Published in final edited form as:
Int J Inf Commun Technol Educ. 2009 ; 5(1): 62–73.

Computer-Based Simulation in Blended Learning Curriculum for Hazardous Waste Site Worker Health and Safety Training

Cheryl West, **Craig Slatin**, **Wayne Sanborn**, and **Beverly Volicer**

Abstract

Intended for the interest of individuals and organizations who provide adult/worker training and education, we present a discussion of a computer-based simulation training tool used as part of a hazardous waste site worker health and safety training curriculum. Our objective is to present the simulation's development, implementation, and assessment for learning utility from both trainee and trainer perspectives. The simulation is blended with other curriculum components of training courses and supports small group learning. Assessment included end-of-course trainee questionnaires and trainer focus groups to addressing simulation utility as a user-oriented learning tool. A majority of trainees reported simulation trainings as useful learning tools with numerous advantages that support a participatory, blended learning curriculum, and raise awareness of potential work site risks and hazards. Trainers reported that the simulation advanced training impact. Evaluation results indicate that the simulation successfully supports small group learning activities.

Introduction

Over the last two decades, computer-based teaching technologies have been implemented for training workers about health and safety hazards on the job. Much has been accomplished in areas of software development, human-computer interface, and learning theory to improve adaptability of these technologies for teaching many kinds and levels of computer-based simulation products designed to deliver education and training. Corporations, public education, and various branches of military service are using and have realized benefits of simulation training materials.

This paper presents a discussion of the application and learning utility of a computer-based simulation developed and provided by The New England Consortium (TNEC) for small group activities in health and safety training for workers engaged in Hazardous Waste Operations and Emergency Response (HAZWOPER). Preliminary evaluation of this new format of simulation training was conducted to assess its utility and benefits from the point of view of both trainees and trainers. Evaluation methodologies included surveys of trainees, focus groups with trainers, and field observations of the developed simulation training. Although an experimental evaluation design was not used, the results are nonetheless informative for discussions of how computer simulation curriculum can be used for worker health education and training. We describe the development of the computer-based simulations that were incorporated into TNEC courses, and follow with a discussion of evaluation methods and results, and finally the implications of these findings.

Address correspondence to: Craig Slatin, School of Health and Environment, University of Massachusetts Lowell, 3 Solomont Way, Lowell, MA 01854; telephone: 978-934-3291; fax: 978-934-3025; e-mail: E-mail: craig_slatin@uml.edu.

Note: To obtain a DVD copy of the simulation, send an email request to: Tnec@uml.edu

NIH-PA Author Manuscript
NIH-PA Author Manuscript

The TNEC Program

Since 1988, TNEC has continually conducted worker health and safety education and training for workers engaged in hazardous waste operations and emergency response (HAZWOPER). Based at the University of Massachusetts Lowell, TNEC includes five worker health and safety advocacy organizations - Coalitions for Occupational Safety & Health, or COSH groups, in Connecticut, Massachusetts (Boston and Springfield), New Hampshire, and Rhode Island. TNEC is a National Institute for Environmental Health Sciences (NIEHS) Worker Education and Training Program (WETP) awardee (one of nearly twenty nationally). The NIEHS WETP supports and promotes model training programs targeted to address specific needs of workers with HAZWOPER duties in a wide range of processes and industrial sectors (NIEHS WETP website: http://www.niehs.nih.gov/wetp/). The program provides its awardees funding to develop training using electronic training technologies intended to establish a high national bar for such HAZWOPER worker health and safety training.

TNEC's curricula and courses are based on models rooted in Freirian theories, the British Trade Union Council, and the Highlander School (Luskin, Somers, Wooding, & Levenstein, 1992; Merrill, 1994, 1995; C. Slatin, 1999; C Slatin, 2001; Wallerstein & Baker, 1994; Wallerstein & Bernstein, 1988; Wallerstein & Bernstein, 1992 pg. 8). These models present interactive approaches that facilitate a learning process wherein workers can reflect upon their existing knowledge and understanding, incorporate new information, and use the information to build worker power through local health and safety strategies.

In 2000, TNEC decided to apply electronic teaching media in blended learning approaches to its worker-oriented occupational health and safety (H&S) training. The intent was to design computer-based training modules that would support collaborative learning among trainees. TNEC's computer-based simulation modules were developed with multiple goals. One was to create modules that could be used effectively to support participatory training as a tool within the small group activity method (SGAM). Another was to introduce students to situations too dangerous or complicated to include in hands-on training modules and extend their preparation for decision-making in actual field settings. Lastly, to use the computer simulation, in addition to other training methods used in the courses, to improve students' preparation for a final hands-on hazardous waste site remediation or emergency response drill activity by extending their practice of collective health and safety protection strategy development.

