Testing Computer-Based Simulation to Enhance Clinical Judgment Skills in Senior Nursing Students

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KEYWORDS

• Experiential learning theory • Nursing education • Simulation
• Computer-based simulation • Clinical judgment

KEY POINTS

- In nursing education, experiential learning is augmented through the use of simulated clinical experiences provided in simulation laboratories.
- A variety of simulations have been reported; however, few studies target the effectiveness of experiential learning through the use of a computer-based simulation available to the individual user.
- An educational intervention based on Kolb's Experiential Learning Theory (ELT) is examined in this pilot study to determine the feasibility of conducting a future larger-scale research project on the effectiveness of ELT to enhance the development of clinical judgment skills.

SIMULATION ENHANCING CLINICAL JUDGMENT

The professional nurse must engage in complex cognition to critically examine multiple variables and make clinical judgments that promote patient care. Reflection about the care of a patient, in the context of the situation, is the basis for judgment.[1–3] The judgment, when used to determine a nursing intervention, exemplifies theoretical science, or the application of knowledge, with practical experience regarding patient care.[4,5] Expert clinical practice requires a nurse to quickly and efficiently evaluate a patient's condition including observed data, and determine an immediate intervention to achieve desired patient outcomes.[5,6]

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The result of poor clinical judgment may lead to detrimental patient outcomes exemplified by "failure to rescue" behavior.[7] An example is found in high-risk areas, such as triage nursing in the emergency department, where patient acuity must be accurately and efficiently determined. Assigning too high of an acuity level may result in the delay of treatment of another patient with a more serious condition, while assigning an acuity level that is too low may lead to a poor outcome for the presenting patient. Nurses clearly must make clinical judgments while providing care and, therefore, student nurses must learn the techniques that require complex cognition. However, in the increasingly complex clinical environment, and especially in high-acuity areas of care, many students and new graduates lack the needed skills for expert clinical judgment.[8] This elusive skill set requires both cognitive gain and experience,[9,10] and teaching the critical thinking skills of clinical judgment may be a challenge for nurse educators.

Most research conducted on educational methods for improving clinical judgment has focused on deliberative and analytical application of scientific knowledge. In the complex world of nursing, expert clinical judgment exceeds the deliberate, conscious, decision-making characteristic of competent performance to include the holistic and intuitive response gained through experiential learning.[11] Benner[12] described 5 levels of nursing expertise in her sentinel work *From Novice to Expert*. Using a model that focuses on actual performance and outcomes in specific situations, the levels of expertise are defined not only by nurses' knowledge but also by their perceptual acuity. Benner posits that clinical judgment is gained through experiential learning that includes reflections on past concrete experiences.[11] In nursing education experiential learning occurs in a skills laboratory and in actual, often limited, clinical encounters with patients.[13] Innovative educational strategies aimed at developing clinical judgment skills prepare the prelicensure professional nurse for quality patient care and fewer failure-to-rescue behaviors. Simulation laboratories have gained great acceptance in education as a strategy to enhance clinical judgment through experiential learning. However, research grounded in a strong theoretical base is needed to design and support effective strategies to meet this goal. An educational intervention based on Kolb's Experiential Learning Theory (ELT)[14] is examined in this pilot study to determine the feasibility of conducting a future larger-scale research project on the effectiveness of ELT to enhance the development of clinical judgment skills.

SIMULATION AND KOLB'S EXPERIENTIAL LEARNING THEORY

Kolb asserts that "Learning, the creation of knowledge and meaning, occurs through the active extension and grounding of ideas and experiences in the external world and through internal reflection about the attributes of these experiences and ideas."[14(p52)] Kolb's ELT was based on this definition and the work of others scholars' theories that include experience as a central role. According to ELT, learning occurs through two dialectically opposed adaptive orientations that guide the comprehension of information.[14] ELT defines a process that follows a cyclical arrangement of an Act, or concrete experience; Reflection on the experience; Conceptualization of the experience; and Experimentation (action or decision making). This active process is applied in real or simulated experiences.[14]

Simulations are defined as the artificial replication of real-world situations designed to provide a safe and nonthreatening, interactive learning environment in which students can practice clinical scenarios, psychomotor skills, and develop critical thinking skills.[15–17] The use of simulation is not new to nursing, and has been used successfully for more than 20 years in a variety of methods and settings. Simulation offers a rich environment to operationalize and test ELT's effectiveness for enhancing clinical judgment.

