# Virtual Healthcare Environments Versus Traditional Interactive Team Training

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## Structured Abstract

**Purpose**: The primary goal of this study was to determine if there was a difference in knowledge, skills, and attitudes resulting from different teamwork training interventions. Subjects were randomized to mannequin-based simulation (MBS), virtual environment (VE), or video-taped lecture. We hypothesized there would be a greater improvement and retention associated with interactive training methods when compared with control. **Scope**: Thirty-eight non-anesthesiology senior residents as well as nurse practitioners in training and practice were recruited. **Methods**: Participants were evaluated on knowledge, skills, and attitudes before, after, and 3 months after the training intervention. **Results**: SAFE-Teams was used to measure skills. SAFE-Teams scores were converted to Z-scores. The mean SAFE-Teams pre-test score across all participants in the three training conditions was 4.33 (or a Z-score of -0.33) and, on average, individuals increased their score by 0.97 (Z-score of 0.50) immediately following training and by 1.11 (Z-score of 0.59) 3 months after training. Comparisons within a training condition using Wilcoxon nonparametric matched pairs analyses of pre- and post-test scores revealed that control and VE conditions significantly improved SAFE-Team scores immediately following training. There was a trend for improvement in the MBS condition ($p=0.11$). Long term, participants in the MBS and VE training conditions improved their performance. There was a trend for improvement in the control condition ($p=0.11$). Wilcoxon sum of ranks tests revealed no significant differences.
**Key Words**: team training, virtual environment, mannequin-based simulation, skills assessment

### Purpose

The primary goal of this study was to determine whether there was a difference in improvement in teamwork skills of individuals exposed to different forms of training: video-taped lectures (as control), mannequin-based simulation (MBS), or virtual environment (VE) simulation training. Our primary hypothesis was that there would be a greater improvement post training and long-term post training associated with both simulation training techniques compared with the control condition.

Secondary objectives were (1) to determine whether there were measurable changes in skill across any of the training methods and (2) to provide descriptive quantitative understanding of the degree of improvement that may be achievable and maintained using relatively short (1.5-hour) one-time training sessions.

### Scope

*Background*

Research suggests that learning is most effective when it is interactive and takes place in a realistic, context-sensitive environment similar to where the skill will be applied (1). Team coordination skills are needed at every level of healthcare, but consensus on best practices for learning these skills still must be reached. Current training methodologies range from passive, auditorium-based lectures to highly interactive, high-fidelity mannequin-based simulations.

Healthcare was the largest industry in the United States in 2004; over 41% of the 13 million healthcare workers are located in hospitals (2). Using these statistics, we estimate that there are approximately 5.5 million hospital workers who use teamwork and communication regularly in their work. One must practice the skills of teamwork and communication to improve, yet there is no practical and/or economically feasible way to do so outside of clinical care.

Different approaches have been used to train teamwork and communication in healthcare. Recently, many medical centers have implemented team training in the form of crisis resource management (CRM) training using MBS (3,4) or individual practice and feedback (5). These programs, based on training in aviation, provide a great deal of fidelity, realism, and interactivity for the learners but require high instructor-to-trainee ratios and force learners to co-locate, thus leading to high cost.

A newer, alternative form of interactive training, used extensively in the military but inadequately explored in civilian healthcare, is that of three-dimensional, interactive, computerized virtual environments. The military values VEs for their interactivity, scalability (ability to impact large number of learners), and distributability (ability to impact learners over a broad range of geographic locations). Because of the large number of healthcare workers that could benefit from team training and the high associated costs of of other interactive methods, it is critical that we understand the strengths and weaknesses of these new forms of interactive learning. Ultimately, through this knowledge, we will be better informed to develop programs that efficiently and effectively lead to desired improvements in teamwork behavior.

The potential benefits of interactive, distributable computer-networked education for team training are substantial and include improved convenience, standardization, and cost. With VEs, an individual could train at a distance (e.g., from the comfort of their own home or office), interactively practicing the skills of teamwork and communication with others located anywhere in the world. Although parts of the training would still require a trained facilitator, much of the initial work could be completed independently at the learner's own convenience and pace. This approach to training has the potential to reach a broader number of healthcare workers than currently possible with MBS. Scalable forms of interactive training also offer a solution for other challenging problems in healthcare, such as skill retention (e.g., through more frequent educational "dosing" than is currently possible). The potential effect of VE is significant and includes the ability to reach a broader audience more frequently---leading to a meaningful impact on patient safety through the reduction of errors related to failures in team communication.

However promising, VE is not a panacea---it has obvious limitations compared with mannequin-based simulation. Although virtual environments are modeled after reality, they suffer from a lack of fidelity, both in appearance and in allowable actions. First, learners are able to interact with only a subset of objects in the VE world. In addition, movements (and other actions) are performed through a keyboard or by clicking a mouse. Perhaps the greatest limitation is with nonverbal communication, especially facial expression and body position---both of which are severely constrained in VEs. There is currently little evidence to guide us as to the impact or importance of these and other details of fidelity and interactivity with respect to training of team skills.

