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Featured Article

# The Effects of Virtual Reality Simulation as a Teaching Strategy for Skills Preparation in Nursing Students

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**KEYWORDS**
virtual reality;
simulation;
catheterization;
skills preparation;
nursing students;
teaching strategy;
three-dimensional technology;
virtual reality development

**Abstract**

**Background:** Advancements in virtual reality simulation hold promise for new instructional strategies for basic nursing skills.

**Method:** Virtual reality simulation was designed to support Foley catheter skill proficiency in students with an associate's degree in nursing. An after-only experimental design was used to evaluate skill performance scores, perceived preparation, and practice time in minutes.

**Results:** Independent-samples *t* test revealed no statistically significant differences between the experimental and control groups; however, mean differences revealed positive trends.

**Conclusion:** Findings from this study support use of virtual reality simulation as a supplemental tool for teaching students critical steps in clinical skills such as the insertion of a Foley catheter.

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## Background

Traditionally nurse educators have embraced teaching methods that allow hands-on practice for developing proficiency in basic nursing skills. The effectiveness of hands-on practice is not questioned; however, new challenges in practice and education call for the development and consideration of alternative teaching strategies. Factors such as medication errors, client safety, inadequate practicum instructional time, and increased rivalry for practicum locations prompt faculty to pursue and incorporate technology-driven simulation strategies (Nagle, McHale, Alexander, & French, 2009). The integration of computerized simulators, mobile devices, clinical information systems, social networking, and virtual classrooms for bridging theory and practice is evident in nursing education (Melynk & Fineout-Overholt, 2011). Advancements in virtual reality (VR) technology offer new methods for teaching basic nursing skills.

VR simulation often is associated with science fiction, futuristic businesses, and computerized gaming systems; few associate this technology with nursing education. However, the use of VR for skills validation dates back to aviation flight training simulations during the 1960s (Hahn, 2011). Although VR simulations have been used primarily

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in practical arenas such as aviation and medical imaging, this technology is advancing into the classroom. Currently, there is limited research addressing the efficacy of VR simulations within academic and clinical curriculums (Strangman & Hall, 2010).

**Key Points**
- VR simulation provides supplemental practice times.
- VR simulation enhances skills preparedness.
- VR simulation improves overall skill performance.

Used in other disciplines for skills training, VR simulation is an operative device that introduces students to the intricacy of clinical situations without harming real clients (Jenson & Forsyth, 2012). VR allows engagement of the operator via communication with the device using graphical displays, auditory indicators, and touch vibrations. VR has been used to mimic laparoscopic procedures, bronchoscopy and stent placement, scopes of the colon and vessels, and ultrasound (Nagle et al., 2009). VR simulation can be efficient when implemented in clinical preparations, skills related to communication, critical thinking, and collaboration (Jenson & Forsyth, 2012). VR simulation holds promise as an effective approach for skills preparation and validation in nursing.

The purpose of this project was to evaluate the effectiveness of VR simulation as a teaching strategy for preparation of students for successful performance and validation of Foley catheter insertion by generic associate degree nursing (ADN) students. The specific research question is, "Is there a difference in successful performance of Foley catheter insertion among ADN nursing students who practice the skill using VR simulation and nonhuman models and those who practice using the nonhuman models only?"

## Literature Review

Review of evidence focused on the use and effectiveness of VR simulation on skills performance validation. Keywords used for database searches included *virtual reality*, *skills validation*, *virtual simulation*, *catheter insertion*, and *teaching strategy*. The databases searched included PUBMED, ProQuest, and Cumulative Index to Nursing and Allied Health Literature. Published between 2008 and 2012, a total of 38 studies were reviewed. Seven studies provided supportive evidence for effectiveness of VR simulation in skills performance validation and validity of VR simulation. The studies were composed of random control trials and descriptive designs.

Multiple studies indicated that the use of VR simulations enhanced clinical skill performances. The results revealed that participants using VR simulation were more proficient with clinical skills (Verdaasdonk, Dankelman, Lange, & Stassen, 2008; Zhang, Hünerbein, Dai, Schlag, & Siegfried, 2008; Kundhal & Grantcharov, 2009). One study indicated trainees who received knot-tying preparation on the VR simulator were quicker and made fewer mistakes (Verdaasdonk et al., 2008). The researchers concluded that VR simulation is a valuable instrument to train laparoscopic knot-tying and may improve simulator-based education. In a study of virtual reality laparoscopic suturing training, Botden, Torab, Buznik, and Jakimowicz (2008) recommend that VR simulation should concentrate on rudimentary skills and module task of procedures in laparoscopic surgery.

