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Jill E. Stefaniak
Old Dominion University, jill.stefaniak@uga.edu

Carman L. Turkelson

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Does the Sequence of Instruction Matter During Simulation?

Jill E. Stefaniak, PhD, CPLP;

Carman L. Turkelson, DNP, RN, CCRN, CHSE

Introduction: Instructional strategies must be balanced when subjecting students to full-immersion simulation so as not to discourage learning and increase cognitive overload. The purpose of this study was to determine if participating in a simulation exercise before lecture yielded better performance outcomes among novice learners.
Methods: Twenty-nine participants were divided into 2 groups as follows: group 1 participated in simulation exercises followed by a didactic lecture and group 2 participated in the same learning activities presented in the opposite order. Participants were administered a multiple-choice cognitive assessment upon completion of a workshop.
Results: Learners who participated in the simulated exercises followed by the didactic lecture performed better on postassessments as compared with those who participated in the simulation after the lecture. A repeated-measures or nested analysis of variance generated statistically significant results in terms of model fit F (α = 0.05; 4.54) = 176.07 with a P < 0.0001. Despite their higher levels of increased performance, 76% of those who participated in simulation activities first indicated that they would have preferred to participate in a lecture first.
Conclusions: The findings of this study suggest that differences occur among learners when the sequencing of instructional components is altered. Learners who participated in simulation before lecture demonstrated increased knowledge compared with learners who participated in simulation after a lecture.
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Key Words: Simulation, Teaching modalities, Instructional sequencing, Experiential learning.

TEACHING THE FUNDAMENTALS OF HEMODYNAMIC MONITORING: DOES THE SEQUENCE OF INSTRUCTION MATTER?

Health care is an ever-changing frontier requiring health care professionals to assume increasingly complex roles with higher levels of critical thinking and clinical judgment than in the past. To be successful, health care professionals today must have strong critical thinking skills, communication skills, collaboration skills, and the ability to participate in problem solving with other professionals.[1] Learning in an acute care environment can be a stressful period for health care professionals when the majority of their training is conducted on-the-job in the hospital setting. To address the learning styles and needs of learners in the acute care environment, many nursing and residency programs are using alternative teaching modalities including the use of high-fidelity simulation to provide a new alternative for contextual learning in acute care settings.[2]

Simulation allows for the development of critical thinking skills by providing learning content in a safe environment without imposing harm to actual patients.[2,3] Implementing a simulated learning experience provides an opportunity for learners to make connections with instructional materials while actively engaging with fellow learners at the same time. In addition, simulation provides an opportunity for the health care professional to remediate and expand their boundaries while learning how to respond to rare or unique patient experiences similar to the clinical environment.[4,5] Instructional strategies such as full-immersion simulation, where the learner is placed in a simulated environment that replicates their actual work environment, must be balanced and appropriately timed to provide learners with the necessary knowledge, skills, and attitudes required for safe practice while not discouraging learning and increasing cognitive overload. The purpose of this study was to determine whether simulation activities have a positive impact on the students' performance when introduced before or after a lecture.

This study explored the research question, do novice nurses who participate in a simulated learning activity before participating in a lecture demonstrate greater levels of improvement on postassessments as compared with those who attend a lecture presentation before a simulated learning activity?

LITERATURE REVIEW

Learning does not always occur in a linear fashion. Lessons too complex to grasp in a single occurrence spiral past us again and again, gradually revealing greater and greater meaning with each repetition.[6] From this perspective, participation precedes learning as learning transpires through the act of insight when these experiences are viewed through a sense of heightened awareness or examined with a new sense of appreciation.[6]

From the Instructional Design and Technology Program (J.E.S.), Department of STEM Education & Professional Studies, Old Dominion University, Norfolk, VA; and Beaumont Health System (C.L.T.), Royal Oak, MI.

Reprints: Jill E. Stefaniak, PhD, CPLP, Instructional Design and Technology, Department of STEM Education and Professional Studies, Old Dominion University, Darden College of Education, Room 251-1, Norfolk, VA 23529 (e-mail: jstefani@odu.edu).