Despite these limitations, the military has successfully used video games to prepare soldiers for combat. Based on success with games-based learning in the military, our 3DiTeams prototype (http://en.wikipedia.org/wiki/3DiTeams) was funded by the Telemedicine and Advanced Technology Research Center (TATRC) of the US Army Medical Research and Materiel Command. 3DiTeams is a virtual environment for learners to practice the skills of healthcare teamwork and communication. The content is based upon TeamSTEPPS®, an evidence-based approach to teamwork and communication published by the Department of Defense and the Agency for Healthcare Research and Quality (6). 3DiTeams was jointly designed and developed by Virtual Heroes (a Division of Applied Research Associates) and the Duke University Human Simulation and Patient Safety Center.

*Context*

This was a hypothesis-driven, laboratory-based experiment designed to compare knowledge, skill, and attitude gains using three separate methods of teamwork and communication training: lectures, mannequin-based simulation, and virtual environment simulation.

*Settings*

MBS, VE, debriefing, and lectures all took place in the Duke University Human Simulation and Patient Safety Center. The VE was 3DiTeams--a virtual environment for team training (developed for the Telemedicine and Advanced Technology Research Center of the US Army).

*Participants*

Non-anesthesiology residents, advanced practice nurses, and advanced practice nurses currently in training participated.

## Methods

*Design and participants*

The research was approved by the Duke University Medical Center Institutional Review Board. The study was an experimental trial using a randomized between-subject study design. Thirty-nine residents and advanced practice nurses participated in the trial. Participants were randomly assigned to one of three training conditions: mannequin-based high fidelity simulation, virtual environment, or control (see Figure 1). After consent, each participant completed a pre-training knowledge, skills, and attitude test. The participants then underwent training in their experimental group. Immediately after training, participants completed a post-training knowledge, skills, and attitude test. Twenty-eight of the participants were retained for long-term follow-up. At approximately 3 months, each received a final long-term post-training knowledge, skills, and attitude test.

*Interventions*

Teamwork training was based on TeamSTEPPS® content (6). Participants in all three conditions first observed a 45-minute video on the concepts of healthcare teamwork and communication. After the introductory video, participants in the control condition watched a 45-minute pre-recorded Powerpoint lecture adapted from the TeamSTEPPS "Essentials" Training Materials.

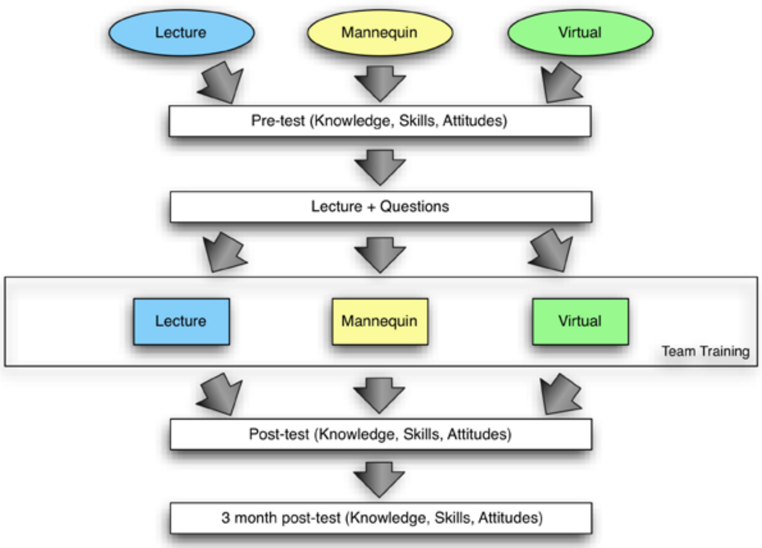


*Figure 1. Study design. Training interventions included lecture (control), mannequin-based simulation, and virtual environment. Subjects underwent testing of knowledge, skills, and attitudes immediately prior to intervention, immediately after intervention, and 3 months post intervention.*

Participants in the MBS and VE conditions were separated into groups of three or four and participated in a facilitator-led simulation, a scenario involving the care of a trauma patient involved in a motor vehicle accident. The content and learning objectives of the MBS and VE were identical. The scenario included several challenging teamwork situations, including 1) a team leader (the facilitator) who assigns a trainee to lead the team but cannot refrain from exerting control to the disruption of other activities, 2) expired blood products, and 3) a team leader who asks trainees to perform a wrong-sided procedure (needle decompression of a pneumothorax). The scenario was followed by a facilitator-led debriefing.