Simulated clinical experiences typically begin with a clinical picture, or case scenario; this initial event is what Kolb terms direct apprehension of a concrete experience. This scenario is followed by transformation of the experience through self-reflection, and includes opposing dialectical thoughts that weigh what is currently experienced (seen, heard, touched) and what is known about similar situations from past experience, intuition, and cognitive knowledge. Having reflected on the experience, abstract comprehension occurs when the learner makes sense of the occurrence and forms a logical basis for decision making and clinical judgment. Finally a clinical judgment is made, which correlates to extension or active experimentation; according to ELT, this step transforms the abstract comprehension by testing it in practice. During the simulation, a clinical judgment in the form of a decision leads the person back to another concrete experience (what happened based on their decision).

LITERATURE ON SIMULATION AND CLINICAL JUDGMENT

Simulation is considered any mock clinical situation, and the delivery of simulation may range from low-technology case studies to high-fidelity, realistic, and sophisticated patient simulators.[18] A mainstay and perhaps a pioneer in experiential learning is the traditional paper case study. The use of case studies in education has been documented for more than 100 years; the typical use is to apply theories and didactic content to simulations of potential real-life events.[19] Case studies may be in-depth descriptions of the scenario or be more detailed, focusing on a specific problem. DeYoung[20] asserts the use of case study allows learners to apply their previous experiences to new learning. Several scholars assert that case-study learning improves problem solving, decision making, critical thinking, and self-directed learning.[19,21] Earlier studies support that the use of case studies for problem-based study increased enthusiasm and motivation in nursing.[22]

Much of the literature on simulation in nursing education has focused on instructor-led simulations, particularly with the explosion of high-fidelity patient simulation. The cost of high-fidelity patient simulators requires substantial time and a financial commitment. Although recommended sessions should be short, the group size is typically small, with assigned role play.[8] An adequate number of educators are required to facilitate the actual simulation and conduct debriefing. Managing large classes of nursing students may require several days and allow only one attempt by each student. Because of these constraints, educators may continue to rely on low-fidelity simulation, such as case studies, to augment experiential learning. Although paper case studies offer a patient scenario and many offer feedback with correct answers, they may not fit the high-tech learning style of today's typical nursing student. An alternative may be a computer-based simulation that incorporates patient scenarios similar to paper case studies, in an interactive gaming-style format.

Computer-based simulation is a computer screen–based program designed for an individual player that includes many aspects of computer-based gaming. Games provide a risk-free space to apply learned knowledge in a virtual environment. Werth and Werth[23] describe gaming as educational strategies that include delivering small chunks of information with interactive trial-and-error activities that allow risk-taking in a safe environment. Computer-based simulation offers a continuous feed of problems, or descriptive case studies, and the player determines a course of action followed by feedback. A scoring method may be available with an option to compete with other players in the virtual world. This type of learning offers independence, self direction, and applicability of learned knowledge in a context that is familiar to today's learner. Computer-based simulation games are interactive, challenging, and give feedback without requiring the educator to invest additional time and resources in creating the feedback.[24]

In a virtual-reality learning environment, educators may provide experiential learning opportunities that through active participation facilitate problem solving and clinical judgment on the patient's care.[25–27] The use of computer-based simulation as an educational resource may facilitate student nurses' ability to provide evidence-based nursing care while reflecting, synthesizing, and applying knowledge in various contexts, rather than a competence-based role. In addition, the simulated environment allows students an opportunity to choose priority nursing interventions with immediate feedback of patient outcomes in a safe learning environment. Computer-based simulation is convenient because it resides on any computer, availability being restricted only by the limitations of access to the computer. Programs that provide instant feedback support the needs of today's learners for guidance that supports reflection and enhances critical thinking skills.

At present, there is no literature published on how computer-based simulation affects clinical judgment and critical thinking skills in the prelicensure student nurse. The research question in the research reported here was: Would a computer-based simulation game improve a student's clinical judgment? The overall aim of this pilot study was to determine the feasibility of using a computer-based simulation with senior nursing students to improve clinical judgment. It is believed that the use of computer-based simulation, when compared with standard printed case-study scenarios, will increase students' clinical judgment as demonstrated by their accuracy and efficiency in prioritizing the necessities of patient care.