SGAM, central to TNEC training courses, is a learner-centered teaching approach that provides trainees with opportunities to apply new and experiential knowledge in developing problem solutions, which are then discussed with a larger group. The larger group discussion allows for exchange between multiple small groups and instructors (Merrill, 1994, 1995; C Slatin, 2001). Computer simulation now supports considerable small group work. TNEC trains individuals with varied educational and professional backgrounds ranging from high school to doctoral level graduate studies. The Hazardous Waste Remediation courses (40-hour Basic & 8-hour Annual Refresher) are delivered to workers employed in or preparing for employment in the construction and utility industries, as well as positions as environmental technicians, or engineers. The training, required by the Occupational Safety and Health Administration's (OSHA) Hazardous Waste Operations and Emergency Response standard, 29 CFR 1910.120, follows a mandatory content agenda. TNEC training curricula are developed and presented to be useful and interesting to all trainees, regardless of their educational background.

Literature Review Regarding Computer-Based Training Simulations

According to Ravert's (2002) review of studies relative to computer-based simulation and education, the key premise of integrating a simulation is that it supports the educational process and offers new potential for learning. Aldrich (2004 pg. 8) asserts that simulation, a fundamental shift in education, bridges the gap between textbook oriented classrooms and skills learned on the job. Simulations integrated within blended learning approaches allow for instructional strategies which combine methods, such as workbooks, video, e-learning, live examples, and teamwork, promote discussion, and use technology where it adds educational value. Criteria stated in literature on blended learning, popular education, and constructivist instructional design (Spiro, Feltovich, Jacobson, & Coulson, 1991), as well as the following core principles for simulation-based teaching-learning process (Black, Thalheimer, Wilder, de Soto, & Picard, 1994), have been integrated within TNEC's training simulation.

1. Anchor the knowledge in authentic situations and activities which are case based and emphasize knowledge construction rather than transmission of information (Spiro & Jehng, 1990).
2. Situate knowledge in multiple contexts and multiple representations of content to prepare for appropriate transfer to contexts (Bransford, 1990; Spiro & Jehng, 1990).
3. Create cognitive flexibility by ensuring that information is seen from multiple perspectives (Jacobson & Spiro, 1995; Spiro & Jehng, 1990).
4. Set the stage but have the students collaborate and generate knowledge for themselves (Brandt, 1999).

Within the last decade, use of computer-based simulation has been piloted and evaluated within a diverse range of learning environments world-wide. In Ireland, simulation has provided an effective delivery of blended learning approaches within the construction industry to deliver life-long learning opportunities (Wall & Ahmed, 2008). Simulation has been successfully applied to numerous educational scenarios in the fields of medicine, engineering, education/teacher training, scientific visualization, manufacturing, prototyping, computer science, environmental education, and business (Gettman et al., 2008; Ioannidou, Paraskevopoulos, & Tzionas, 2006; Lainema & Nurmi, 2006; Mujber, Szecsi, & Hashmi, 2004; Nickerson, Corter, Esche, & Chassapis, 2007; Park et al., 2007; Passman, Fleser, Dattilo, Guzman, & Naslund, 2007; Pfahl, Laitenberger, Ruhe, Dorsch, & Krivobokova, 2004; Smolle, Prause, & Smolle-Jüttner, 2007; Wignall et al., 2008). In concurrence with our experience reported here, integration of simulation provides a blended learning approach that is safe, efficient, provides complex models of reality that facilitate continuous problem-solving and enhanced comprehension, and cultivates critical thinking and collaborative learning (Hmelo-Silver, 2003; Lainema & Nurmi, 2006; Smolle et al., 2007; Wall & Ahmed, 2008). Dutch researchers evaluating integration of simulation as an instructional tool for a range of educational settings concluded that key directions for future research should focus on the added value of this pedagogical method to contribute to problem solving skills and as a unique catalyst to initiate collaborative discussion and reflection in learning environments for competence based and discovery learning (van Merriënboer & Brand-Gruwel, 2005).

Advantages of educational simulation noted in the literature include the ability to present serious and or uncommon situations, allowance for student errors without repercussions to the learner, self-paced learning, and development of higher order thinking skills (Botsis, Hlkiotis, & Kourlaba, 2004; Jacobson & Spiro, 1995; Ravert, 2002). Additional advantages include the potential for immediate feedback, reinforcement and consistent curriculum across learners (Aldrich, 2004). Unrealistic scenario presentations have been cited as a challenging disadvantage in simulation programs (Ravert, 2002). TNEC strove to capture the advantages of simulation-based curriculum while overcoming this limiting disadvantage.