The MBS was conducted in the Duke University Human Simulation and Patient Safety Center and included a Laerdal SimMan® (with relevant patient physiology displayed on monitors) along with realistic equipment (e.g., blood cooler and bags, drug syringes, needle for decompression).

The virtual environment simulation involved a computer-monitor-displayed three-dimensional representation of a patient and relevant care environment. Care actions in the virtual environment involved selecting the relevant actions from context-sensitive menus linked to the patient and objects in the care environment. Participants communicated with one another through microphones and headphones while seated in the same room, each with their own first-person view into the shared environment. The facilitator for both training sessions was blinded to participant assessment scores and had no vested interest in the success of the 3DiTeams.

*Measures*

We probed knowledge, attitude, and skills at three times: immediately prior to intervention, immediately following intervention, and approximately 3 months post intervention.

Our knowledge instruments were adapted from TeamSTEPPS® training materials (6) and other sources (7) and converted to multiple choice formats when necessary. Forty-five questions were developed by experienced clinicians and teamwork and communication experts. The questions were crafted to reflect TeamSTEPPS® learning objectives and terminology. To create three separate tests, we recruited 38 nursing students, residents, and clinicians and research personnel to participate in a small online survey. Participants had varied facility with healthcare team concepts. We administered the 45-item knowledge test to 38 study participants via an online survey tool. Each question was answered correctly by an average of 78% of participants (standard deviation 17.05%). Three questions were deemed poorly written and discarded---participants were more likely to choose an incorrect answer than to choose the correct answer. The remaining questions were divided into three 14-item tests by selecting groups of three questions in which participants had attained similar scores and assigning one to each test. The tests were then reviewed by teamwork experts, clinicians, and patient safety experts to judge consistency with learning objectives. Questions were clarified based on their recommendations.

We measured attitudes related to teamwork and communication using the Collaborative Healthcare Interdisciplinary Relationship Planning Scale (CHIRP). Hollar et al have validated CHIRP (8), demonstrating a unidimensional internal consistency for all 36 items of 0.850.

Our measurement of teamwork and communication behaviors was the Standardized Assessment for Evaluation of Teamwork (SAFE-Teams, a method of assessing individual team skills using standardized actors, which was validated in a separate study funded by the National Board of Medical Examiners [9]). SAFE-Teams is an observer-scored, behaviorally anchored rating system that focuses on INDIVIDUAL teamwork and communication behaviors in the context of challenging healthcare scenarios. The tool is superior to other methods in that (1) it uses standardized, highly scripted scenarios that rate an individual's interaction with actors (not dependent on other participant's behavior); (2) stresses critical teamwork behaviors in realistic, difficult situations; and (3) contains a simple scoring system based on easily identified, observable behaviors.

SAFE-Teams places each individual participant in a short, structured scenario, working side-by-side with actors playing standardized team members. Actors assume the roles of patients, family members, or healthcare providers in highly scripted scenarios (e.g., a timid co-worker overwhelmed by multiple simultaneous tasks or an overbearing attending who is unwilling to recognize his or her mistakes). Students are expected to demonstrate team skills, such as assertion, situation assessment, assistance, conflict resolution, and communication. Clinical knowledge was de-emphasized in order to make the tool widely applicable to participants across multiple domains (e.g., physicians, nurses, other health professionals).

SAFE-Teams behaviors are scored from 0 to 3 (0, didn't exhibit behavior; 1, performed behavior, but not ideal; 2, ideal performance of the behavior). Behaviors are categorized into the following skills: assistance, communication (closed-loop communication and structured language), situation assessment, assertiveness, and conflict resolution. Students are scored on discreet behaviors specific to the scenario. For example, observers are not required to score "assertiveness" but rather whether he or she failed to push for a patient to be sent to radiology immediately (scored as "0"); voiced their concern once or twice (scored as "1"); or voiced concern at least twice and asked to speak with another authority (scored as "2"). Within each scenario, observers score four specific behavioral responses. Thus, for each scenario, participants could achieve a total score that ranges from 0 to 8, with 8 representing perfect performance across all teamwork behaviors assessed.

Three different actor teams performed the scenarios and rated the participants. Actors were blinded to the participant training condition. Because we had limited time available for assessment and wanted to evaluate the learners with different scenarios each time they were rated, we generated three sets of scenarios that were matched with respect to teamwork skill evaluated. Within each set of three scenarios (pre, post, and long-term post) there were two ratings associated with assistance, two associated with situation assessment, three or four associated with communication, and four or five associated with conflict resolution and assertion. In order to counteract scenario-related variability, we partially counterbalanced the presentation of scenario sets within training condition and test timing. Because we were unable to to fully balance scenario within test timing and training conditions, we also corrected for differences in difficulty across scenarios by transforming the SAFE-Teams scenario scores to a Z-score based on the mean and standard deviation across all performance measures collected in the study involving that scenario. Analyses of skills were conducted on SAFE-Teams scenario Z-scores.