Evidence supports that VR simulation distinguishes the participant's experience levels. Zhang et al. (2008) verified that the skills parameters of the Lap-Mentor® virtual simulator can be used to differentiate laparoscopic skills among medical students with various degrees of laparoscopic experience. Furthermore, the simulator can be used in training courses as an evaluation tool. In addition, Kundhal and Grantcharov (2009) conclude that evidence supports the validity of VR simulations as objective instruments for evaluating laparoscopic skills. Moreover, these researchers conclude that VR simulation can be used in practica to evaluate procedural skills pertinent for slightly invasive procedures.

Another study indicates that VR simulations with haptic feedback are effective in skills validation. VR simulators that incorporate haptic feedback provide the participant with the sensation of actually inserting the needle through the skin. Haptic feedback capabilities are expensive and often times not feasible (Doong, Fung, Jeng, Tsai, & Tsai, 2008). However, the researchers developed and used a VR intravenous (IV) injection simulator with a visual feedback device that was more economical. The participants' skill performance was evaluated and documented in every test established on objective standards of the technique phase and amount of error (Doong et al., 2008). The researchers verified that the IV injection simulator system with visual feedback was stable and practicable. The simulator also is an effective tool in computer-assisted education for clinicians and in clinical preparation for nursing (Doong et al., 2008).

In a study of faculty perceived importance of and readiness to use VR simulation, Jenson and Forsyth (2012) indicated that VR simulation heightens the learners' understanding of the process. Most participants stated that the VR simulation improved self-consciousness of differences in client reactions to IV catheter insertion; several implied that VR simulation heightened both skill and self-assurance in starting an IV. All participants strongly agreed that the use of VR simulation for IV insertion before the student's actual clinical practicum would be most efficient. Furthermore, VR simulations incorporate simple adjustable teaching approaches similar to actual client situations in a safe environment that heightens the capacity for nurse educators to address the intricacy of teaching in present-day health care settings (Jenson & Forsyth, 2012).

VR also assists in the retention of clinical skills. In a posttraining investigation of colonoscopy skills in medical students, researchers reported that skills attained on VR simulators were retained for at least 4 months whether preparation is independent or proctored (Snyder, Vandromme, Tyra, & Hawn 2010).

## Conceptual Model

An evidence-based approach to instruction informs sound pedagogy for nursing education and safe practice in the health care setting (Bonis, Taft, & Wendler, 2007). Therefore, an evidence-based practice model was appropriate to guide the design, implementation, and evaluation of VR simulation for Foley catheter insertion.

Steven's (2012) ACE Star Model of Knowledge Transformation accentuates the essential stages to convert one method of knowledge to the next and integrate best research evidence with clinical proficiency and client inclinations. As illustrated in Supplementary Figure (see online extra at www.nursingsimulation.org), the model is depicted as a five-point star defining the progression of change that knowledge must transition through to be applicable to clinical practice (Kring, 2008). Knowledge transformation is described as a recurring process that transitions through discovery, summary, translation, integration, and evaluation (Stevens, 2012).

During the discovery stage, evidence was collected from distinct studies related to VR and its usefulness and effectiveness in teaching and validating technical skill proficiencies. A review of literature revealed that VR simulation has been used effectively for skill development and retention in related disciplines. Although limited, research related to the effectiveness of VR simulation for skill development and proficiency in nursing is supportive.

The summary stage provided assistance with the evaluation of the VR simulation research studies and synthesis of ensuing knowledge into an evidence summary (Stevens, 2012). In this stage, studies regarding VR simulation and skills validation were identified and retrieved using various search engines. Articles pertaining to VR and skills were selected from a variety of peer-reviewed journals such as nursing education and other professional disciplines.

The translation stage provided guidance in transformation of the evidence related to VR and Foley catheterization. Evidence supported clinical guidelines for proper Foley catheter insertion (Potter, Perry, Stockert, & Hall, 2011). These guidelines were used in the development of the steps captured in the VR simulation. Thus, the discovery, summarization, and transformation of knowledge guided the development of the Foley VR simulation.

