Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.7, No.9, 2016

Traditional Instruction Versus Virtual Reality Simulation: A Comparative Study of Phlebotomy Training among Nursing Students in Kuwait

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Abstract
This quasi-experimental study compared differences in phlebotomy performance on a live client, between a control group taught through the traditional method and an experimental group using virtual reality simulation. The study showed both groups had performed successfully, using the following metrics: number of reinsertions, pain factor, hematoma status, duration of tourniquet application, time to complete the procedure, and successful completion of procedure. Utilizing t-test in comparing the control and experimental groups, no performance metric was found to be significant. Total time to complete the procedure for both groups had the lowest p value, but was of no significance. Both methods for phlebotomy training were found to be equally effective. Nurse educators are challenged to recognize the advantages and limitations of both methods to pave their way in an enhanced quality phlebotomy program.
Keywords: Traditional method, Virtual reality simulation, Phlebotomy, Performance metrics

1. Introduction

Technological advancement necessitates the evaluation of innovative instructional strategies, such as the virtual reality simulation. Computerized technology as a means of educating nursing students is at a crossroads since clinical performance and competencies of students remain a challenge to nurse educators (Forsyth and Jenson, 2012). Instructional strategies, such as simulation, that enhance students' clinical competency and critical-thinking skill, offer a strong potential in achieving learning and evaluation goals (Decker et al., 2008). Computer based simulation wherein students practice skills in a "risk-free setting" and critically analyze patient situations is an answer for nurse educators (Walsh, 2010).

The virtual reality simulator (VRS) is a relatively new and complex multisensory technology system which offers users an experience of real life situation in an artificial environment and enables their immersion in a virtual world (Mahrer and Gold, 2009). VRS provides an entirely novel opportunity in the simulation of skills such as phlebotomy, by using computers for knowledge acquisition, skill training, evaluation, and eventually certification.

Phlebotomy, vein puncture for blood withdrawal has evolved into a profession necessitating specialized education and training. Traumatic or repeated punctures, pain, hematomas and others can result from an improperly performed procedure. Nurses, therefore need to master the skills and techniques of drawing blood and collecting quality specimen by using the safest means possible. Moreover, they have to develop a positive attitude, sound judgment, and highly effective communication skills to interact with patients. Nurses are the vital link between the patients and the laboratory.

Nowhere has the change in content delivery and clinical education methods been more evident than in the clinical aspects of nursing education (Bodily, 2012). The challenge for nurse educators is to utilize simulation and traditional methods as instructional tools and to design testing strategies focusing on evaluating practices which are deemed the best. Virtual reality and the traditional method for phlebotomy training both have their benefits and drawbacks. Nurse educators have the ultimate responsibility to examine these educational tools for more effective outcome measurements geared towards the improvement of patient safety and care.

Review of Literature

Computer-based clinical simulations are a powerful teaching and learning tool because of their capacity to expand healthcare students' clinical experience through practice based learning (Rogers, 2011). Most of the research studies conducted on the use of the patient simulator have been in medical settings. In 2005, Issenberg et al. did an extensive review of the medical literature on simulation. Out of the 670 articles identified, they used 109 of these for their analysis which made them conclude that simulation can enhance learning by providing: feedback (47% of articles), repetitive practice (39%), curriculum integration (25%), a range of difficulty levels (14%), clinical variation (10%), a controlled environment (9%), individualized learning (9%), defined outcomes

(6%), and simulator validity (3%).

One of the earlier studies which evaluated nursing student and faculty perceptions about VRS using the LaerdalSim Man Universal Patient Simulator was conducted by Feingold et al. (2004). They surveyed 65 students who had participated in simulations during two consecutive semesters, using a 20-item tool. A similar 17-item tool was utilized to survey four faculty members. While the majority of students and faculty agreed that simulations were valuable, only half of the students responded that simulation skills were transferable to an actual patient care setting. From the faculty perspective, simulations reinforced clinical objectives but require preparation, time and support to use the technology.