Development and Integration of the Hazardous Waste Site Simulation

The simulation development and implementation process began in 2000 and spanned four years. An multidisciplinary team of worker health educators, a computer programmer, graphic designers, industrial hygienists, HAZWOPER technical experts, and a videographer was assembled to develop and design the training curricula and hardware and software components. Classroom piloting as well as TNEC trainer, trainee, and advisory board feedback shaped implementation. The final simulation consists of six modules loosely based on an actual emergency hazardous waste removal action site at an abandoned plating facility in the Boston region.

In practice, the simulation is delivered at a hybrid PC station, where three to four trainees work through the six training modules as a team. Trainee teams are seated at a round table on which three flat panel display monitors are placed at 120-degree angles to each other (Figure 1) allowing trainees to see each other easily and interact during the simulation. Students wear headsets that permit them to hear the simulation and each other without interference from the noise of other groups engaged in the same activity throughout the computer laboratory.

The first three simulation modules, utilized on the first day of the 40-hour training, present trainees with instructions, an overview of the simulation experience, a simulated site briefing, and simulated site interviews. Trainees are prompted to simulate information gathering in order to develop a preliminary Health and Safety Plan (HASP) prior to entering the simulated site. Simulation modules four through six are integrated into the last day of the course as a review activity. In the fourth module, trainees participate in three different simulated site worker roles--entry team, site supervisor, and decontamination team leader--as they navigate within a three dimensional graphic model of the subject facility. During the fifth module, trainees simulate screening site drums and select a hazard code for each drum. In the sixth module, trainees select tools to move drums and stage them based on substance incompatibility. In modules four-six, trainees explore possible consequences of choices (tools, level of personal protection equipment, monitoring instruments, work zones), make decisions based on simulated site roles, and are provided with simulation feedback regarding these choices. Trainees are encouraged to discuss what they have learned and communicate with team members. Trainers monitor the small group learning processes, giving attention to individual and group variation in pacing and learning. After completing all six simulation training modules, 40-hour course trainees participate in a hands-on incident drill where they apply what they have learned and further practice hazardous waste site work activities.

Computer-based Simulation Evaluation Plan

Trainee and trainer feedback was used to assess the success and utility of the simulation as a learning and teaching tool. The evaluation was organized around three areas:

1. usefulness of the simulation program as preparation for the incident drill training;
2. value of the simulation training format as a learning and teaching tool; and,
3. usefulness of simulation training in supporting SGAM learning.

Reported here are the trainees' and trainers' perceptions of the simulation's utility as a learning tool, as well as their perceptions of the challenges the simulation poses in the training course. The simulation modules were designed to: 1) enhance trainees' understanding of and ability to decide upon strategies for protecting the health and safety of workers in hazardous waste work environments; 2) be user-friendly and user-oriented in ways that enhance methods of trainer instruction and trainee learning; 3) provide interactive learning processes which engage adult learners in group learning processes.

Methods

A total of 466 trainees attended 33 TNEC courses from June 2002 to June 2004. Two hundred seventy-four attended the 40-hour basic training courses and 192 attended the 8-hour refresher courses. Table 1 shows the number of trainees registered by type of course and self reported education levels. The majority of unreported educational levels were from job training program participants or workers employed in construction or municipal services (assessed via class roster comparisons). Hazardous waste work experience of trainees enrolled in the TNEC program ranged from never working on a site to extensive site experience.

Survey instruments were completed by 334 trainees (72%). Due to administrative and programmatic scheduling problems, not all trainees were asked to complete the survey. Trainees were provided questionnaires at the beginning of the simulation training and were requested to complete feedback after the hands-on incident drill for the 40-hour training. The 8-hour refresher course trainees completed simulation feedback after concluding three simulation modules. Questionnaires using open-ended questions inquired about trainee perceptions in terms of simulation utility as a learning tool. In addition, trainees were asked to rate, on a 10-point scale, the simulation’s use as a review activity.

An iterative content analysis of all final trainee data collected during the two-year timeframe was conducted. Emerging response patterns and themes were then used to create response categories. Trainee data were condensed and summarized into broad categories of what trainees liked, did not like, and what was helpful, or not helpful as preparation for the final hands-on incident drill. These response categories were then coded and tabulated. Evaluation methods also included focus groups with trainers to obtain their perceptions of how trainees were able to use the simulation modules, to identify teaching challenges that the simulation tools presented, and to determine whether the simulations supported SGAM learning. Trainer focus group data supplemented understanding gained through the trainee surveys.

Results

Responses from both trainee surveys and trainer focus groups indicated broad agreement on the educational usefulness of the simulation modules. The following discussion addresses first the trainee responses, and then the trainer evaluations. Trainee evaluations of the simulation program included responses to both qualitative and quantitative findings. Qualitative response categories describing simulation module utility are summarized in Figures 2–4.

