1984) believed this type of learning propels the learner from novice to expert. Benner’s novice-to-expert theory not only applies to psychomotor skill development, but also to the development of a type of thinking that leads to clinical salience. Simulation is a type of problem-based learning in which students are introduced to a real practice situation, allowed to grapple with the situation, and use new and existing knowledge to solve the problems presented by the situation at hand. The students’ current thinking skills are tested.

Flexible thinking is one of the 21st-century skills that was first mentioned by Barak and Levenberg (2016b), who extended the cognitive flexibility theory and defined such a skill from educational and social perspectives in advanced technologies learning environments. Originally, leading cognitive flexibility theorists Spiro and Jehng (1990) referred to cognitive flexibility as “the ability to spontaneously restructure one’s knowledge, in many ways, in adaptive response to radically changing situational demands” (p. 165). According to Cañas et al. (2003), cognitive flexibility refers to one’s ability to adapt to new and unexpected environmental conditions. Barak and Levenberg (2016a) proposed three main factors that underline and measure flexible thinking, especially in contemporary education:

- open-mindedness to others’ ideas (the ability to learn from others, manage teamwork, and listen to multiple perspectives)
- adapting to changes in learning situation (the ability to find multiple solutions, solve unfamiliar problems, and transfer knowledge to new situations)

- accepting new or changing learning technologies (the ability to easily adjust to new and advanced technologies and effectively use them to promote meaningful learning) (p. 82).

In Dewey's (1933/1997) seminal work, he defined reflection as "active, persistent and careful consideration of any relief or supposed form of knowledge in the light of grounds that support it and the further conclusions to which it tends" (p. 9). Few nursing educators have defined reflective thinking from the perspective of learning theory. Saylor (1990) described reflective thinking as "the artistry of combining a professional repertoire with current clinical problems to invent unique responses" (p. 11). In Reid's (1993) definition, she referred to reflective thinking as "a process of reviewing an experience of practice in order to describe, analyze, evaluate and so inform learning about practice" (p. 305). Tutticci et al. (2016) argued that reflective thinking is a key element of the undergraduate nursing curriculum. Moreover, in a situated or problem-solving learning environment, reflective thinkers control their learning and persistently reassess what they have learned and how to apply knowledge in real-world situations. Simulation and debriefing allow students to demonstrate knowledge, skills, and values learned in theory courses to provide safe and quality care. Reflective observation is included in Kolb's experiential learning cycle model (1984) as an important component as students involve rethinking and reconsiderations of past events and prior experiences with the intention of finding alternative solutions and achieving learning that involves high order thinking. However, only a few studies have measured reflective thinking and experimentally examined its impact on nursing students' simulation experience (Tutticci et al., 2017; Tutticci et al., 2016; Weatherspoon & Wyatt, 2012).

### **Purpose of the Study and Research Hypotheses**

The purpose of the study was to investigate the impact of HFS on nursing students' flexible thinking and reflective thinking and examine the relationship between flexible and reflective thinking. The research hypotheses guiding the study involved understanding and investigating the impact of HFS on nursing students' flexible thinking and reflective thinking:

- H1: There is a statistically significant difference in students' flexible thinking before and after experiencing the HFS.
- H2: Students will have medium to strong perceptions of reflective thinking after experiencing the HFS.
- H3: There is a statistically significant relationship between students' flexible thinking and reflective learning.

### **Methods**

The study uses a quantitative, pretest/posttest survey design. Students enrolled in an undergraduate nursing program at a university in the southern United States were recruited to participate in this study. This study was approved by the Institutional Review Board (IRB) and all students received the consent form describing the purpose of the study, researcher's contact information, and time (15 to 20 minutes) to fill out the questionnaire one week prior to the simulation and a post-survey immediately following the simulation. Students who would voluntarily participate in the study signed the consent form and returned it to their instructor. Ninety students completed both pre- and post-surveys and all of them were female. The majority of them ( $n = 56, 62.2\%$ ) reported being in the age range of 20 to 24.

### **Instrumentation**

#### **Flexible Thinking in Learning (FTL) Scale.**

Students' flexible thinking was measured by Barak and Levenberg's (2016b) Flexible Thinking in Learning

(FTL) scale that consists of three subscales: Learning Technologies Acceptance (TA; 5 items;  $\alpha = .85$ ), Open-mindedness in Learning (OM; 7 items;  $\alpha = .91$ ), and Adopting to New Learning Situation (AL; 5 items;  $\alpha = .91$ ). Barak and Levenberg (2016b) reported that the Cronbach's alpha of the total scale was 0.91, indicating strong internal consistency. Moreover, the alphas for the Learning Technologies Acceptance, the Open-mindedness in Learning, and the Adopting to New Learning Situations subscales were all acceptable (0.90, 0.84, and 0.83, respectively). The questions included, for example, "I adjust quickly to new learning technologies," and "I do not have trouble getting used to new learning situations." For this study, reliability of FTL was measured with Cronbach's alpha;  $\alpha = .90$ , which indicates strong internal consistency.