Practice integration involves the implementation of applicable change, or action into training or practice (Stevens, 2012). The Foley VR simulation was implemented in the Fundamentals of Nursing course.

Evaluation is the fifth and final step of knowledge transformation. Practice time in minutes, perceived levels of preparedness, and successful completion of the skill were monitored. Data were analyzed to determine the project outcomes and effectiveness of VR as a teaching strategy for proper insertion of a Foley catheter.

## Methodology

All students enrolled in the first level Fundamental of Nursing course were invited to participate in the study without coercion at the beginning of the course. Thirty-seven students consented to participate in the project. Exclusion criteria included previous enrollment in a fundamentals course or previous nursing degrees. Of the 37 students who consented, 17 students withdrew from the study. Eight students withdrew from the Fundamentals course and nine students voluntarily withdrew from the study, therefore, N = 20.

The setting chosen for this project was a community college located in the southeastern part of the United States. This college has a traditional, generic ADN program as well as an online hybrid program. The facility also houses a computer laboratory designated for nursing students.

The development of VR simulation incorporated various steps and techniques required for the proper insertion of a Foley catheter such as cleansing the perineal area from front to back, keeping the labia retracted, lubricating the catheter tip, attaching the syringe, inflating the balloon, and disconnecting the syringe. The simulation provided on screen prompts that gave step by step instructions on how to insert the catheter. Another feature included an alarming buzzing sound if a step was performed incorrectly and advancement to the next step was prohibited. The VR simulation was available to the experimental group from any location. The only requirement was using a device with a mouse.

There was no cost to the students. The computers and VR program were available at the community college. The program was available via a password protected Web site to grant access from home. A graphic designer, simulation modeling developer, and engineer assisted in the construction of the VR simulation program.

## Tools and Data Collection Tools

### Tools

#### Foley Catheter Simulation

The VR simulation was developed into a three-dimensional model using Autodesk Maya and deployed using the Unity game engine. This method ensured a common interface regardless of the location from which students viewed the training. Any feedback from the simulations was limited to on screen prompts and visual keys.

The model reinforced the concepts of proper cleaning of the female labia, testing for proper technique, and compliance with aseptic guidelines. Additionally, the model supported training on the proper method for insertion, inflation, and monitoring of a catheter in a female client. The simulation enabled the ADN students to practice the physical steps necessary to complete the catheterization procedure according to best practices.

## Data Collection Tools

### Demographic Questionnaire

Participants completed a demographic questionnaire that included exact age, grade point average (GPA), and ethnicity. Demographic data were collected to describe the sample and compare demographic characteristics to study outcomes.

### Log Sheets

Students maintained a log of practice time using the VR simulation and the nonhuman model. The log consisted of columns that indicated the date, time practice began, and time practice ended, and total time in minutes. Log sheets were provided to each participant.

### Skills Evaluation Tool

The Fundamentals of Nursing Simulated Skills Evaluation Placement grading tool was used to evaluate skills performance of the students. The tool consists of A and B sections. Section A consists of five preparation steps, and Section B consists of 24 procedural steps. The overall performance score was based on satisfactory completion of the 29 steps with passing scores ranging from 75 to 100.

### Visual Analog Perceived Preparedness Scale

Postintervention assessment of the ADN students' perceived level of preparedness for the catheterization skill was implemented using an online visual analog scale program. The Visual Analog Perceived Preparedness Scale was administered immediately after completing the procedure. The scale allowed participants to indicate level of preparedness for performance of the Foley catheterization skill.

With the use of a computer-generated 100 mm straight line, the line was anchored with "very unprepared" at 0 mm to "very prepared" at 100 mm. Distance in millimeters was measured and reported using an online program (http://www.nrlc-group.net/software/AdaptiveVisual.php).

## Procedures

ADN students enrolled in Fundamentals of Nursing were provided necessary information for informed consent, including the nature of the involvement, possible problems and benefits, and accessible options for participating in the institutional research board-approved research. Additionally, the students were informed about the method and security of data collection and how to withdraw from the research at any time. Students were assigned randomly to two groups. The experimental group used the VR program to practice catheterization skills. The control group did not have access to the VR program.