Trainees were asked: “W*hat did you like about this simulation? Why?”* All trainees responded to this question, and their responses were grouped by category, as indicated in Figure 2. Forty percent (40%) of these trainees reported that simulation modules were useful learning tools. Comments included that the simulation helped to promote individual learning, provided virtual practice, enhanced decision-making capacity, improved ability to evaluate information, and provided opportunities to “learn from mistakes.” Twenty-eight percent (28%) identified the simulation as providing a realistic “feel” and “ walk through” of the simulated site, which provided an opportunity to explore risky hazardous sites “without consequence.” Group discussions (16%), teamwork and “collaborative” learning were also reported as ways that the activity enhanced “problem solving” skills and ways to “synthesize information.” Some trainees reported increased awareness of H & S as well as a preference for simulation training versus “simply lectures and handouts.”

Trainees’ responded to the question, “*What didn’t you like about the simulation? Why?”*, and these data are shown in Figure 3. One hundred fifty-nine respondents who said that there was “nothing that I didn’t like,” or had nothing to report, were excluded from the table. As shown in Figure 3, of responses from the 175 who did report problems, 32% described the simulation as useful but thought it was “too long” or “repetitive,” while 25% reported problems with computer hardware and/or software maneuverability. Approximately 17% of the trainees described limited information options and 9% experienced limited group interaction. The educational and professional differences within the trainee population resulted in some trainees reporting simulation modules as too fast paced, while others reported instructions as “too repetitive.”

Trainees also were asked: “Did the simulation help in any way to prepare you for the hands-on incident exercise in which you participated today? If yes, in what ways? If no, why not?” As shown in Figure 4, a total of 119 trainees responded to this question. The majority of those responding (54%) commented that the simulation provided useful learning in terms of hazard identification, information gathering, decision-making, health and safety awareness and action planning or strategy development. Useful learning also included opportunities to test out thinking, enhance memory, raise awareness regarding potential site dangers and enhance capacity to know what hazards were important to identify. Approximately 18% reported that the simulation supported drill activity teamwork through assignment of different site “roles,” and promoting “cooperation” and “communication.” A smaller percentage indicated the simulation as realistic and useful practice. Of those who responded, 12% reported that the simulation training did not help to prepare them for the hands-on training incident, stating that “real incidents are more chaotic,” or that there was “not enough time” or a lack of team communication in their group. Overall, trainees reported that the simulation provided useful incident drill practice and useful learning and teamwork practice.

Trainees were not specifically asked how well the simulation modules supported small group activities, yet nearly 100 trainees reported that simulations generated and supported group discussions. Identifying work site hazards, clarifying hazardous work site procedures, and practice developing crucial health and safety plan (HASP) strategies were reported by many trainees as skills facilitated by the simulation. Role perspectives and enhanced decision-making processes were reported by trainees to be useful learning experiences provided through simulated case scenarios.

In addition to qualitative response data, trainees were asked to rate the usefulness of the simulation training activity on a scale from 1 (not very useful) to 10 (very useful), and 178 responded. The average ranking was 8.52 with a standard deviation of 1.43. Ninety-two percent (92%) of trainees responding to the quantitative rating scale reported simulation usefulness scores between 7 to 10, on the same scale.

TNEC Trainer Perceptions of Simulation Training Modules

Focus groups were used to examine the extent to which the simulation programs met the needs of trainers and to obtain their perceptions of how students were able to use and learn from the simulation.. Two focus groups were conducted with twelve and fifteen trainers in each session. Trainers were generally very positive about the ways in which they perceived the simulation modules as enhancing training impact. They described the simulations as beneficial teaching tools, useful for trainee learning and as “a way to integrate discussed learning elements.” Trainers asserted that trainees could begin “to understand the impact of their decisions without experiencing hazardous risks and consequences found on a real site.” They commented on how the use of simulation programs provided students with preparation for preliminary site investigation without leaving the classroom. Within a safe environment, students made strategic work decisions the context of the “reality” and “seriousness” of a hazardous waste site. Trainers noted that students were able to ask stronger questions after the simulation experiences, indicating deepened levels of content comprehension, contrasted to training sessions conducted without the simulations.

Trainers reported that the simulation modules provided engaging learning activities which helped trainees synthesize and apply what they were learning throughout the course. Trainers stated that use of the simulations “allows students time to review information, do a preliminary site investigation, and make it all more concrete in their minds, in preparation for the hands-on activity."

Trainers also gave feedback about the need for additional trainer-training to help them learn how to teach with the simulation modules. They commented that the computer-based simulation challenged their comfort levels and self-confidence. Some were skeptical of using a simulation because it removed trainers from the more central role in the teaching process. Technology failures or potential technology glitches were reported as a source of trainer anxiety.