During the validation of SAFE-Teams, we found a fixed reliability (for comparisons involving the same scenarios using the same raters) of greater than 0.8 could be achieved with a set of three scenarios and two actor-raters. A relative reliability (comparison involving randomly selected scenarios and raters) of 0.7 could be achieved with two actor-raters and nine scenarios. The study described here was designed based on preliminary validation data (prior to availability of these findings); the presentation design fits neither a fully random nor a fully fixed presentation situation (nine fixed scenarios per participant, but a variable presentation of three scenario sets within the three time conditions). We estimate the reliability associated with this design to be somewhat greater than what would be expected for a comparison involving three random scenarios and two random raters (about 0.5) but less than a comparison involving completely fixed scenarios and raters (0.8 or higher).

Our primary goal was to determine whether the rate of teamwork *skill* improvement (immediate and long term) was greater for the two interactive, simulation-based training conditions than for the passive, lecture-based learning. First, we compared improvement in teamwork skills within each of the three training conditions. To attain pre, post, and long-term post scores, we averaged the three SAFE-Teams score per participant at each test time to obtain a single SAFE-

Teams score per participant and test time. We compared pre-test and post-test (immediate and long-term) scores within each training condition using a Wilcoxon nonparametric matched pairs analysis.

If there were any significant within-training condition improvements, we then conducted an analysis to determine whether the degree of improvement was different between training conditions. We calculated immediate improvement by subtracting the average pre-test score from the average post-test score for each participant. We calculated long-term improvement by subtracting the average pre-test score and long-term post-test score for each participant. We then compared the degree of improvement across training conditions by comparing immediate improvement and long-term improvement across all possible pairs of the three training conditions using the Wilcoxon sum of ranks (Mann-Whitney) test.

The same nonparametric analyses were conducted for within-group tests of improvement and between-group tests of differences in degree of improvement for knowledge and attitude survey results.

Finally, as post hoc analyses, to better understand the implications of the results for the purposes of future research, we assessed whether or not individuals who have higher pre-test scores show improvements at similar rates as those with lower pre-test scores through a linear correlation of the combined data from all three training conditions of pre-test score and immediate and long-term improvement. Additionally, because we discovered that the standard deviation associated with SAFE-Teams scoring was significantly greater than the estimates based on a different observational scale (10) that was used for power prediction purposes, we conducted post hoc power analyses for SAFE-Team scores for both between- and within-group training comparisons. We conducted additional power analyses based on our future intent to screen individuals and then remove participants who have little room for improvement in their teamwork skills.

*Limitations*

Despite our belief that games-based learning holds great promise in the continuum of healthcare education, our study suffered from various limitations.

The study was underpowered. The initial power analyses were based upon standard deviations associated with previous work (10). We found greater variability during the validation of the SAFE-Teams, leading to an underestimation of the number of required participants for the study described here. On the positive side, SAFE-Teams can more discreetly differentiate poor performers, but, for the purposes of this study, it led us to significantly underestimate the sample size required to meet our primary objective.

Training for the skills assessment led to significant delays and challenges. Actors were chosen from the standardized patient pool. However, unlike a standardized patient scenario, SAFE-Teams scenarios required actors to play healthcare workers (e.g., doctors, nurses, pharmacists). We underestimated the amount of training required to train the actors to an acceptable level of competence. Ultimately, this required us to develop complete training packets that included items such as phonetic spelling of medical words, expected behaviors, and word-by-word scripts. These additions led to hours of additional practice beyond our original estimate. Even when fully trained, because of their limited medical knowledge, the actors had difficulty improvising if the participant strayed from the script. In future studies, we will use healthcare workers (e.g., medical students, nurses, or EMTs) as SAFE-Teams actors. This will minimize training time and will allow greater flexibility to respond to unanticipated situations.

Our funding included limited development of a civilian environment. Our intent was to carry out this study in a virtual civilian emergency room (modeled after Duke Hospital's Emergency Department) rather than the original setting of 3DiTeams (a combat support hospital). The original content was inserted into the civilian environment. In preparation for the study, we found major issues with the civilian ED that would have negatively impacted our training. We made the decision to use the older, stabler version of 3DiTeams in this study. Although the content of the cases was the same, the impact of the setting (combat support hospital instead of a civilian emergency room) is unknown.

A final limitation of our study was the design of our educational intervention. Both the MBS and VE learning interventions contained two parts: a training scenario and a debriefing. Because of monetary and logistical constraints, debriefings were performed live, in a classroom (rather than at a distance, as would be preferable with VEs). We don't know the impact of this choice. The debriefing could have been the catalyst behind our our findings. With the design of our educational intervention, it is impossible to tell if it is the learning intervention itself, the debrief itself, or the combination of the two that led to improved performance over time. Future studies will focus on teasing apart this issue.