### **Questionnaire of Reflective Thinking (QRT).**

Kember et al. (2000) developed this 16-item, 5-point Likert scale to assess students' levels of reflective thinking: Habitual Action (HA;  $\alpha = .81$ ), Understanding (UND;  $\alpha = .65$ ), Reflection (REF;  $\alpha = .69$ ), and Critical Reflection (CREF;  $\alpha = .90$ ). Kember et al. reported that the Cronbach's alpha of the four scales ranged from 0.62 to 0.76, indicating acceptable internal consistency. The questions included, for example, "When I am working on some activities, I can do them without thinking about what I am doing," and "I sometimes question the way others do something and try to think of a better way." The scale displayed acceptable internal consistency ( $\alpha = .77$ ) in this study.

### **Simulation Setting and Scenarios**

The researchers' university has used HFS for approximately four years. Simulation experiences are incorporated into both clinical and non-clinical courses and used as an extension of clinical rotations. More theory-based courses are adopting simulation as a pedagogical strategy to augment content. The use of simulation helps develop the qualities of critical thinking, therapeutic nursing interventions, effective communication, and professional behaviors (Jefferies & Rizzolo, 2006). Moreover, in technology-enhanced simulation environments, students interact and communicate with instructors, peers, and learning interfaces via a diverse set of technological tools and resources. Thus, educators have the ability to prepare students to be flexible thinkers, so they are capable of being open-minded and adapting to changes in learning situations and accepting new or changing technologies (Barak & Levenberg, 2016a).

Simulation scenarios used in these courses were developed by a simulation coordinator who completed the National League for Nursing's Leadership Development Program for Simulation Education along with several highly qualified instructors of nursing with many years of teaching and clinical experience. Students enrolled in three 300-level nursing courses—Foundations of Nursing Practice, Adult Health I, and Psychosocial Nursing—were invited to participate in the study. Each course is designed with specific student learning outcomes to measure the learner's ability to perform safely and effectively in the clinical setting. The simulation experiences associated with each course are designed to allow students to gauge their own ability to transfer theory to practice with the assistance of instructors in a non-threatening environment. At least a week prior to each simulation, students were provided with preparatory materials to review and research. When students entered the simulation lab, they were provided a pre-briefing that included an overview of the scenarios they would encounter, what to expect, and a detailed nursing report of each simulated client. Students then performed the scenarios, which ran for 20–30 minutes. Sessions were followed up with a structured debriefing.

The Foundations of Nursing Practice simulation consists of students being presented with information to prepare for a client care experience as if they are attending their first day of clinical in the hospital setting. These students have only attended clinical in long-term care settings prior to this experience. This is the first simulation experience for these students. The high-fidelity mannequins are used in this simulation, and the objectives are for students to satisfactorily assess the stable clients with respiratory and cardiac diagnoses, administer medications correctly and on time, communicate effectively, and document appropriately for hospitalized clients.



Students rotate through three different simulation experiences in Adult Health I using high-fidelity mannequins. The first scenario consists of a client diagnosed with chronic obstructive pulmonary disease (COPD) and heart failure (HF) who is experiencing an exacerbation. The objectives of this experience are to have the student adequately perform a system-specific assessment of the cardiac and respiratory systems and complete a series of orders provided by the primary care provider (PCP) in a timely and efficient manner. The PCP orders include applying oxygen, administering intravenous furosemide, which requires the student to place an IV, inserting an indwelling urinary catheter, and contacting respiratory therapy to administer a breathing treatment. The second scenario in this experience involves a high-fidelity mannequin presented as a client who has been involved in a work-related incident. Students are expected to assess the client, recognize the classic symptoms of fluid volume deficit, and take appropriate actions while managing client complaints of pain. The third scenario in this simulation experience uses a high-fidelity mannequin who presents as a client with chest pain and experiences cardiac arrest. The objective for this scenario is for the student to perform basic cardiopulmonary resuscitation in a timely and effective manner according to the basic cardiac life support (BCLS) standards by which they are certified.

Scenarios in Psychosocial Nursing provide simulated care to live actors. One of the live actors has a diagnosis of schizophrenia and is experiencing a psychotic break. Objectives of this scenario are for the student to recognize the client is a danger to self and others, stay with the client, communicate effectively, and maintain client safety. The other live actor is a severely depressed client. Objectives for this scenario are for the student to recognize the client is at high risk of suicide, stay with the client, administer medications correctly and in a timely manner as ordered by the PCP, and utilize effective therapeutic communication in a rapidly changing environment. After rotation through the simulation experiences students attend debriefing.