Discussion

The evaluation demonstrates that TNEC's computer simulation successfully provides high quality curricula in which hazardous waste site work can be explored without risk. The findings show that a computer simulation with the applied hardware setup was able to support small group problem solving exercises. These were successfully blended with hands on drills enabling trainees to apply what they learned. Results indicate that the integration of a computer-based simulation with other training methods and materials can be useful for participatory training. The simulation raised trainee awareness of potential risks and hazards of HAZWOPER work sites. Offering computer video as opposed to text-based training provided numerous training advantages as reported by trainees and trainers. Simulation trainings demonstrated value as a method for reviewing as well applied learning from past work experience.

Overall, trainers found the computer-based simulations useful and well-suited technology for HAZWOPER training. Several organizational and technological challenges remain, such as providing sufficient training and transition time for trainers to feel confident managing altered classroom dynamics, preparing for technology failures, addressing human-computer interface issues, trainer and trainee computer literacy barriers, and development of contingency or back up plans for computer failures. Evaluation efforts pointed to the importance of providing ongoing access to computer-based simulation technicians for software and hardware issues as well as the need to document, track, and communicate effective problem solving strategies relative to technology issues.

Theoretical and practical implications can be inferred from evaluation results. Blended learning strategies that apply case-based simulations in which trainees safely gain skills can engage adult learners in a dynamic educational process. Collaborative knowledge development among peers encourages collective problem solving and decision-making through "realistic" simulation scenarios to test out construction of knowledge rather than didactic transfer. A computer simulation that supports small group activities can provide a useful learning platform and teaching tool with multiple modes of information gathering and inquiry. We anticipate that transfer of contextual knowledge can enhance workers' capacity to prevent harm to self and others in a real world work setting. This, however, will need to be tested in the future.

The evaluation indicated a challenge in terms of accommodating the simulation to a diverse range of trainee education and experience. It might be helpful to conduct pre-assessment or pre-training sessions for trainees with less computer experience, but the course format and content requirements prohibit time for such activities. Simulation training modules were designed in ways that did not require strong computer literacy yet still presented a challenge for a small percentage of trainees.

Evaluation strengths included an emphasis on user orientation of the simulation training, providing guidance for useful training, building simulation training experience in the HAZWOPER field, and promoting continuous training improvement. The evaluation was limited by the lack of a scientific design. Consequently, the results may be biased due to subjective inquiry, missing trainee data, and inability to assess knowledge transfer to the workplace. Regardless of limitations, the analysis demonstrates the development of a computer-based simulation that successfully supports small group learning and is a useful learning and teaching tool in a HAZWOPER training course.

Wide acceptance of the computer-based simulation at a NIEHS WETP Trainers' Exchange conference presentation held in March 2003 confirmed the success of this project. The simulation was presented to trainers from the program's nearly twenty awardees from around the U.S. In addition, the United Steel Workers of America training program has decided to include this computer-based simulation in its training courses, which predominantly use SGAM activities.

Conclusion

Initially, TNEC was skeptical of using computer-based simulations for HAZWOPER trainings. There were a number of challenges to address such as critical decisions around simulation components, human-computer interface issues, developing authentic and relevant training scenarios, and integrating appropriate instructional materials for worker-oriented training. Such challenges were effectively met through cross-disciplinary team development. The computer-based simulation provides a number of benefits reported by both trainees and trainers. It offers safety that is often too expensive or impractical to build into hands-on training, and supports small group activity-based learning. Integrated with the existing successful training curricula and methods, the computer simulation has supported a blended learning experience that has enhanced and expanded learning and teaching processes.

Acknowledgements

This paper results from the collective efforts of staff at member organizations of The New England Consortium. We would like to thank the consortium's organizational and individual members for their commitment to worker health and safety and public health.

Author's Note: This work was funded by a grant from the National Institute of Environmental Health Sciences to the University of Massachusetts Lowell (NIH/NIEHS #2 U45 ES06172-9 through 12). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIEHS, NIH.

References

Aldrich C. Simulations and the Future of Learning: An Innovative (and Perhaps Revolutionary) Approach to e-Learning: Pfeiffer. 2004

Black, J.; Thalheimer, W.; Wilder, H.; de Soto, D.; Picard, P. Constructivist Design of Graphic Computer Simulations. Paper presented at the The National Convention of the Association for Educational Communications and Technology; 1994.

Botsis T, Hlkiotis SC, Kourlaba G. Computer Simulation of the Human Respiratory System for Educational Purposes. Computers, Informatics, Nursing 2004;22(3):162–170.

Brandt S. The use of a computer-assisted cooperative learning classroom environment to teach job skills to adults. Journal of Educational Technology Systems 1999;28(1):97–104.

Bransford, JD. Anchored instruction: Why we need it and how technology can help. In: Nix, D.; Sprio, R., editors. Cognition, education and multimedia. Hillsdale, NJ: Erlbaum Associates; 1990.

