Optimizing Performance Outcomes for Emergency Management Personnel Through Simulation Based Training Applications

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Abstract. There has been much in the news about response to natural disasters and catastrophic events such as Hurricane Katrina and the Deepwater Horizon oil spill in the Gulf of Mexico. Many challenges face the first responder community that are in many ways new and previously not encountered by a community of hard working and dedicated people. The issues range from demographics in our society, changes in weather patterns, multiple generations in the workforce and many new methods of technology being explored for modernizing the training. A review of the challenges and potential solutions as implemented by two agencies offers some answers to the question, "Why is this so hard?"

Keywords: Knowledge loss · Job performance · Eliciting knowledge · Simulation applications · Demographics · Learning outcomes

1 Introduction

"Any sufficiently advanced technology is indistinguishable from magic."
Authur C. Clarke

The design and development of a successful simulation based learning intervention can be both exciting as well as challenging. But it is not magic and this paper will present the challenges and how several different agencies have dealt with the challenges and achieved what to many seem magical results. Often the excitement to modernize can drive efforts to focus more on the technology and lessen the effort for accurate detailing of complex performance requirements of first responders. For such applications, the required outcomes are very complex behaviors possessed by successful expert performers but often hard to capture, even describe and measure. These complex behaviors are accomplished by experienced personnel, and are not always obvious as they are internally processed, i.e. situational awareness, problem solving and decision making, and often done without much deliberate thought by the SME. To be able to capture and document these complex performance outcomes and translate them into learning strategies and simulation scenarios that can facilitate the learning for students to practice and master them can be a challenging and a time-consuming effort. This is due to many factors including changes in the workforce itself, improvements in housing and infrastructure and the explosion of technology available for training of the workforce.

2   Background

Per a U.S. Bureau of Labor Statistics report published in the Fall of 2001, the 20th century has seen a remarkable change in the American workforce in many ways. In addition to a tremendous growth in numbers of over 6 times, the shift from industries dominated primarily production occupations, such as farmers and foresters, to those dominated by professional, technical and service worker, such as business and public service. At the beginning of the century 38% of the labor force worked on farms, and by the end of the century the number was less than 3%. Similarly, service industries went from 31% to 78% during that same period. At the same time workplace safety improved dramatically with deaths and injuries on the job for railroad workers dropping from 2550 in 1900 to 56 in the 1999 Fisk (2003).

Many forces contributed to the major changes in the workforce to include capital, demographics, immigration, technology, education and a larger government involvement with such programs as run by OSHA and Department of Labor. No single factor can account for the largest but technology is clear as a key factor, including electricity, communication devices, transistors, fiber optics, fire proofing, computers, the internet, and many more. These technologies were not only effecting the workplace but in the home reducing the labor of homemakers and enhancing the safety and comfort of the homes themselves. This shifted the workforce with the large influx of women from home to the workplace and with it greater investments in industries to produce more labor saving devices and later more information technology devices. The technology likewise had a major impact on medical advances, increasing the life span of individuals and fewer severe illnesses. Those who were injured on the job were more likely able to return to work. The workforce also shifted based on immigration providing a crucial influx of people seeking to find employment and a better job to improve their way of life. From 1929 to 1965 strict immigration laws that limited less skilled immigrants enhanced the workforce as the shift to less production jobs to service. Education played an important role, with significant advances in high school graduation increases, noted as 14% in 1900 and the figure growing to 83% by 1999. Likewise the growth of secondary learning attendance grew from 1910 where it was 3% to 1999 it was 25%, and earning of college graduates was 62% higher than their high school graduate collogues. However the workforce successes of the 20th century may not be what is needed for the 21st.

3   Current Issues

3.1   Workforce and Workplace Dynamics

The amazing trends in the workplace and workforce that was experienced in the 20th century has begun to again shift as several factors began to change in the final decades of the century and the first decade and a half of the 21st. According to a US Department of Labor, *futurework*, Trends and Challenges for the Work in the 21st Century, published on Labor Day, 1999,

"Perhaps the best place to gain a glimpse of the future of work is in the newspaper. Not the front page—but the want ads. A few decades ago, employers were in search of typists, switchboard operators, mimeograph repair technicians, keypunchers and elevator operators. Newspapers

even had separate job listings for men and women. Today's want ads are seeking Webmasters. LAN operators. Desktop publishers. And many job seekers no longer turn to the want ad pages but to the Web pages. They find their jobs on the Internet." A Report of the United States Department of Labor; ALEXIS M. HERMAN, SECRETARY