## Results

*Principal Finding: Skills evaluation results*

The mean SAFE-Teams pre-test score across all participants in the three training conditions was 4.33 (or a Z-score of -0.33) and, on average, individuals increased their score by 0.97 (Z-score of 0.50) immediately following training and by 1.11 (Z-score of 0.59) 3 months after training. The mean immediate and long-term improvements (Z-scores) by training condition are shown in Figure 2. Comparisons within a training condition using Wilcoxon nonparametric matched pairs analyses of pre- and post-test scores revealed that both the control and virtual environment simulation training conditions significantly improved SAFE-Team scores immediately following training (left set of bars in Figure 2). There was a trend for improvement in the high-fidelity simulation condition (p=0.11). Long term, participants in the simulation and virtual environment training conditions improved their performance (right set of bars in Figure 2). There was a trend for improvement in the control training condition (p=0.11). The Wilcoxon sum of ranks (Mann-Whitney) tests comparing degree of improvement between training conditions revealed no significant differences.

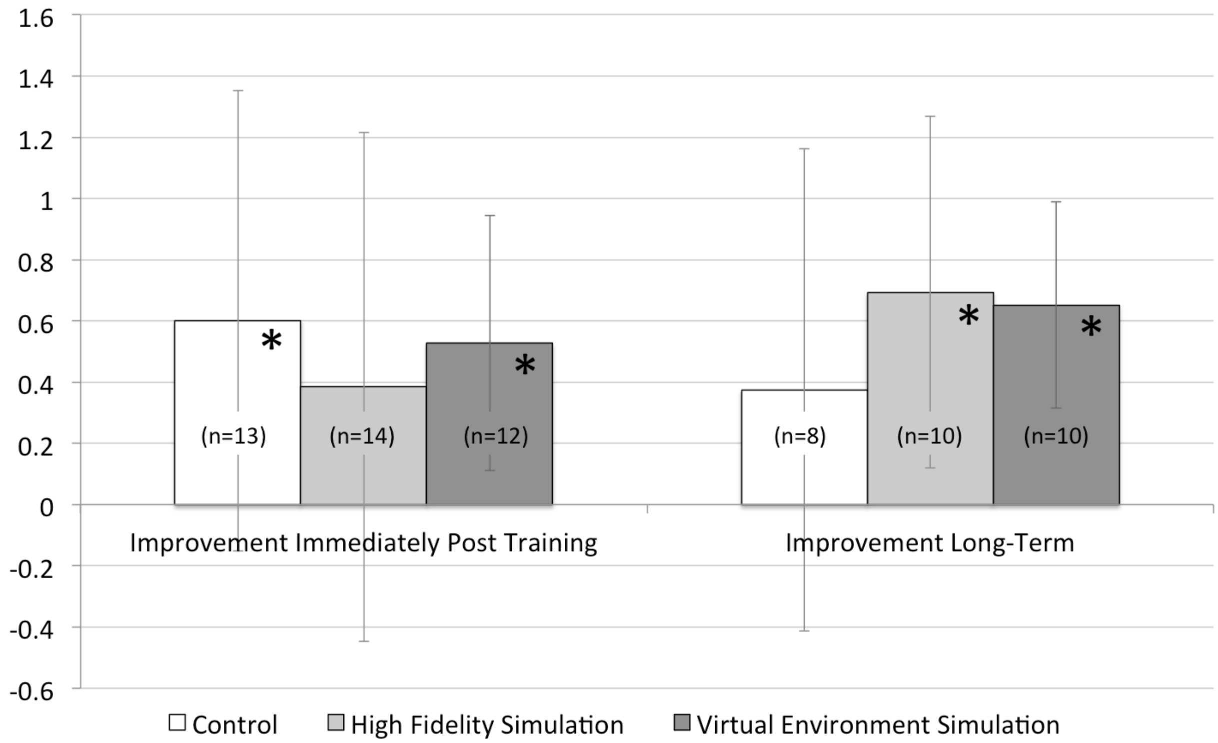


*Figure 2. Mean improvement immediately following training and 3 months after training across the three training conditions. Error bars represent +/-1 standard deviation. An asterisk indicates a significant improvement (p<0.05) based on paired within-group comparisons.*

*Improvement in skills by pre-test score correlations*

When the data from all 39 participants were grouped, we identified a significant linear correlation between pre-test score and improvement for both immediate improvement (R=-0.60, p<0.001) and long-term improvement (R=-0.65, p<0.001). The top seven participants (18%) showed little or no improvement with training (see Figure 4). Participants in this range had SAFE-Teams scores on the order of 4.5 to 6.8 on the SAFE-Teams scale of 1-8 (recall that some scenarios were more difficult than others, and Z-scores were used to control for this). Participants with the greatest improvement (e.g., those ranked 34, 35, 36) improved their SAFE-Teams scores by approximately 2 points, or 20%.