Gettman MT, Le CQ, Rangel LJ, Slezak JM, Bergstralh EJ, Krambeck AE. Analysis of a Computer Based Simulator as an Educational Tool for Cystoscopy: Subjective and Objective Results. The Journal of Urology 2008;179(1):267–271. [PubMed: 18001785]

Hmelo-Silver CE. Analyzing collaborative knowledge construction: multiple methods for integrated understanding. Computers & Education 2003;41(4):397–420.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Ioannidou IA, Paraskevopoulos S, Tzionas P. An interactive computer graphics interface for the introduction of fuzzy inference in environmental education. Interacting with Computers 2006;18(4): 683–708.

Jacobson MJ, Spiro RJ. Hypertext learning environments, cognitive flexibility, and the transfer of complex knowledge: An empirical investigation. Journal of Educational Computing Research 1995;12 (4):301–333.

Lainema T, Nurmi S. Applying an authentic, dynamic learning environment in real world business. Computers & Education 2006;47(1):94–115.

Luskin J, Somers C, Wooding J, Levenstein C. Teaching Health and Safety: Problems and Possibilities for Learner-Centered Training. American Journal of Industrial Medicine 1992;22(5):665–676. [PubMed: 1442796]

Merrill M. Trust in Training: the Oil, Chemical, and Atomic Workers International Union Worker-to-Worker Training Program. Occupational Medicine: State of the Art Reviews 1994;9(2):341–354.

Merrill M. Sharing Power: OCAW Worker-Trainers and the Small-Group Activity Method. New Solutions, a Journal of Environmental and Occupational Health Policy 1995;5(2):39–50.

Mujber TS, Szecsi T, Hashmi MSJ. Virtual reality applications in manufacturing process simulation. Journal of Materials Processing Technology 2004:155–156. 1834–1838.

Nickerson JV, Corter JE, Esche SK, Chassapis C. A model for evaluating the effectiveness of remote engineering laboratories and simulations in education. Computers & Education 2007;49(3):708–725.

Park J, MacRae H, Musselman LJ, Rossos P, Hamstra SJ, Wolman S, et al. Randomized controlled trial of virtual reality simulator training: transfer to live patients. The American Journal of Surgery 2007;194(2):205–211.

Passman MA, Fleser PS, Dattilo JB, Guzman RJ, Naslund TC. Should simulator-based endovascular training be integrated into general surgery residency programs? The American Journal of Surgery 2007;194(2):212–219.

Pfahl D, Laitenberger O, Ruhe G, Dorsch J, Krivobokova T. Evaluating the learning effectiveness of using simulations in software project management education: results from a twice replicated experiment. Information and Software Technology 2004;46(2):127–147.

Ravert PMRN. An Integrative Review of Computer-based Simultion in the Education Process. CIN: Computers, Informatics, Nursing 2002;20(5):203–208.

Slatin, C. Training for Action: The Political Economy of the Superfund Worker Training Program, Unpublished Dissertation. University of Massachusetts Lowell; Lowell, MA: 1999.

Slatin C. Health and Safety Organizing: OCAW's Worker-to-Worker Health and Safety Training Program. New Solutions, a Journal of Environmental and Occupational Health Policy 2001;11(4): 349–374.

Smolle J, Prause G, Smolle-Jüttner FM. Emergency treatment of chest trauma -- an e-learning simulation model for undergraduate medical students. European Journal of Cardio-Thoracic Surgery 2007;32 (4):644–647. [PubMed: 17702590]

Spiro RJ, Feltovich PJ, Jacobson MJ, Coulson RL. Cognitive flexibility, constructivism, and hypertext: Random access instruction for advanced knowledge acquisition in ill-structured domains. Educational Technology 1991:24–33.

Spiro, RJ.; Jehng, J. Cognitive flexibility and hypertext: Theory and technology for the non-linear and multidimensional traversal of complex subject matter. In: Nix, D.; Spiro, RJ., editors. Cognition, Education, and Multimedia. Hillsdale, NJ: Ehrlbaum; 1990. p. 163-205.

van Merriënboer JJG, Brand-Gruwel S. The pedagogical use of information and communication technology in education: a Dutch perspective. Computers in Human Behavior 2005;21(3):407–415.

Wall J, Ahmed V. Use of a simulation game in delivering blended lifelong learning in the construction industry - Opportunities and Challenges. Computers & Education 2008;50(4):1383–1393.

Wallerstein N, Baker R. Labor Education Programs in Health and Safety. State of the Art Reviews, Occupational Medicine 1994;9:305–320.

Wallerstein N, Bernstein E. Empowerment Education: Freire's Ideas Adapted to Health Educatio. Health Education Quarterly 1988;15(4):379–394. [PubMed: 3230016]

Weinger M, Lyons M. Problem-Solving in the Fields: An Action-Oriented Approach to Farmworker Education About Pesticides. AJIM 1992;22:677–690.