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The tenets of cognitive learning theory are based on how individuals obtain, process, and use information.[7] An educator's role in the learning process reflects a responsibility to create an environment and experience where the learners are able to discover and construct knowledge by themselves.[8] Emphasis should also focus on connecting learner experiences to theory using critical reflection within a collaborative context where one can consider new possibilities and meanings that may have otherwise remained invisible.[6]

Educators must take into consideration the effects that cognitive load will have on learners as they are acquiring new information and skills. Cognitive load theory is based on a cognitive structure consisting of a limited working memory that interacts with an unlimited long-term memory.[9] The cognitive load theory can alleviate cognitive overload by using the working memory to develop schemas without overwhelming the limited processing capacity possessed by the learner.[10] Schemas are mental structures that chunk information into meaningful information that can be stored and easily retrieved within a learner's long-term memory. "The working memory can store approximately seven elements but operates on just two to four elements."[11] Developing schemas allows the learners to chunk the information that is being provided to them in such a way that they are able to store the information in their long-term memory. Cognitive load theory considers the structure and complexity between tasks in relation to a learner's individual cognitive architecture.[12] When learners are presented with information with which they are familiar, they are able to retrieve the information from their long-term memory, thus reducing the need for the working memory to process all the incoming information.[13]

Research that has been conducted comparing simulation with traditional methods of instruction has demonstrated that participants retain knowledge learned from or during a simulated activity for longer periods.[14,15] The simulated experiences promote increased self-confidence and improve problem solving abilities.[16] A review of the current literature revealed that there is a paucity of literature or empirical research addressing the sequencing of educational interventions.[17]

METHODS

Study Design

This randomized control group study consisted of a prospective review of educational materials and assessments that were used during an introductory workshop to teach the fundamentals of hemodynamic monitoring to a group of critical care nurses. Approval for this study was obtained by the ethics committee of the participating hospital. Participants provided written consent and were allocated to 1 of 2 training groups. All participants were assigned reading material to be completed before attending the workshop.

Participants

Twenty-nine novice critical care nurses enrolled in a critical care nursing residency training program participated in a half-day workshop to review the fundamental concepts of advanced hemodynamic monitoring, placing emphasis on central line placement, waveform analysis, interpretation of clinical data, and the assessment of multivariate patient cases. All participants were novice critical care nurses who had recently graduated with an undergraduate nursing degree and had less than 1 year of critical care nursing experience. The participants had recently been enrolled in a 10-week critical care nursing residency program. The hemodynamic monitoring workshop took place after 5 weeks of training.

Of the 29 participants, 27 were female and 2 were male. Because of the unequal distribution of male participants, sex was not a variable that was analyzed during the study. Age was also not a variable that was analyzed during the study because all participants had the same level of experience and amount of experience.

Order of Instruction

Before participation in the workshop, participants were required to review reading materials that had been introduced during a previous class. Participants were given 1 week to complete the prereading assignment. Both groups attended core critical care classes including electrocardiogram interpretation, basic hemodynamics, shock, sepsis, ventilator management, and pharmacology before the advanced hemodynamic sessions. Participants were additionally provided with a preparatory package 1 week before the session, which included a course overview, objectives, and supplemental reading designed to further prepare them for the simulation workshop. At the beginning of the workshop, all participants were administered a 14-question multiple-choice cognitive assessment composed of questions related to advanced hemodynamic assessment, interpretation, and appropriate interventions for critical care patients. The knowledge assessment was developed by a group of nurse educators who were responsible for teaching the course.

The 29 participants were randomly assigned to 2 groups as follows: group 1 participated in simulation activities followed by a didactic lecture on hemodynamic monitoring and group 2 participated in the same activities in the opposite order. The simulation and lecture activities are depicted in Figure 1.

Participants from group 1 then moved to the simulation exercises, whereas group 2 remained in the classroom setting for didactic content. Simulation sessions included 2 complex patient scenarios, with each scenario lasting approximately 1 hour each. Scenario time included a prebriefing (15 minutes), simulation (15 minutes), and debriefing (30 minutes). A prebriefing was provided before a simulation scenario, which provided participants with information pertaining to their patient and allowed them an opportunity to ask course directors questions. During the prebriefing, participants were also provided with an opportunity to see how the patient simulator worked and could interact with it. Participants were presented with 2 of 4 potential scenarios highlighting one of the following multidimensional patients:

- Cardiogenic shock after a motor vehicle crash,
- Neurogenic shock after a fall from a ladder,
- Sepsis after a surgical procedure, and
- Hypovolemic shock after a gunshot wound (Table 1).