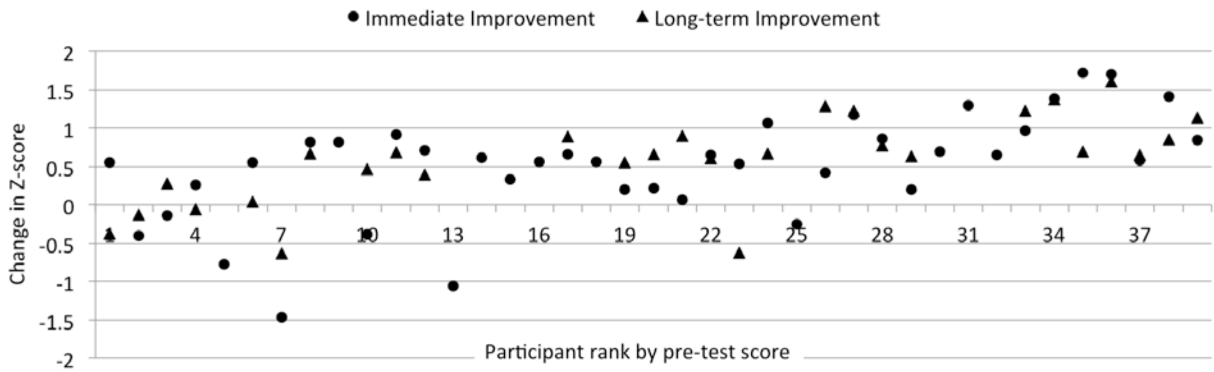


*Figure 3. Participant immediate and long-term improvement in SAFE-Teams Z-score by rank.*

*Power analyses*

We estimated power based on both a paired t test and two-sample t test for the existing data. Using a standard deviation estimate of 0.5 (the Z-score standard deviation for immediate improvement across all participants), with a difference in mean Z-score of 0.4 (the lower boundary of the differences detected in our study), the estimated power for a within-group (paired) comparison involving a sample size of n=12 is 0.70. In order to detect a difference in degree of improvement between training conditions on the order of 0.3 (similar to the largest between-group difference observed), a sample size of 12 per group has a power of 0.29. In order to achieve a power on the order of 0.7 for a similar difference in improvement between groups, the study would require approximately 34 participants in each training condition.

*Other outcomes: Attitude and knowledge survey results*

There was no significant attitude change in any of the training conditions immediately following training or at the 3-month interval. The mean pre-test knowledge score across all participants was 81% correct, and participants improved on average 8% immediately following training and 2% long term. Comparisons within training conditions using Wilcoxon nonparametric matched pairs of pre- and post-test scores revealed that the high-fidelity simulation group improved their knowledge immediately post training. The control group revealed a trend toward improvement (p=0.08) immediately following training. None of the three training conditions showed long-term improvement in knowledge. The Wilcoxon sum of ranks (Mann-Whitney) tests comparing degree of improvement between training conditions revealed no significant differences.

*Other results*

For SAFE-Teams, most participants found the actors' behaviors and scenarios to be realistic (77% and 82%, respectively, agreed or strongly agreed with these statements). Although 85% of participants believed the scenarios assessed important team skills, only 56% believed that they acquired these skills through participation in the study. However, a different picture emerged when the latter statement was analyzed by training condition: 39% of participants in the control condition felt that they had acquired important team skills, compared with 50% and 83%, respectively, of participants in the high-fidelity simulation and virtual environment simulation conditions. In general, participants rated the training and evaluation experience favorably: 72% gave it a “good” or “excellent” score. Again, participants in the different conditions rated this item differently: 46% of the control group, 86% of the high-fidelity simulation group, and 83% of the virtual environment simulation group gave it a positive score.

*Discussion*

Interactive forms of learning have been shown to be superior to passive when attempting to alter behavior (1). Although all three conditions of our study had the potential to change teamwork and communication skills, those taught with interactive methods (e.g., MBS or VE) had greater skill retention. There is no evidence to suggest long-term retention of teamwork skills in the lecture-based group. Unfortunately, the study was underpowered to make a definitive conclusion. Despite this limitation, the degree of improvement associated with VE was similar to that of MBS. If it is true that VE training leads to better retention of teamwork and communication skills over time, it implies that the learners are better able to make connections between what they experience in the interactive training and application to their day-to-day practice---allowing them to continue to practice beyond the short, formal, interactive training period.

It is interesting to note that knowledge improvements seemed short lived, but skill improvements seemed to be maintained over time. This suggests that participants do improve behavior even if their recall of specific team skill names, such as “call-out” or “SBAR,” may degrade. This might represent a limitation of our knowledge survey. If this is a reproducible finding, it would suggest that studies of teamwork and communication that rely solely on knowledge may be inadequate without also measuring changes in behavior.