Wignall GR, Denstedt JD, Preminger GM, Cadeddu JA, Pearle MS, Sweet RM, et al. Surgical Simulation: A Urological Perspective. The Journal of Urology 2008;179(5):1690–1699. [PubMed: 18343441]

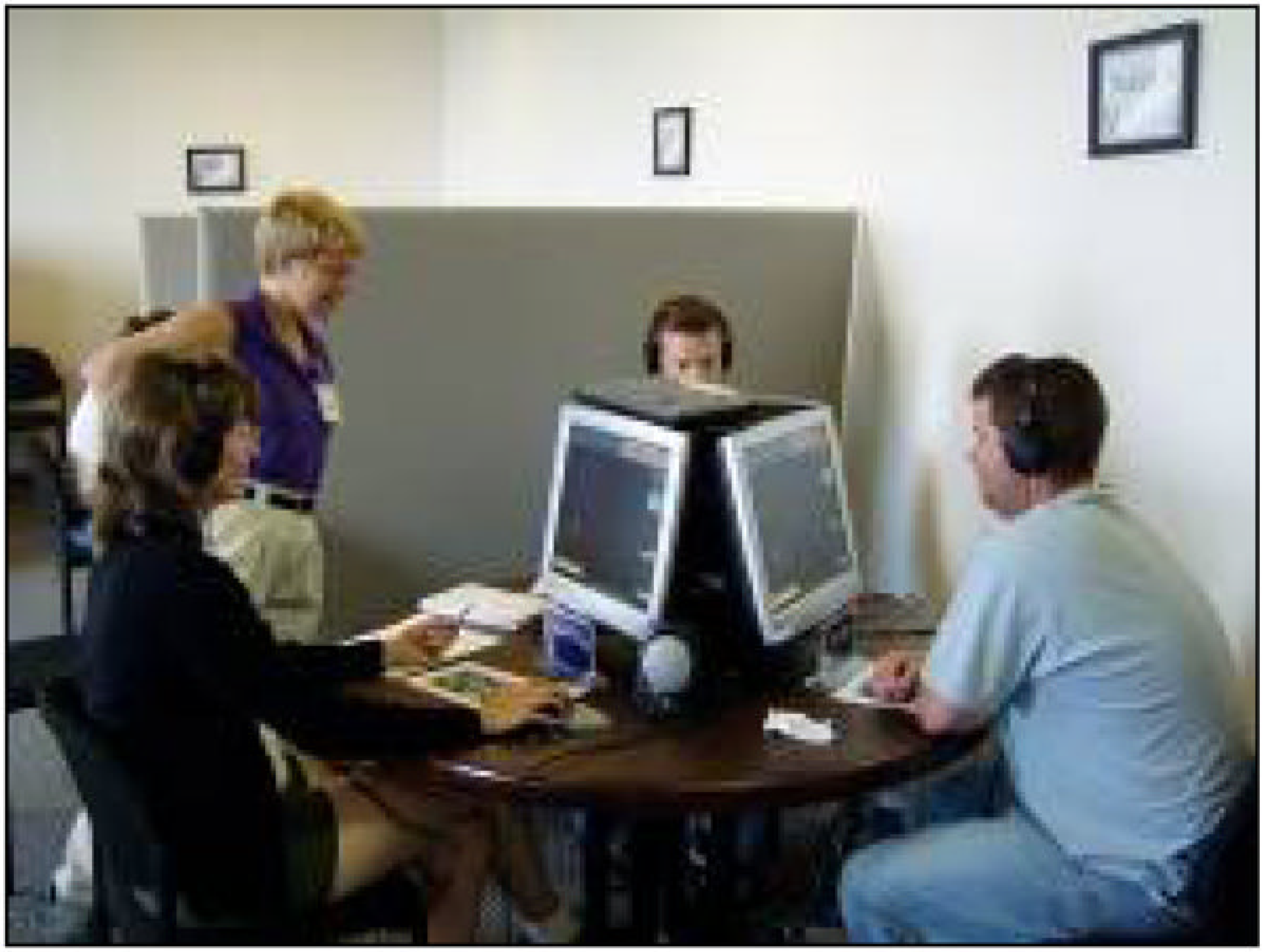

Figure 1.
Simulation Training Station

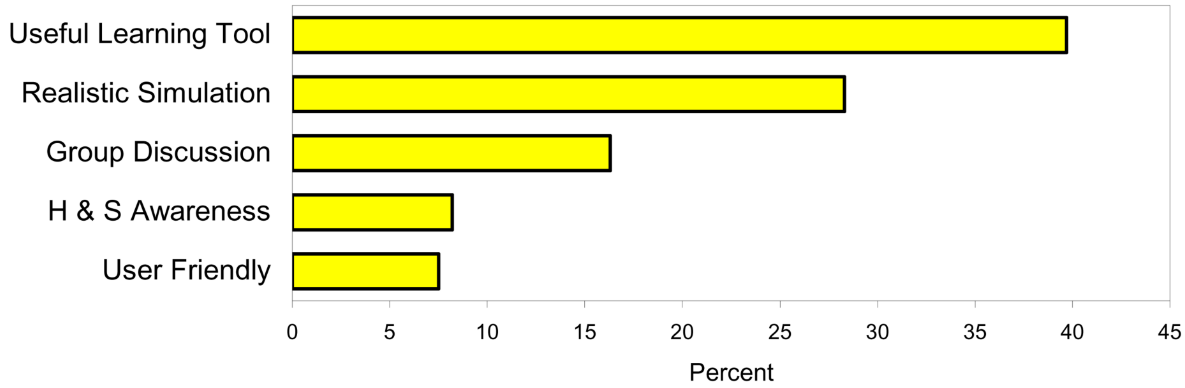

Figure 2.
Categories of Simulation Benefits; per Trainees (n=334)

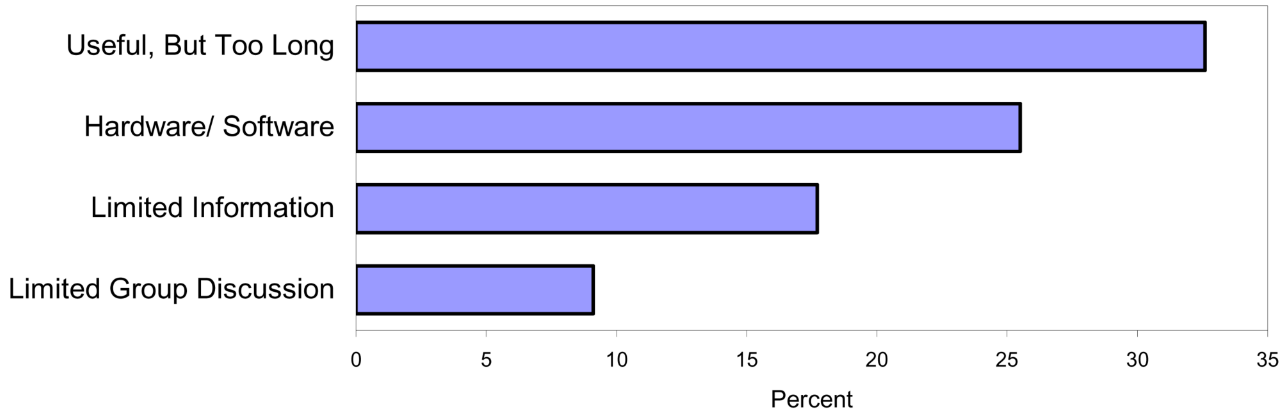

Figure 3.
Categories of Dissatisfaction with Simulation; per Trainees (n=175)