### Data Collection and Analysis

All participants received the consent form describing the purpose of the study, researcher's contact information, and time (15 to 20 minutes) to fill out the questionnaire. Before and after the simulation, the Flexible Thinking in Learning (FTL) scale was distributed in an online survey format. The Questionnaire of Reflective Thinking (QRT) was only distributed after students experienced the HFS. Paired samples *t*-test was conducted to examine if there is a statistically significant difference in students' level of flexible thinking before and after students experienced the HFS. The researchers calculated descriptive statistics for students' reflective thinking and conducted the multivariate correlational analysis to examine the relationships between flexible thinking and reflective thinking.

## Results

Mean scores of three subscales increased before and after the simulation (see Table 1). The mean Learning Technology Acceptance score was 3.86 (*SD* = .48) before the simulation and 4.01 (*SD* = .54) after the simulation; the mean Open-Mindedness in Learning score was 3.96 (*SD* = .51) before the simulation and 4.07 (*SD* = .52) after the simulation; and the mean Adapting to New Learning Situation score was 3.45 (*SD* = .62) before the simulation and 3.71 (*SD* = .71) after the simulation. Moreover, the results of *t*-test analysis revealed that only the change in Adapting to New Learning Situation mean score was statistically significant ( $t(43) = 2.84, p < .01$ ).

In terms of students' reflective thinking (see Table 1), participants reported the highest mean score on the Understanding level ( $M = 6.05, SD = .61$ ), followed by the Reflection level ( $M = 5.69, SD = .70$ ), the Critical Reflection level ( $M = 5.20, SD = 1.02$ ), and the Habitual Action level ( $M = 4.79, SD = 1.11$ ).

**Table 1:** Descriptive Data and Paired Samples T-Test (N = 90)

Measures	Pretest	Posttest	<i>t</i>	<i>p</i>
<b>Flexible Thinking</b>				
Learning Technology Acceptance (TA)	3.86 (.48)	4.01 (.54)	1.93	.062
Open-Mindedness in Learning (OM)	3.96 (.51)	4.07 (.52)	1.56	.127
Adapting to New Learning Situation (AL)	<b>3.45 (.62)</b>	<b>3.71 (.71)</b>	<b>2.84**</b>	.008
	<i>Mean</i>	<i>SD</i>		
<b>Reflective Thinking</b>				
Habitual Action (HA)	4.79	1.11		
Understanding (UND)	6.05	0.61		
Reflection (REF)	5.69	0.70		
Critical Reflection (CREF)	5.20	1.02		

Table 2 displays the results (post-simulation) of intercorrelations between the three flexible thinking and the four reflective thinking subscales. The results revealed students' perceptions of Learning Technology Acceptance were positively and significantly correlated with Understanding and Reflection ( $r = .357$ ,  $r = .413$ , respectively). Moreover, positive and significant correlations were also found between Open-Mindedness in Learning and Understanding ( $r = .485$ ,  $p < .01$ ) and Reflection ( $r = .481$ ,  $p < .01$ ).

**Table 2:** Intercorrelations of Post-simulation Flexible Thinking and Reflective Thinking

Variable	Flexible Thinking			Reflective Thinking				Mean	SD
	TA	OM	AL	HA	UND	REF	CREF		
1. TA	—	<b>.654**</b>	<b>.606**</b>	.097	<b>.357*</b>	<b>.413**</b>	.204	3.95	.56
2. OM		—	<b>.596**</b>	-.008	<b>.485**</b>	<b>.481**</b>	.149	4.02	.49
3. AL			—	.031	.082	.084	.044	3.67	.66
4. HA				—	.107	.165	.265	4.61	1.03
5. UND					—	<b>.377**</b>	.256	6.02	.63
6. REF						—	<b>.409**</b>	5.70	.70
7. CREF							—	5.24	.96

Notes.  $N = 90$ , \*\* $p < .01$ , \* $p < .05$

Abbreviations: TA, Learning Technology Acceptance; OM, Open-Mindedness in Learning; AL, Adapting to New Learning Situation; HA, Habitual Action; UND, Understanding; REF, Reflection; CREF, Critical Reflection.