With respect to secondary objectives, we identified a skills “ceiling effect” for participants who pre-tested high. The top 18% showed no improvement over time. The negative correlation between pre-test score and degree of improvement showed that individuals with more “room for improvement” did improve more following training. The greatest rates of improvement were on the order of 20% on the SAFE-Teams scale, with a median improvement on the order of 10%. This brings to light the question of, in this day of shrinking resources, whether individuals should be screened and intervention offered only to those who could benefit from training (e.g., low pre-test scorers).

It is not clear whether longer training sessions or different approaches to training (e.g., coaching) might lead to greater gains. It is expected that this would be the case.

One must interpret our findings cautiously. Our participant pool was limited to a subset of learners from medicine and nursing (residents and advanced practice nurses). One must be careful to generalize our findings to the continuum of healthcare; what is beneficial for advanced practice nurses may not be beneficial for baccalaureate nurses. More research investigating the applicability of this form of learning across the healthcare continuum is still needed.

*Significance and Implications*

Based on these preliminary data, there appears to be enough evidence to continue to pursue the use of VEs for team training as a scalable, distributable alternative to MBS.

## Bibliography

1. Davis D, O'Brien M, Freemantle N et al. Impact of formal continuing medical education: do conferences, workshops, rounds, and other traditional continuing education activities change physician behavior or health care outcomes? JAMA. 1999;282(9):867–874.

2. U S Bureau of Labor Statistics. Career Guide to Industries: Health Care. U.S. Bureau of Labor Statistics, Office of Occupational Statistics and Employment Projections; 2005.

3. Gaba D, Howard S, Fish K et al. Simulation-based training in anesthesia crisis resource management (ACRM): A decade of experience. Simulation & Gaming. 2001;32(2):175–193.

4. Small S, Wuerz R, Simon et al. Demonstration of high-fidelity simulation team training for emergency medicine. Academic Emergency Medicine. 1999;6(4):312–323.

5. Morey JC, Simon R, Jay GD et al. Error reduction and performance improvement in the emergency department through formal teamwork training: Evaluation results of the MedTeams project. Health Services Research. 2002;37(6):1553–1580.

6. Agency for Healthcare Research and Quality. TeamSTEPPS Team Strategies & Tools to Enhance Performance & Patient Safety [Internet]. teamstepps.ahrq.gov. Rockville, MD: Agency for Healthcare Research and Quality; [cited 2011 Feb. 3]. Available from: http://teamstepps.ahrq.gov/

7. Wright MC, Luo X, Richardson WJ et al. Piloting team coordination training at Duke University Health System. Proceedings of the HFES 50th Annual Meeting. San Diego, CA: Human Factors and Ergonomics Society; 2006. p. 949–953.

8. Hollar D, Hobgood C, Foster B et al. Concurrent Validation of Collaborative Healthcare Interdisciplinary Planning, a New Instrument for Measuring Healthcare Student Attitudes towards Interdisciplinary Teamwork. Academic Medicine. Academic Medicine.

9. Wright M, Segall N, Hobbs G et al. Standardized Assessment for Evaluation of Teamwork: Feasability, Reliability, and Validity. (under review)

10. Wright MC, Phillips-Bute BG, Petrusa ER et al. Assessing teamwork in medical education and practice: relating behavioural teamwork ratings and clinical performance. Medical Teacher. 2009 Jan;31(1):30–38.

Total Enrollment Report: Number of Participants Enrolled to Date (Cumulative) By Ethnicity and Race

| Ethnic Category | Females | Males | Unknown or not reported | Total |
|---|---|---|---|---|
| Hispanic or Latino | 0 | | | 0 |
| Not Hispanic or Latino | 25 | 14 | | 39 |
| Unknown (individuals not reporting ethnicity) | 1 | 0 | | 1 |
| **Ethnic Category: Total of All Participants*** | 25 | 14 | | 39 |

| Racial Categories | Females | Males | Unknown or not reported | Total |
|---|---|---|---|---|
| American Indian/Alaska Native | | | | |
| Asian | 2 | 3 | | 5 |
| Native Hawaiian or Other Pacific Islander | 0 | | | 0 |
| Black or African American | 3 | 1 | | 4 |
| White | 20 | 10 | | 30 |
| More than one race | | | | 0 |
| Unknown or not reported | | | | 0 |
| **Racial Categories: Total of All Participants *** | 25 | 14 | | 39 |

*****The ethnic category total must equal the racial categories total.

## Publications

1. Taekman JM, Shelley K. Virtual environments in healthcare: immersion, disruption, and flow. Int Anesthesiol Clin. 2010;48:101-21.
2. Hobgood C, Sherwood G, Frush K et al. Teamwork Training with Nursing and Medical Students: Does the Method Matter? Results of an Interinstitutional Interdisciplinary Collaboration. Quality and Safety in Healthcare. 2010 Apr; doi: 10.1136/qshc.2008.031732.