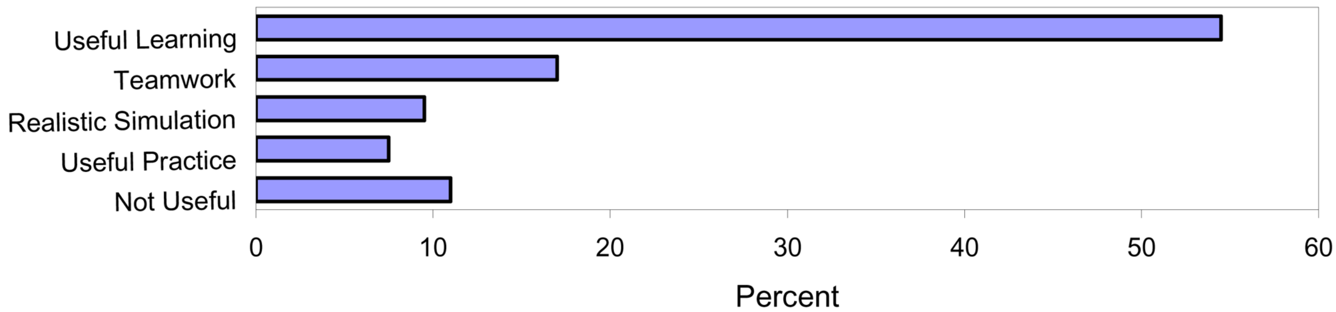

Figure 4.
Simulation Preparation for the Incident Drill (n=119)

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 1

Trainees by type of course and level of education (n=466)

COURSE	REGISTERED	Undergraduate College or higher	High School/GED or less	Education Unreported
40-Hr Basic	274	118 (43%)	59 (21.5%)	97 (35.5%)
8-Hr Refresher	192	161 (84%)	23 (12%)	8 (4%)
Total	466	279 (60%)	82 (17.5%)	105 (22.5%)