The experimental group was administered a password and URL for Web site access to the program in the computer lab 1 week before the catheterization skills validation procedure. They also were granted access from home via a password-protected Web site. Additionally, each participant in the experimental group was administered a log-in sheet and asked to record the amount of time spent using the VR program. The experimental and control groups received the same didactic instructions in a classroom setting followed by demonstration of a Foley catheter insertion on a nonhuman model by the laboratory faculty. Both groups practiced catheterization on a nonhuman model in the laboratory during designated times assigned by the instructor. Participants in both groups then performed a catheterization procedure on a nonhuman model under the supervision of an expert utilizing a grading tool to determine the study outcome.

## Data Analysis

Data were compiled into a dataset and analyzed using SPSS, version 22.0 (IBM Corporation, Armonk, NY). The results were compared between the experimental and control groups. Descriptive statistics were used to describe the sample and student performance outcomes. Inferential statistics compared differences in number of items successfully completed on the skills validation tool. Independent samples *t* tests were conducted to examine for differences in visual analog scores, overall performance scores, and practice time in minutes. Pearson correlations were used to analyze the relationship between the overall performance scores and the visual analog scores.

## Results

The sample was evenly divided into experimental and control groups. Each group was primarily white (90%, n = 9) in race. One participant in each group was black/African American. Mean and range for age and GPA of both groups are found in Table 1. The participants in the

**Table 1** Age and GPA of Participants Divided Into Two Groups (N = 20)

| | Experimental Group (n = 10) | | | Control Group (n = 10) | | |
|---|---|---|---|---|---|---|
| Characteristic | M | SD | Range | M | SD | Range |
| Age | 24.50 | 3.67 | 19-33 | 27.10 | 7.78 | 19-42 |
| GPA | 3.15 | 0.50 | 2.50-3.80 | 3.26 | 0.46 | 2.50-4.0 |

*Note.* GPA = grade point average; M = mean; SD = standard deviation.

**Table 2** Frequencies of Selected Experimental and Control Group Skill Variables (N = 20)

| | Experimental Group | | Control Group | |
|---|---|---|---|---|
| Catheterization Skills | n | % | n | % |
| Successfully completed skill | | | | |
| Yes | 10 | 100 | 9 | 90 |
| No/recheck | | | 1 | 10 |
| Attached syringe successfully | | | | |
| Satisfactory | 10 | 100 | 9 | 90 |
| Unsatisfactory | | | 1 | 10 |
| Lubricated catheter tip successfully | | | | |
| Satisfactory | 10 | 100 | 10 | 100 |
| Unsatisfactory | | | | |
| Keeps labia retracted without contamination | | | | |
| Satisfactory | 7 | 70 | 8 | 80 |
| Unsatisfactory | 3 | 30 | 2 | 20 |
| Cleansed properly | | | | |
| Satisfactory | 10 | 100 | 8 | 80 |
| Unsatisfactory | | | 2 | 20 |
| Inflated balloon successfully | | | | |
| Satisfactory | 10 | 100 | 10 | 100 |
| Unsatisfactory | | | | |
| Disconnect syringe successfully | | | | |
| Satisfactory | 10 | 100 | 10 | 100 |
| Unsatisfactory | | | | |

experimental group were younger and had a lower GPA than those in the control group.

Frequencies of successful completion of skills with selected categorical variables of both experimental and control groups are found in Table 2. The experimental group scored higher for the categories *successfully completed skill*, *attached syringe successfully*, and *cleansed properly* compared with the control group. However, the control group scored slightly higher (80%, n = 8) on the variable *keeps labia retracted without contamination* compared with the experimental group (70%, n = 7).

The mean (M), standard deviation (SD), and range of experimental group and control group variables visual analog score, overall performance score grading tool, and reported time of participation in minutes for virtual simulation and nonhuman model log sheets are found in Table 3. The visual analog and the overall performance scores for the experimental group were greater compared with the control group scores. The control group spent more time on the nonhuman models (M = 182.50, SD = 71.92) than the experimental group spent in minutes combined between virtual simulation (M = 31.10, SD = 20.99) and nonhuman models (M = 125, SD = 66.08).