## Scientific Abstracts

1. Taekman JM, Segall N, Hobbs G et al. 3DiTeams–Healthcare team training in a virtual environment. *Anesthesiology*. 2007;107:A2145.
2. Taekman JM, Segall N, Hobbs G et al. 3DiTeams–Healthcare team training in a virtual environment. *The Journal of the Society for Simulation in Healthcare.* 2008;3(5) Supplement:112.
3. Segall NS, Wright MC, Turner DA, Hobbs G, Maynard L, and Taekman JM. Virtual healthcare environments and traditional interactive team training: A comparison. Agency for Healthcare Research and Quality Annual Conference; 2010 Sept 7.
4. Segall NS, Wright MC, Turner DA, Hobbs G, Maynard L, and Taekman JM. Virtual Healthcare Environments vs. High-Fidelity Mannequin-Based Team Training: A Comparison of Skill Acquisition. International Meeting on Simulation in Healthcare; 2011 Jan 25.

### Presentations

1. Taekman JM. Serious Games. Technology Integration Program for Nursing Education and Practice Meeting; 2007 Aug 7; Durham, NC.
2. Taekman JM. 3DiTeams: Team Training in a Virtual Environment. Graylyn Technology Innovation in Medical Education Conference; 2007 Sept 10; Winston-Salem, NC.
3. Taekman JM. Workshop on 3DiTeams–Team Training in a Virtual Interactive Environment. American Society of Anesthesiologist Annual Meeting; 2007 Oct 16; San Francisco, CA.
4. Taekman JM. TeamSTEPPS and Simulation. Second Annual TeamSTEPPS Consortium Meeting; 2008 Mar 17; Durham, NC.
5. Taekman JM, Segall N, Hobbs G, and Wright MC. 3DiTeams–Healthcare team training in a virtual environment. American Association of Medical Colleges, Group on Information Resources; Professional Development Conference; 2008 May 2.
6. Taekman JM. 3DiTeams: Healthcare Team Training in a Virtual Environment. First Annual North Carolina Advanced Learning Technology Summit; 2008 May 13; Durham, NC.
7. Taekman JM. Serious Games. Technology Integration Program for Nursing Education and Practice Meeting; 2008 Aug 4; Durham, NC.
8. Taekman JM. Learning in the Age of Bits and Bytes. Stead Memorial Lecture Keynote, Medical Alumni Weekend/Department of Medicine Grand Rounds; 2008 Oct 23; Durham, NC.
9. Taekman JM. Cutting Edge 3-D Virtual Environments for the Health Care Professional. Leadership Symposium on Digital Media in Health Care; 2008 Nov 22; Tampa, FL.
10. Taekman JM. State-of-the-Art Serious Games and Virtual Environments in Healthcare. International Meeting on Simulation in Healthcare; 2009 Jan 12; Orlando, FL.
11. Taekman JM. Determining the Efficacy of Serious Games. International Meeting on Simulation in Healthcare; 2009 Jan 13; Orlando, FL.
12. Taekman JM. Learning in the Age of Bits and Bytes. Second Annual Emerging Technologies in the Operating Room Conference; 2009 June 10; Orlando, FL.
13. Taekman JM. Serious Games and Simulation in Healthcare. Second Annual Emerging Technologies in the Operating Room Conference; 2009 June 10; Orlando, FL.

14. Taekman JM. Melding Games and Simulation for Healthcare. Games for Health Conference; 2009 June 11; Boston, MA.
15. Segall, N, Wright, MC, Turner, DA, Hobbs, G, Maynard, L, & Taekman, JM. Virtual healthcare environments and traditional interactive team training: A comparison. AHRQ 2010 Annual Conference. 2010. Bethesda, MD.
16. Taekman JM. Simulation and Patient Safety. Foundation for Anesthesia Education and Research Lecture, American Society of Anesthesiologists Annual Meeting; 2009 Oct 19; New Orleans, LA.
17. Taekman JM. Could a Game Save Your Life? HealthCampRDU (Keynote); 2010 May 14; Blue Cross Blue Shield Campus, Durham, NC.
18. Taekman JM. Simulation Business Models (Invited Panel Member). American Association of Medical Colleges Annual Meeting; 2011 Nov 8; Denver, CO.
19. Education is Broken, Grand Rounds, University of North Carolina, Department of Anesthesiology, 2011 Dec 14; Chapel Hill, NC.
20. Wright MC and Taekman JM. Assessing Healthcare Teamwork Skills in Simulation. International Meeting on Simulation in Healthcare; 2012 Jan 30; San Diego, CA.
21. Education is Broken, Teaching with Technology Conference, Georgia Health Sciences University, 2012 Mar 23; Augusta, GA.