Scerbo et al. (2006) examined the effectiveness of a traditional approach using simulated limbs as compared to virtual reality simulator (VRS) for training phlebotomy. Better performance was noted with participants trained with simulated limbs than those trained with a VRS. The metrics recorded by the virtual reality system, nonetheless, may highlight some aspects of performance which could eventually prove beneficial. The research stressed the potential for simulators to improve patient safety by providing trainees practice on devices rather than patients. In a later study, Sotto et al. (2009) compared the effectiveness of simulation versus traditional methods for teaching IV cannulation. A significantly higher success in starting an IV on an actual patient was demonstrated by students trained on the IV simulator. In 2011, Daniel et al. assessed the effectiveness of training students using mannequins and simulators and found a significant relationship between the number of IV insertion attempts and the type of training.

As computer technology advances and VRS gain the distinction of being an educational device, the present study increases in significance. Although still sparse in comparison to medical literature, evidence on the use of patient simulation in nursing education and practice is continuously accumulating. A clear paucity however, exists in research studies related to patient simulation, particularly in the field of phlebotomy. If health practitioners, including students, could practice procedures such as phlebotomy on VRS before doing it on patients, safety and quality of care could be assured. In the preparation of health professionals, the effectiveness of VRS as an instructional strategy should be evaluated, especially if it has already been integrated into the undergraduate program.

Aims of the Study

The purpose of this study was to compare the differences in the skill performance of phlebotomy between a group taught through the traditional method (control group) and another group using virtual reality simulation (experimental group). The study sought answers for the following research questions:

1. What was the level of performance of phlebotomy on an actual patient by the control group?
2 What was the level of performance of phlebotomy on an actual patient by the experimental group?
3. Were there significant differences between the two groups' performance of phlebotomy on an actual patient?

Definition of Terms

The following definitions were used in this study:

1. Traditional method: the strategy or method of instruction used in teaching phlebotomy skills to students with the use of the plastic simulated arm.
2. Virtual Reality Simulation (VRS): a computer based simulation of an imagined or real environment, which offers a highly interactive experience to students.
3. Phlebotomy: a technique for blood withdrawal and sample collection wherein the vein is punctured.
4. Experimental group: the students who have been exposed to the use of the Virtual Reality Simulator, specifically, CathSim system.
5. Control group: the students who have been exposed to the traditional method of learning phlebotomy skills.
6. Performance metrics: the assessment indicators for the phlebotomy procedure used in the CathSim system, namely:
   a. pain factor,
   b. duration the tourniquet was applied,
   c. hematoma status,
   d. number of re-insertions,
   e. time to complete the procedure, and
   f. whether the procedure was successfully completed or not.

Method

Design

This study was quasi-experimental, with a control group and experimental group to evaluate the effectiveness of the traditional method of teaching phlebotomy skills to the students as compared to the virtual reality simulator.

Setting

The research was conducted in two settings, namely: the College of Nursing, Kuwait (which stands out as the only educational facility in the country which offers Associate Degree of Nursing and Bachelor of Science in Nursing programs) and in the Phlebotomy Clinic of Al Amiri Hospital in Kuwait. The College of Nursing is guided by the promulgation of accredited organizations such as the National League of Nursing, World Health Organization, and the International Council of Nurses, in its aim to develop "professional registered nurses". The system of nursing education resembles that of the American and Canadian systems.

The Bachelor of Science in Nursing (BSN) program consists of nine semesters and is limited to female and male Kuwaiti students. On the other hand, the Associate Degree of Nursing (ADN) program is composed of five academic semesters and admits both female and male students, representing different nationalities – Kuwaitis and nationals from the Gulf Cooperation Council, and other Arab countries. There is homogeneity in culture and language despite differences in nationality.

The Al Amiri Hospital is one of the six regional hospitals under the Ministry of Health in Kuwait. Its Phlebotomy Clinic is in the Outpatient Department and has a daily average of 250 patients who come in for blood extraction.