During the simulations, the participants were required to take care of multiple patients and balance between patient needs in a surgical intensive care unit. Although half of the participants participated in the simulation, the other half observed. This provided each participant with an opportunity to

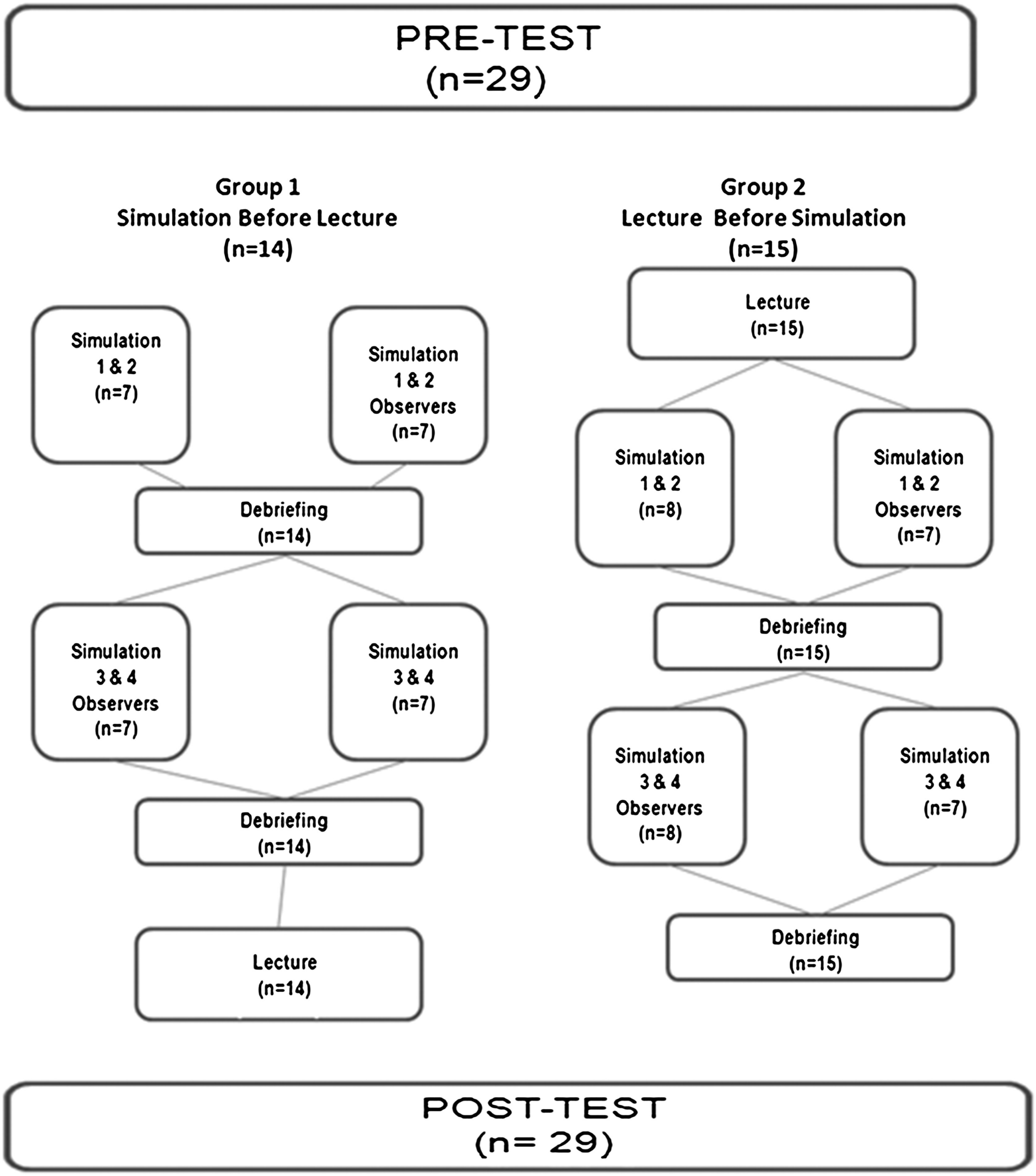

FIGURE 1. Sequencing of Simulation and Lecture Activities

participate and learn from others. Participants were expected to work as a team of nurses. One participant was assigned to be the leader of the simulation. Simulation confederates were placed within the simulated intensive care unit rooms to act as physicians providing the participants with clinical feedback when prompted by the participants. Confederates were

TABLE 1. Simulation Scenarios

Scenario	Summary
Elderly patient with trauma, blood loss, and cardiogenic shock	Elderly patient with blunt trauma with blood loss and progressive hemodynamic instability in the SICU, several hours after transfer from the trauma bay.
The dry patient with trauma with the fluid-stingy physician	Young, healthy patient with trauma with classic hypovolemia shock upon admission to SICU after repair of femoral artery injured by single GSW associated with massive blood loss.
The middle-aged woman with urosepsis in need of goal-directed therapy	Middle-aged woman with septic shock from obstructing urethral stone admitted to the SICU from the OR after successful cystoscopy and stone removal.
Young patient with trauma in spinal shock, complicated by unexpected hypovolemia	Young male house painter fell 20 feet from ladder and is now experiencing spinal cord injury. Complete trauma workshop negative for any other injuries. Patient is now in spinal shock.