METHODS

This study used a pretest-intervention-posttest experimental design with a randomly selected control and experimental group to determine the feasibility of a computer-based simulation in improving student's clinical judgment. Once the study was approved by the Institutional Review Board, the participants were recruited from baccalaureate nursing programs who were seniors, enrolled in a local university in the Southeast, and older than 18 years. The population recruited for this study was primarily female, with approximately 5% to 10% being male. The majority of students were non–degree-holding students with a median age of 22 years. All had completed their general education courses and were enrolled full-time in nursing courses that included clinical experiences. All senior nursing students in their final semester before graduation were invited to participate. Thirty-two participants were recruited and 23 participants voluntarily enrolled in the study. Following initial recruitment, written consent was obtained from all participants. None of the participants withdrew once the study began.

Intervention

A computer simulation was sought that targeted advanced clinical judgment skills for nurses. Clinical areas with potentially high acuity and a rapid pace were considered. Emergency triage was selected because of the high levels of clinical judgment necessary in this nursing role. Triage is a system to rank patients according to the severity of their condition and their need for medical care, irrespective of the order of arrival or other factors such as age, ethnicity, or religion.[28] Triage is an inherently complex and dynamic process that requires rapid assessment and prioritization of patients, often with limited information.[29] Failure to recognize and prioritize those who have the most urgent problems and are in need of immediate care may lead to serious negative outcomes, including death.[30] However, the overcautious triage nurse may jeopardize other patients by increasing their wait times when a high-priority level is assigned to a patient unnecessarily. Typically the role of triage nurse is assigned to the most experienced nurses; however, this notion is being challenged and more nurses with limited experience are filling the role. Considine and colleagues[31] found that specific educational preparation and appropriate decision support tools enable less experienced nurses to work effectively in emergency triage. For these reasons described, emergency triage was considered a good fit for innovative teaching strategies that increase knowledge and experience in a safe environment with the goal of increasing clinical judgment.

A product offered by SwiftRiver Online Learning titled Emergency Room Triage Software[32] was used for the experiential education intervention. The simulation included short descriptive case studies that required the user to assign an acuity level, an emergency room (there are choices of standard rooms or trauma rooms), and an appropriately trained nurse (higher acuity levels require a more experienced nurse than lower acuity levels). The simulation prompted players with messages, for example, "You failed to admit a higher acuity patient first." The simulation did not have an unfolding scenario; it was static in the presentation of options so that each student had the same experience. A screenshot of the game is shown in **Fig. 1**.

Instrument

The instrument was developed by the researcher for this study and is known as the Triage Acuity Instrument (TAI). The TAI was based on the *Emergency Severity Index, Version 4: Implementation Handbook* (Gilboy and colleagues, 2005) and consists of multiple short case presentations representing a patient presenting to the Emergency Department. The instrument is designed to test the clinical judgment skills by measuring the user's ability to accurately assign patient acuity scores as defined by

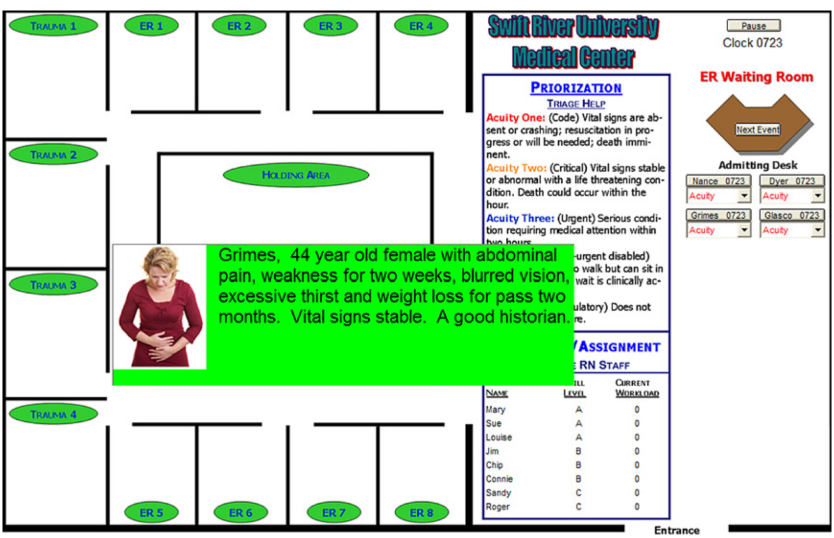

Fig. 1. SwiftRiver Emergency Room Simulator.

the Emergency Severity Index.[33] The score was based on the total number of questions answered correctly in the allotted time.

Before the study, the TAI was reviewed for validity by 2 experienced nurse educators with expertise in test and measurements. Both agreed that TAI assessment results should satisfy the validity criteria listed by Nitko[34]; in particular, content representativeness and relevance; representation of thinking skills and processes; reliability and objectivity; fairness to different types of students; and economy, efficiency, practicality, and instructional features.