Participants

The participants of the study included all the 62 ADN female students enrolled in level two during the second semester of the academic year 2011 – 2012. The sample consisted of two groups, randomly selected, with 33 students comprising the control group and 29 students in the experimental group. Level two students were the focus since the procedure being experimented on is taught during this period. BSN students and ADN male students, who represented approximately 3% of the entire college enrollment, were excluded from the study. Other exclusion factors were: prior experience with VRS in the College, for students in the control group; and prior experience in phlebotomy, for those in the experimental group.

Instruments

There were two written instruments used for the study. The first instrument was a questionnaire developed by the researchers to assess the socio-demographic characteristics of the respondents. Items included in the questionnaire were: age, nationality, educational level attained prior to enrollment in the College, and data on prior experience with the VRS in the College, or practice of phlebotomy before the current level**.** Respondents likewise commented on their experience while practicing phlebotomy on clients in the Clinic.

The second instrument was a standardized Phlebotomy Skill Checklist formulated by the manufacturers of the CathSim system which was utilized by the mentors in the Phlebotomy Clinic. The Skill Checklist was composed of 26 items, 23 of which were focused on the necessary steps for the completion of a phlebotomy procedure, and the remaining three items were related to overall performance. All items were answerable with a "yes" or "no" except for three. These were: 1) duration the tourniquet was applied, which was expressed in minutes and seconds; 2) time taken to complete the procedure, also expressed in minutes and seconds, and 3) pain factor from the client's perspective which was rated on a scale of 0 – 10, wherein 0 – 3 is equivalent to mild pain, 4 – 6; moderate pain, and 7 – 10; severe pain. Space was allotted at the end portion of the checklist, for entry of steps in the procedure wherein the student was confused, had mistakes, or did not do well.

Materials

Two basic materials were utilized for the study. In the traditional approach of training for phlebotomy, a simulated plastic arm was used. This has several potential sites for phlebotomy and contains latex veins covered by vinyl skin; however, only the antecubital fossa was used in this study.

The simulation device used for the study was the Virtual Reality Simulator, specifically, the CathSim system, which has a phlebotomy module with six patients. The learner selects a case after which an image of the patient's arm appears on the computer screen. With the computer's mouse, the computer guides the student through the steps of selecting an insertion site, palpating the site, and applying the tourniquet. A magnified image of the insertion site and a virtual needle then appears on the screen. The mouse is used to position the virtual needle for insertion. Once the insertion site is chosen, traction is applied to the simulated skin pad. The needle is then inserted into the virtual arm, with the needle unit of the AccuTouch device fully retracted. Progress is monitored on the screen. When the needle has accessed the vein, the mouse is clicked on icons representing the collection tubes. The participant then attaches a physical tube to the needle unit of the AccuTouch device. On the screen, if the vein access is successful, the virtual collection tube appears to fill with blood. The number of test tubes to be filled depends on the given situation and once completed, the student releases the tourniquet and detaches the tube from the AccuTouch device by using the mouse. The procedure is completed when the image on the computer screen displays the needle being deposited into a biohazard sharps

container.

Performance Metrics

In this study, six performance metrics from the CathSim system were utilized to evaluate training, namely: procedure was successful; number of reinsertions; pain factor; hematoma status; duration of tourniquet application; time to complete the procedure. Successful performance of the procedure is indicated if the student completed the blood withdrawal or not. Number of reinsertions represents the number of times the student inserts the needle before achieving successful performance. Pain factor as a metric is increased by factors such as deep needle penetration, inappropriate needle angle or movement of the needle after it is embedded in the skin (Scerbo, 2006). If the vein wall is scraped or if both vein walls are passed through by the needle, hematoma occurs. Other metrics considered were the duration of tourniquet application and time to complete the procedure.

Pilot study

The questionnaire was tested on a group of five students with the aim of checking on the clarity of the questions to be modified accordingly. No significant modifications were suggested.

The skill checklist to be used in the phlebotomy clinic by the mentors were given to them in a prior session to elicit their comments. The mentors had no major suggestions.