Independent samples *t* tests were conducted to examine differences in visual analog scores ($t_{(11.719)} = 1.194$, $p > .05$), overall performance scores ($t_{(18)} = 0.821$, $p > .05$), and reported time in minutes spent on nonhuman models ($t_{(18)} = 1.862$, $p > .05$) between the two groups. Pearson correlations were conducted to examine the relationship between the visual analog scores and the overall performance scores. Findings revealed a moderate positive relationship between the overall performance score and the visual analog score ($r = 0.411$, $p < .05$). Using group as the controlling variable, further analysis using partial correlation revealed a less significant correlation between the overall performance score and the visual analog score ($r = 0.380$, $p = .054$).

Pearson correlations were conducted to examine the relationships between age of participants and total scores of the continuous level study outcomes. There was a significant relationship found between age and the overall performance grading tool score ($r = 0.567$, $p < .01$), indicating that as age increased so did the overall grading tool score.

## Discussion

All participants in the experimental group successfully completed the skill on the first attempt, whereas nine of the ten participants in the control group were successful. One participant in the control group had to repeat the process for validation of the Foley catheter insertion skill.

Although there were not statistically significant differences between the experimental and control groups, most likely because of the small sample size, mean differences

**Table 3** Mean (M), Standard Deviation (SD), and Range of Experimental Simulation Versus Control Variables (N = 20)

| | Experimental Group (n = 10) | | | Control Group (n = 10) | | |
|---|---|---|---|---|---|---|
| Outcome Variables | M | SD | Range | M | SD | Range |
| Visual analog score | 92.85 | 6.54 | 80.75-100 | 86.10 | 16.63 | 55.50-100 |
| Overall performance grading tool | 94.92 | 5.04 | 86.89-100 | 92.77 | 6.58 | 79.31-100 |
| Minutes spent on virtual simulation | 31.10 | 20.99 | 15-70 | N/A | N/A | N/A |
| Minutes spent on control model | 125 | 66.08 | 0-225 | 182.50 | 71.92 | 90-300 |

*Note.* N/A = not available.

revealed positive trends. The experimental group's visual analog score (92.85) and the overall performance score grading tool score (94.92) were greater compared with the control group's visual analog score (86.10) and overall performance grading tool score (92.77). The control group spent more time on the models than the experimental group spent in minutes combined between virtual simulation and nonhuman models. Overall, the relationship between the performance grading tool scores and the visual analog scores were positive. Thus, students who scored greater on the performance grading tool also had a greater perceived level of preparedness.

The ACE Star Model was used to translate knowledge for application of evidence for support of VR simulation for Foley catheter insertion. Via the use of three-dimensional and gaming engine software, a Foley VR simulation was developed based on current clinical guidelines for catheter insertion. Students in the experimental group were provided access to the Foley VR simulation in preparation for completing the Foley catheter skills validation. Although the sample was small, evaluation of outcomes indicated positive trends for increasing perceived levels of preparedness and overall performance scores and reducing the amount of practice time in minutes.

## Limitations

There are several limitations of this study. The small sample size decreased the likelihood of finding statistical significance between the experimental and control groups regarding perceived level of preparedness, overall performance scores, and total practice time in minutes. Another limitation was the withdrawal of participants from the course and study. Three students in the experimental group indicated that they were unable to download the simulation and were reassigned to the control group. Another limitation is that practice times using the VR simulation and non-human model were self reported by the participants.

## Implications

This VR simulation provides additional practice opportunities for the ADN students without their having to travel to school during available lab hours. Instructors can review skills missed and how many of the 36 steps in the VR Foley simulation were completed. VR simulation allows the faculty to evaluate the students' performance electronically. The project will be sustained by incorporation into the Fundamentals and other nursing clinical courses at a community college.

More research is needed to validate application of VR simulation for development of skill proficiency related to the insertion of a Foley catheter. Advancements in virtual simulation technology will provide opportunities for expanded application in clinical skill development.

## Conclusion

Studies support benefits of using VR simulation as a supplemental teaching strategy in nursing and other disciplines. To date, research regarding VR simulation for development of clinical skill proficiency is limited. Overall, the studies were beneficial but lacked large sample sizes. Several of the studies focused on the validity of VR and indicated that it was a reliable method.

Findings from this study support use of VR simulation as a supplemental tool for teaching students critical steps in clinical skills such as insertion of a Foley catheter. All participants in the experimental group successfully completed the skill. Descriptive findings suggest greater performance scores and perceived levels of preparedness among those who participated in the VR simulation.

## Supplementary Data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ecns.2014.10.001.

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