Procedures

The study began with a standardized lecture on triage to all participants given by a course instructor, who was not a part of this research team. Following the lecture all participants completed the TAI as the pretest. The test was administered in a quiet, comfortable classroom, and demographic information forms were completed. The TAI was designed to test for accuracy and efficiency. Accuracy was assessed as the total number of correct responses and efficiency was determined as the number of correct responses within a time limit of 30 minutes. The instrument contained more questions than could be answered within the time limit. The purpose was to provide a method to test for the maximum number of answers in a finite period of time as a correlation of efficiency.

Following completion of the pretest, one half of the students were randomly assigned to the experimental (A) group and half to the control (B) group. The control group remained in the classroom and the experimental group was relocated to the computer laboratory.

After a 15-minute break, Group A was instructed to begin the intervention of the single-player simulated computer game. The simulation began with a basic description of how to play. During the same time period the control group participants remained in the classroom and received a paper study guide. The study guide was compiled using the case studies supplied by the simulation developer; therefore, it covered the same scenarios used in the simulation intervention. Nurse educators commonly use the case-study approach to augment teaching.[35] The case study may briefly describe a typical client with a disorder, treatment, or situation, and ask the student to explain the connection between symptoms and signs or to determine a nursing intervention.[35] During the intervention time, no further instructions were given to either the control or the experimental groups. The participants worked individually for a period of 1 hour.

Immediately following the intervention and a 15-minute break, the participants were given the TAI as a posttest. As previously described, a 30-minute time limit was maintained and testing stopped when time was called. After completion of the posttest, the researcher announced that data collection was complete and thanked the subjects for their participation.

DATA ANALYSES AND RESULTS

Before attempting statistical analyses of test data, an informal evaluation of the dependent variable (posttest score) distribution for both the control and experimental groups was performed using box plots and Q-Q plots. No serious threats to normality were noted. Because this was a pilot study, pretest scores for both groups, overall (control plus experimental groups) pretest scores, and overall (pretest plus posttest) scores were also evaluated using box plots and Q-Q plots. Again, no serious threats to normality were noted; however, the pretest scores for the experimental group reflected a skewed-right distribution. In attempting to determine the effects of control-experimental group interventions, analyses focused on differences between pretest and posttest performance and the influence of sample demographic variables. Because of the large observed difference between control group and experimental group pretest scores (**Table 1**), study variables were analyzed using repeated-measures analysis of variance (ANOVA) and *t*-tests, both independent-sample and paired-sample. A repeated-measures ANOVA was performed to investigate interaction of time (from pretest to posttest) by group and to determine if there was a change in test scores over time. The Levene test of equality of error variances was not significant for either pretest or posttest. The interaction of time by group was not significant, $F(1,21) = 3.863$, $P = .063$, partial $\eta^2 = .155$, indicating that scores of both groups changed similar amounts from pretest to posttest. The main effect of time was significant, $F(1,21) = 34.007$, $P<.001$, partial $\eta^2 = .618$, pointing to a global change in test scores from pretest to posttest. While most subjects in each of the study groups experienced an increase in number of correct responses from pretest to posttest, one subject in both the control and experimental groups scored lower on the posttest than on the pretest.

Because the pretest means for the control group (mean = 74.273, 95% confidence interval [CI] 63.231–85.315) and the experimental group (mean = 56.250, 95% CI 45.678–66.822) were so far apart, independent *t*-tests were run to determine if the groups differed in pretest scores, age, or experience. (There was insufficient variability for testing differences in education, race, or gender.) As expected, a Levene test for equality of variances indicated that the variance of the pretest scores for the control and experimental groups was significant, $t(21) = 2.45$, $P = .023$. No significant differences were found in age, $t(21) = .073$, $P = .943$, or experience, $t(21) = 1.96$, $P = .068$.

Again, because the control and experimental groups differed so greatly in pretest means, comparing the degree of improvement between them was difficult. Thus, paired *t*-tests were run for each group to compare pretest and posttest scores. The control group pretest-posttest mean difference was −20.000 (standard deviation [SD] = 21.029) correct responses, whereas the experimental group pretest-posttest mean difference was −40.333 (SD = 27.763) correct responses. The experimental group showed a very significant improvement, $t(11) = -5.033$, $P<.001$; the control group showed a marginally significant improvement, $t(10) = -3.154$, $P = .010$. The effect size was large, with Cohen's $d = .97$.