Procedures

Participants in the control group were trained through the traditional method, utilizing the simulated limbs, in accordance with the items in the checklist. The researchers introduced the equipment for phlebotomy and had demonstration on the successful performance of the procedure. A return demonstration ensued and verbal feedback regarding the participants' performance was provided by the researchers.

The experimental group (VRS group) was introduced to the CathSim system and was instructed on how to use the AccuTouch. Under the supervision of the researchers, the participants practiced for a five hour session on at least three case patients. The criteria for successful performance were emphasized to them.

Exposure to the Phlebotomy Clinic on an actual patient was done on an alternate basis between the experimental group and the control group, a week after their respective training. For the first week, the experimental group was exposed, followed by the control group on the second week, until all the participants had their experience in the Clinic. Since only six to eight participants were accommodated in the Clinic every Monday and Tuesday, it took a total of six weeks for the completion of their exposure.

Questionnaires were filled up by the participants in the classroom setting after their complete exposure to the Phlebotomy Clinic. This provided them the opportunity to express their comments on their actual performance on a patient.

Ethical considerations

This study is a follow through of a related project which has been approved by the Research Committee of the College of Nursing and subsequently, that of the Public Authority for Applied Education and Training (PAAET), of which the College is a constituent. The researchers informed the participants orally and in writing about the nature of the study and the utilization of the outcomes for evaluation of the technology used – the VRS. Participation in the study was on a voluntary basis. Confidentiality and anonymity were maintained throughout the study.

After their phlebotomy experience on an actual patient, the members of the control group were exposed to the VRS to ensure observance of ethics and to provide them with the same experience. This portion, however, is no longer a component of the study itself. Both the control and experimental groups were therefore exposed to the two instructional methods for phlebotomy training – the traditional and the VRS.

Data collection

Data were obtained from 62 female students from level two of the Associate Degree of Nursing Program at the College of Nursing registered during the second semester of 2011 – 2012. A researcher supervised the filling up of the questionnaires by the students themselves in the classroom setting.

Two phlebotomists designated to assess the students' phlebotomy performance on actual patients in Al Amiri Clinic accomplished the phlebotomy skill checklist to which they have been oriented prior to its use. Inter-rater reliability is relatively high and differences are relatively minimal, taking into consideration that these mentors have been consistently rating students assigned in the above mentioned clinic for the past seven years.

Data Analysis

For statistical analysis, survey data were processed using the SPSS version 17. Frequencies of the variables were highlighted through descriptive statistics (means and standard deviations). To compare the control and

experimental groups utilizing the performance metrics, a t-test was performed.

Results

Demographic Data

The sample consisted of two groups, with 33 students comprising the control group and 29 students in the experimental group. The age range for the sample was between 19 and 22 (77%) with age 20 as the most common (41.9%).

Only 3 % of the sample composed Kuwaiti nationals; the rest were other Arab nationals. Prior to enrollment in the College of Nursing, 69.4% of the sample graduated from the public four year high school program, while 25.5% had education in the Nursing Institute (equivalent to two years education) instead of the regular four year program.

Comparative Findings between the Control and Experimental Groups

Data analysis showed that both, the control and experimental groups, met all the criteria in the checklist which indicated successful performance of the procedure. There were, however, no significant differences in results in the various performance metrics.

Table 1. Comparison of Significant Frequency Percentage of Control and Experimental Groups Using the Performance Metrics

Performance Metrics	**Group I (Control) N= 33**		**Group II (Experimental) N = 29**		**t-test for Equality of Means**		
	Mean	**SD**	**Mean**	**SD**	**t**	***df***	***p***
Pain factor	1.91	0.522	1.86	0.441	-.384	59.917	.702
Duration the tourniquet was applied	14.39	14.701	10.10	0.409	-1.676	32.056	.104
Hematoma status	1.03	0.174	1.00	0.000	-1.000	32.000	.325
Number of reinsertions	1.25	0.508	1.24	0.435	-.071	58.831	.943
Time to complete the procedure	20.67	20.728	13.45	12.894	-1.667	54.343	.101