GSW indicates gunshot wound; OR, operating room; SICU, surgical intensive care unit.

responsible for knowing the script of the scenario and providing participants with requested data. After 2 simulation scenarios had been completed, course directors led a debriefing session with the participants to review both simulations at the same time. The debriefing allowed for the participants to ask questions regarding the status of their patient and different treatment options available and provided them an opportunity to explain why they may have performed certain tasks during the simulation. Before the completion of the program, all participants were asked to complete a survey to gauge their preference with regard to the format of the workshop (simulation followed by didactic lecture vs. didactic lecture followed by simulation). Prospective data were collected in the form of a pre-post knowledge assessment administered on the day of the workshop covering material presented within the didactic sessions and reinforced in the simulated scenarios. The pretest was administered to all participants at the beginning of the workshop, and the posttest was administered at the end of the workshop.

RESULTS

Data obtained from the preassessments and postassessments composed of 14 multiple-choice questions were imported into SAS version 9.3 and analyzed (Table 2).

A repeated-measures analysis of variance generated statistically significant results in terms of model fit F ($\alpha = 0.05$; 4.54) = 176.07 with a $P < 0.0001$, but the lack of variation suggested that any differences between the 2 groups were not present. Further analysis using Tukey multiple comparisons confirmed this $t(\alpha = 0.05; 2) = 0.08$ with a $P = 0.9403$.

However the Tukey multiple-comparison procedure found a significant difference between assessment times with $t(\alpha = 0.05; 55) = -5.24$ and $P < 0.0001$. This suggests that the intervention had an impact on the participants in the workshop study.

Results also indicated that 76% of the participants from group 1 stated that they would have preferred to have a didactic lecture first followed by simulation. The preference for a didactic lecture followed by simulation was mirrored among participants in group 2 with 71% of the participants indicating that it would not be their preference to have simulation first followed by didactic lecture. Of the participants in group 1, 43% indicated that the format (simulation first followed by didactic lecture) enhanced their understanding of the course material versus 72% of group 2 (didactic lecture first followed by simulation).

DISCUSSION

Previous research has demonstrated that participants retain knowledge learned from or during a simulation for longer periods compared with when the same skill was taught using a more traditional method.[17–19] It can be speculated that learners who were exposed to the simulation activities before attending a lecture were more apt to perform better because they had an opportunity to activate previous knowledge that they had experienced during the simulation activity while discussing key components of hemodynamic monitoring during the lecture. Findings of this study were congruent to findings in a study[17] that explored whether there were significant differences among surgical residents who received instruction before simulation in the surgical arena as opposed to learners who received instruction after participating in simulation. Participants who received instruction after simulation demonstrated higher mean knowledge scores as compared with participants who received instruction before simulation. Although additional research is needed in this area, it can be speculated that cognitive load influenced learners' performance. Participating in a lecture after simulation provided students with the ability to activate their previous knowledge from the simulation that they had most recently participated.

Strategies that can be used during a simulation training session to alleviate cognitive load involve the use of worked examples, drill, and practice sessions, allowing learners the opportunity to familiarize themselves with the case and the equipment that they are working to solve. The more opportunities learners have with interacting and familiarizing themselves with the information that is being presented to them, the more apt they are to make connections between the learning materials and transfer the information from their working memory to their long-term memory.

Although the participants had been assigned reading materials before attending the workshop, many admitted that after completing the pretest, they had not reviewed the materials. This suggests why the pretest scores were considerably low to begin with. The lack of reading preparation before the workshop may have influenced the pretest-posttest scores. Because of statistical significance being present in both groups when comparing the times of assessment (before and after), we can say that the intervention is effective within the groups but not differing in effects between the 2 groups, which means that the intervention had the same positive effect on both groups and suggests that participants were from the same population.

The results of the posttest scores suggest that learners who were engaged in simulation before the didactic lecture retained more information and demonstrated a better performance on postassessments as compared with those who participated in the simulated exercises after the didactic lecture. Participating in the simulations first provided learners with a participatory experience that they could reflect back to during the didactic lecture. The didactic lecture that was presented after the simulations helped solidify the concepts that were presented during the full-immersion simulated learning experience.