Assessment score reliability, pretest and posttest, was indicated by means, standard error of means, and 95% CI for groups, time, and groups by time (**Table 2**). It should be observed, however, that the comparatively low pretest score mean of the experimental group and its skewed-right distribution may not be representative of

Table 1
Group statistics for test performance, age, and experience

	Group	N	Mean	Std. Deviation	Std. Error Mean
Pre-test Score (# correct)	Control	11	74.27	19.432	5.859
	Experiment	12	56.25	15.772	4.553
Post-test Score (# correct)	Control	11	94.27	20.180	6.084
	Experiment	12	96.58	32.250	9.310
Age (years)	Control	11	24.91	6.332	1.909
	Experiment	12	25.08	5.178	1.495
Experience (months)	Control	11	17.64	20.432	6.160
	Experiment	12	4.08	10.698	3.088

Table 2
Overall means for group test scores, time (Pre-and Post-Test), and groups x time

Factor	Group or Test	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Group	Control	84.273	5.806	72.198	96.347
	Experimental	76.417	5.559	64.856	87.977
Time	Pre-Test	65.261	3.675	57.618	72.905
	Post-Test	95.428	5.673	83.631	107.225
Groups x time	Control Pre-test	74.273	5.310	62.231	85.315
	Control Post-test	94.273	8.195	77.231	111.315
	Experimental Pre-test	56.250	5.084	45.678	66.822
	Experimental Post-test	96.583	7.846	80.267	112.900

future samples from the population under study. Still, the small magnitudes of the standard errors and their relative consistency in each of the comparisons (group, time, groups by time) provides a measure of confidence in the reliability and validity of TAI scores for assessing intervention effects.

DISCUSSION

Emergency Room Simulator[33] is a single-user computer-based simulation designed to provide experiential learning in a safe environment. The program reinforces prior learning on prioritizing acuity levels of patients presenting to the emergency room and improved clinical judgments as measured by cognitive gain (accuracy) and time to decision (efficiency). The design of the program supports ELT through concrete clinical experience, time for reflection, and comprehension followed by feedback on active experimentation (decision making).

There were limitations to the study. The sample size was small, and to generalize these findings and determine the program's efficacy the intervention should be tested with larger samples of senior nursing students. Because of the small sample, there was insufficient variability for testing differences in education, race, or gender. Students saw a similar test (the pretest) and although the clinical scenarios varied, some may have scored better the second time regardless of the intervention. Experiential learning occurs over time and should be tested over a longer period to determine the retention of knowledge, which would further support Kolb's theory that learning is experiential and transformative. Efficiency may be related to confidence, and additional research that seeks confidence levels of the participants would be beneficial in determining the efficacy of the intervention. The instrument was new, and additional testing to determine validity and reliability is needed.

IMPLICATIONS FOR ELT IN NURSE EDUCATION

Nurses are often the first point of contact with patients in high-acuity areas. Their clinical judgment must be accurate and efficient; however, clinical judgment requires reflection on concrete experiences to shape understanding and build critical thinking skills. Nurse educators may find it difficult to provide the needed breadth and depth of experience for their students in the actual clinical setting. Although other forms of simulation, such as high-fidelity patient simulators, offer educational opportunities, they are expensive and time intensive. The use of computer-based simulation, such as Emergency Room Simulator, as an adjunctive learning strategy provides experiential learning that is available as often and at any time desired. Computer-based simulation or similar programs may serve as a valuable resource for nurse educators seeking alternative ways to increase clinical judgment skills in the prelicensure nursing student. It may also be used in the workplace to enhance the clinical judgment of existing registered nurses. Additional testing may include using the simulation for registered nurses interested in emergency triage.

SUMMARY

Experiential learning, such as computer-based simulation, promises to be a valuable tool for increasing clinical judgment skills. The use of case studies has long been used in education, and incorporating this teaching/learning strategy into an interactive, autonomous computer-based simulation offers an additional aid in potentially enhancing clinical judgment. Availability of Internet-based programs through work, college, or personal computers makes the simulation experience easily accessible to learners. According to this initial pilot study, the software program Emergency Room Simulator holds promise as an innovative computer-based experiential learning strategy to promote clinical judgment skills in a safe and easily accessible format. Additional testing is needed on this and other computer screen–based experiential learning programs. This study contributes to knowledge in health care research by suggesting innovations that have promise in developing clinical judgment skills through experiential learning.

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