Table 1 reveals that the mean and standard deviation values of the control group were higher in five performance metrics (pain factor, duration the tourniquet was applied, hematoma status, number of reinsertions and, time to complete the procedure) when compared with that of the experimental group. Likewise, Table 1 shows that in comparing the control and experimental groups using the t-test, no performance metric was significant. The total time to complete the procedure for both groups had the lowest p value, but was of no significance. In like manner, the two groups had the same performance metric with the highest *p* value, namely, the number of reinsertions. There is no significant difference, however.

Table 2. Comparison of Significant Frequency Percentage of Control and Experimental Groups Using the Performance Metric on Successful Completion

Performance Metric	**Group I (Control) N= 33**		**Group II (Experimental) N = 29**	
	Mean	**SD**	**Mean**	**SD**
Complete procedure successfully	1.00	0.000 *	1.00	0.000 *

*t cannot be computed because the standard deviations of both groups are 0.

Table 2 shows that the experimental and control groups, when compared using the performance metric on successful completion of the procedure obtained zero (0) for their standard deviation. Both groups demonstrated a perfect success rate.

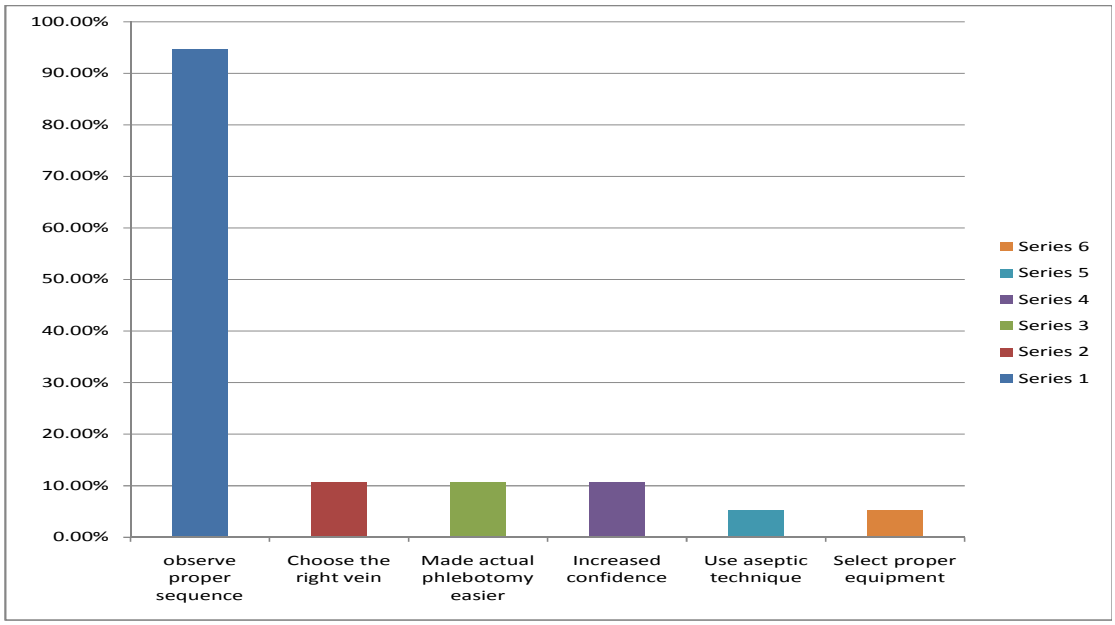

Figure 1. Comments of the Experimental Group on the Virtual Reality Simulation

At the end of the questionnaire, the experimental group was asked to remark whether their exposure to the VRS helped them in their actual practice on the clients. Positive remarks were given by 65.5% from the experimental group. As can be gleaned from Figure 1, most of the comments focused on how VRS taught them to do the procedure observing proper sequence (94.7%). Other comments revealed the following: VRS emphasized the use of aseptic technique; made the performance of phlebotomy easier; showed them how to choose the right vein; helped them select the proper equipment; and increased their confidence.