## Discussion

The purposes of this study were to understand nursing students' learning experience and to examine their perceived flexible and reflective thinking after experiencing HFS activities. In terms of flexible thinking, students possessed a significantly higher competency in adapting to new learning situations post-simulation. Adaptively responding to changing demands and challenges is vital for nursing students when facing real clinical caring situations. Flexible thinkers adapt to different roles and contexts and make necessary compromises and work effectively with diverse teams to accomplish a common goal (Partnership for 21st



Century Skills [P21], 2009). Moreover, flexible thinkers tend to think “in addition” to how others might typically think and are willing to take risks on finding alternative and creative solutions even if there is possibility of failure (Mann et al., 2017). Those capabilities and skills are important for nursing students not only to succeed in further simulation experiences but also to persistently maintain high levels of achievements in the nursing profession. This finding is in accordance with previous studies stating the necessity of adopting simulation practice learning to enhance clinical quality, simulated learning processes, and promoting competency (Handley & Dodge, 2013). Moreover, students from prior studies perceived simulation practice learning as a valuable learning approach that strengthens their clinical decision-making and self-confidence (Blum et al., 2010; White et al., 2019).

Participants in this study reported the lowest score on the Habitual Actions in comparison to the other three Flexible Thinking in Learning (FTL) subscales. This study reveals that as students experience the HFS, they have less attention to relying on their habitual actions. Lethbridge et al. (2013) explained that only in some circumstances in nursing practice, such as when a nurse finds a patient in cardiac arrest, would the use of Habitual Action be appropriate in performing immediate nursing interventions. Moreover, Understanding had the highest score and it significantly correlates with Reflection, indicating that nursing students are applying their existing knowledge and comprehension of different learning situations further enabling them to attempt reflection in practice and simulation. This finding coincides with prior studies (Buzdar & Ali, 2013; Kember et al., 2000; Lethbridge et al.) where Understanding and Reflection were found to be the most commonly used reflective thinking skills when students were learning in classroom or practice environment.

In terms of the relationship between students’ flexible thinking and reflective thinking, the findings reveal that students’ perceptions of Learning Technology Acceptance and Open-Mindedness in Learning were positively and significantly correlated with Understanding and Reflection. This suggests that if students have higher perceived flexible thinking skills, they are more likely to possess Understanding/Reflection in simulation practice.

### **Limitations of the Study**

One of the limitations in this study that should be considered is a small sample size from one nursing program in one university. Therefore, the findings of this study have limited generalizability. For future studies, data should be collected across multiple nursing programs or institutions. Next, as all instruments are self-report measures, it might lead to some particular issues with stability of the measures and pose a threat to the reliability of the findings. More quantitative data should also be collected to measure nursing students’ reflective thinking, such as facilitator’s observational notes and reflective journals in post-simulation debriefing.

### **Implications for Practice and Future Research**

This study seeks to close the gaps of literature on HFS research by taking flexible thinking into account while investigating the effects of the HFS on nursing students’ thinking skills. The findings suggest that simulation-based learning plays a significant role in promoting nursing students’ flexible thinking skills as they intervene with cognitive and metacognitive learning activities and purposefully transfer their learning experience through Kolb’s four phases of the learning cycle. Simulation educators must take into account students’ adaptability skills and their willingness to consider multiple perspectives in order to develop nursing students’ clinical reasoning through structured pre-simulation and post-simulation activities.

Furthermore, the results on reflective thinking provide evidence that the current simulation-based learning in the nursing program is effective and able to promote students’ Understanding and Reflection more than Critical Reflection. These findings provide support to program directors and nursing educators as they seek

evidence on the pedagogical values of HFS and consider the task of developing students' critical reflection skills, which are the top objectives of clinical practice.

For future research, we suggest that nursing educators further examine the influences of different simulation scenarios or various types of simulation techniques on reflective thinking and investigate to what extent students' learning achievement can be predicted by reflective thinking. Furthermore, additional independent variables (e.g., emotional intelligence and nursing practice self-efficacy, etc.) and the number of students' simulation experiences may be important factors that contribute to their perceived flexible and reflective thinking and should be brought into account for future investigations. In addition, a longitudinal approach could be adopted in order to further examine the cause-effect relations among factors of HFS effectiveness, flexible thinking, and reflective thinking.

## Conclusion

This study aims to evaluate the effect of high-fidelity simulation (HFS) with both mannequins and live actors on nursing students' flexible and reflective thinking. The results add to a growing body of literature by providing empirical support for the values of clinical simulation on nursing students' flexible thinking. High-fidelity simulation can expose students to controlled and dynamic clinical environments allowing them to attempt the transfer theory to practice, learn from collaborative and active learning tasks, and be open-minded to multiple perspectives and in diverse situations. Moreover, during the time of post-simulation interactions, students are encouraged to reflect objectively on their performance in each scenario. The input from peers and instructors provides students with the opportunity to assess their personal ability to transfer theory to practice and evaluate if the theory design of the course is providing them with the needed information to care for the clients presented in the clinical simulation scenarios.

## Conflict of interest

There is no conflict of interest known to the authors.

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