Despite their higher levels of increased performance on the posttest, 76% of the participants from group 1 indicated that they would have preferred to have a didactic lecture first followed by simulation. The preference for a didactic lecture followed by simulation was mirrored among participants in group 2 with 71% of the participants indicating that it would not be their preference to have simulation first followed by

TABLE 2. Pretest and Posttest Data

	Test	n	Mean	SD	Minimum	Maximum
Group 1 (simulation before lecture)	Pretest	14	5.4	1.5	4	9
	Posttest	14	8.9	2.1	6	12
Group 2 (lecture before simulation)	Pretest	15	5.9	2.3	1	10
	Posttest	15	8.1	2.2	4	11

didactic lecture. Further supporting this preference for a "traditional format," only 43% of the participants from group 1 indicated that the format (simulation first followed by didactic lecture) enhanced their understanding of the course material versus 72% of group 2 (didactic lecture first followed by simulation).

The timing of when to engage learners in simulated activities is dependent on the amount of previous knowledge they have before engaging in a simulated activity. For purposes of this study, all participants had been provided with a preparatory package of information related to the subject matter that they were required to familiarize themselves with before the workshop. Participating in simulation before additional lectures may have assisted the learners with making connections between course material and clinical concepts.

Limitations

It should be noted that this was a pilot study and the lack of significance could be due to the small number of participants involved. Limitations of this pilot study include the use of convenience sampling methods from our sample population. This strategy potentially limits the ability to generalize our findings to the greater population of learners, particularly nurses in the acute care field. In addition, the small sample size may further limit the ability to generalize the findings to a broader population outside those identified in our project. To increase the sample size, additional workshops would have to be conducted perhaps at a multisite location health care system.

Sex and age were not collected for purposes of this study owing to the fact that all participants were nurses who were new to working in a critical care environment. Future studies involving a more even distribution of male and female participants could explore whether any significant differences arise when comparing how males and females participate in simulated activities before didactic lectures. Age was also not factored into the study owing to the fact that all participants were participating in a critical care orientation and had relatively the same level of nursing experience. Future studies warrant the exploration of the potential effects that sex and age may have on learning in a simulated environment.

Another limitation that arose during this study was that many of the participants had not reviewed their preparatory materials before the workshop. Lack of preparation for the workshop may also have influenced the pretest-posttest scores. Although it cannot be discerned that all participants failed to complete the reading materials, if this study were to be duplicated in the future, course instructors should establish a mandatory pass rate on the cognitive knowledge assessment at the beginning to ensure that all participants had a strong understanding of the materials included in the preparatory package.

Evaluative measures used during this study were a limitation that must be considered. The only form of assessment used was a multiple-choice test to assess the learners' knowledge that had not been previously validated. Future studies would warrant the need to validate not only the questions that were included on the knowledge test but also the incorporation of additional assessment tools such as procedural checklists and direct observations.

Implications for Practice

This study presents an opportunity to the field of simulation to take a closer look at instructional strategies that are currently in place to teach learners in simulated environments. Very little research has been done looking at the sequencing of instructional strategies, particularly in simulation, and the effects that they may have on a learner's performance outcomes. If additional research is conducted pertaining to this topic, medical education specialists will be better poised for developing instruction that is efficient and enhances retention. Additional evaluative metrics need to be developed to measure continued effectiveness of simulated activities.[20]

Implementing an immersion-based simulated learning experience provided an additional opportunity for the learners to see the relevance and connection between hemodynamic monitoring and other key concepts while actively engaging with their peers caring for multiple complex patients simultaneously.

CONCLUSIONS

This study was conducted to begin examining whether the sequence of simulated instruction matters in medical simulation. It was revealed that participants who participated in a simulated learning environment demonstrated an improvement with regard to their knowledge of hemodynamic monitoring as compared with those who attended a didactic lecture before a simulated learning activity as demonstrated by their scores on a multiple-choice knowledge test. Simulated learning experiences are not meant to be a replacement for the experiences a learner would gain from caring for an actual patient. They can provide a training opportunity for the health care professional to develop a process for decision making, critical thinking skills, abstract knowledge, technical skills, and self-confidence all within a safe, controlled environment and with environmental distractors being controlled by the instructor. This idea underscores the concept of learning as a helix or a process not occurring in a linear fashion but rather a spiraling process. Learners are more apt to make greater connections between course content materials if simulations are designed taking into consideration that learning does not occur in a linear fashion.

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