Discussion

This study aimed to comparatively evaluate the efficacy of phlebotomy training using the traditional method (simulated limbs) and the virtual reality simulator (CathSim system). There were no significant differences between the control and experimental groups.

The lower mean and standard values of the experimental group, while not significant, indicated that this group produced less pain and hematoma on the clients, had fewer reinsertions, took less time in having the tourniquet on the client and less time for completing the procedure.

The dearth of studies on the use of VRS suggests that the simulated limbs are more effective for phlebotomy training (Scerbo et al., 2006) which runs counter to the findings of this study. Findings in this research disagree with the results showed in the study of Scerbo et al. (2006) wherein students using the simulated limbs obtained higher scores on both the post-test and the field test with actual patients than those who utilized the CathSim system. These findings may be due to the design characteristics of the two systems which may significantly differ. The VRS offered practice in fewer steps of the phlebotomy procedure and some steps were critically different (Scerbo et al., 2006). For example, in the VRS, a student clicks on an icon instead of actually tying a tourniquet. Another study which compared the use of the traditional method with a VRS in the teaching of medical students found that those trained in the traditional manner performed more efficiently than those trained solely by VRS (Wandell, 2010).

McGhee et al. (2011), however, suggested that incorporation of virtual reality improved learning experience, shifted from passive to active learning, and assured patient safety. Jung et al. (2012) confirmed the educational effectiveness of practical exercises using intravenous simulators incorporating virtual reality/haptics (based on the sense of touch) device technologies. In that study, the group trained on both the IV arm and IV simulator scored highest on procedures for venipuncture and required significantly less time than the other two groups, one of which utilized only the conventional arm model (IV arm), and the other group used solely a VR/Haptics IV Simulator.

Neither the virtual reality based system nor the traditional method can be deemed perfect in and of

itself or totally represent the procedure done on an actual patient. While the simulated arm may more closely resemble phlebotomy as performed on a patient, there are several distinctive features of the VRS not obtained with simulated arms (Scerbo et al, 2006). An example of this is the index of hand steadiness which could be an indicator of pain, and the formation of hematoma based on the trainee's performance. In this study however, the pain factor and hematoma formation were not significant. Many students using the simulator, however, reported that it was harder to manipulate both a needle assembly and a mouse simultaneously.

Conclusion

The traditional and the VRS as methods for phlebotomy training both appear to be effective. In this study, there was no significant difference between those trained using the VRS and those using the traditional method (simulated limbs). The superiority of the VRS or the traditional method in phlebotomy training cannot be established. Both groups demonstrated a high success rate in phlebotomy training. Innovative strategies such as VRS, however, have the potentials to bridge the gap between theory and practice for nursing students and transform nursing education by increasing patient safety and by reducing student anxiety. There are certain features of the VRS which are appreciated by the subjects. The challenge for nurse educators will be to recognize the advantages and limitations of both methods to pave their way in an enhanced quality phlebotomy program.

Limitations and Recommendations

In this study, the evaluation of the performance of phlebotomy by the students was done on actual patients who came in randomly at the clinic. This therefore posed a limitation in terms of choice of patients, particularly over the control of individual characteristics.

Any conclusions drawn would be tentative, considering the relatively small sample size. Replication of this study in Nursing institutions in other countries is recommended. Future studies may investigate variations in the type of phlebotomy training, after carefully considering the ethical and cost aspects. For instance, a group would be purely trained in the mannequin; another group would utilize the VRS, and a third group would have the combination of the mannequin and the VRS. The element of time may also be considered wherein the relationship between practice time and skill acquisition may be noted, considering that more practice can yield better results.

Acknowledgement

The authors deeply appreciate the expertise and time shared with us by the following:
Dr. Shu- hua Wu, for the editing of our final paper; Dr. Ali Felah Al Hajraf, for the statistical analysis, and; Dr. Amira Sharaf, for the paper submission detatils.

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