The report continues describing that the new workplace had arrived by 1999 energized by a new economy, "powered by technology, fueled by information and driven by knowledge." That the fastest growing jobs include computer engineering, data base administrators, system analysts, securities and financial workers and a host of professional assistants in medicine, legal and desktop and web specialists. These jobs call for a sizable amount of cognitive skills and expert knowledge, which in many ways marks a much greater percentage of jobs in today's workplace being viewed as knowledge based than even 50 years ago when manufacturing and products were the focus of the workplace. This is complicated by the fact that families are working harder, with more dual income households than ever and real wages fell through the last 2 decades of the 20th century. Many workers both young and old wonder if they have the skills to stay ahead of the future workplace. This situation is further complicated by the large number of Baby Boomers retiring and taking with them significant amounts of job knowledge and expertise, gained over decades of work. AARP, referencing a Pew Research Center (2010) report, states that 10,000 boomers reach the traditional retirement age of 65 every day, with the trend beginning in 2011 and is forecast to continue for the next 14 years. One researcher stated about the potential loss of knowledge, "It's one of those sleeping giants most people don't think about. If you don't do something proactively today, you're going to be stuck with employees who know basic tasks but don't have that institutional knowledge." (Pena 2013). Even when organizations try to use their experts to train new personnel, the gap in experience and knowledge is often too big to overcome in a training program that was designed for audiences of earlier generations.

The workers of today remain interested in 3 major issues in their lives; economic security over their lifetime, including food on the table, roof over their heads and a secure retirement; work and family balance, resources and time to enjoy family life and meet the needs of children and aging parents; safe and fair workplace, free from health hazards and discrimination and unfair employment practices. These needs are not assured for the future and will be substantially affected by major changes in the workplace and the readiness of the workforce. The many changes in diversity, technology and globalization will demand new high-skilled jobs and lessening demand for low skill work. The bottom line per the report is that "skills are the ticket" and that in the information-based, skills based economy, knowing means growing.

3.2   Education Situation and Readiness to Workforce

Given the need for skills and job knowledge capable workers, the trend in education in the U.S. seems to be moving in the opposite direction. 30 years ago, America was the leader in quality and quantity of high school diplomas yet today they rank 36th in the world. 1.3 million high school students don't graduate on time annually and only 1 in 4 of high school students graduate college-ready in the 4 core subjects of English, Reading, Math and Science. These core cognitive skills are critical to the ability to learn on the

job and to take on the newer jobs requirements of the high tech and knowledge hungry workforce. The US Census listed that a steady decline in people of both genders in high school graduate for ages retiring Baby Boomers (55+) 28.5 million to 35–54 GenX of 23.8 million to 25–34 (NextGen) of 10.9 million. A report from the American Management Association (1998) stated the skills of cognitive and communication skills are lacking in new employees and in many cases, there is a mismatch between what skills jobs require and the ones applicants possess. More than 20% of adults in America read at or below the fifth grade reading level. The report further states that 36% of applicants lacked the required math and reading skills, which was an increase reflecting tighter labor markets and rising demand for such skills. In the US Department of Education report, entitled *Adult Literacy in American*, (Kirsch 1993), it is reported that:

> *"Although Americans today are, on the whole, better educated and more literate than any who preceded them, many employers say they are unable to find enough workers with the reading, writing, mathematical, and other competencies required in the workplace. Changing economic, demographic, and labor-market forces may exacerbate the problem in the future." Further, "What many believe, however, is that our current systems of education and training are inadequate to ensure individual opportunities, improve economic productivity, or strengthen our nation's competitiveness in the global marketplace."*

The study goes into detail of the process that was used for this historic study, as no data on literacy had ever existed before and because of the concern of the impact this has on the workforce and in the future and that many of those surveyed were out of school and education could not improve the situation alone. Bottom line results indicated that over 51% of those survey or 94 million people were at the bottom 2 levels of the scale, with limited reading and computational skills and yet 75% in the lowest level and 97% in the second lowest level described themselves as "well" or "very well" on a perceived "at risk" element of the survey, although they routinely got help from family members or friends during their day to day activities. Only 21% performed in the 2nd highest levels of the survey items on prose, documents and quantitative literacy, which were associated with the most challenging tasks in the assessment battery. Although the study makes no absolute comments or recommendations about their findings, they do state that the society has grown much more technologically advanced and that there is a greater need for individuals to become more literate and to develop more advanced skills. The possible implications of general decline in formal education achievement while the increases in technology impact on the workplace coupled with other societal impacts has the potential to drive the need for training outside of the formal school system to fill the gap of the workforce to meet the need of more complex job tasks and growing impact of high consequence low incident situations which range from major disasters, like the Deepwater Horizon oil spill, to natural disasters and the response to Hurricane Katrina or the more regular daily challenges of fire and rescue responses.

4 Impact on Training for Emergency Management Personnel

As stated previously, the challenges of today's workforce are complicated by the rapid changes that have occurred in the 20th century and in some cases, such as the Baby Boomers retirement, not a problem that has had to be dealt with previously. And with the populations

size the impact of disasters or daily problems can cause turbulent reaction across the nation with 24 hour news channels and video technology being so ubiquitous. Situations that at one time were limited to local news are now national headlines and increase the impact and in some cases the consequences of less than ideal circumstances. In many cases the public sector has had to bear the brunt of this and is challenged by reduced budgets while dealing with the workforce trials, educational shortfalls and retiring experienced personnel. Law Enforcement and Fire Rescue are in the forefront of dealing with this problem as they are faced with life and death situations daily with less experienced personnel and reduced training budgets. These occupations were historically trained much like trade skills, with young officers being provided basic skills of the physical demands of keeping the peace and fighting fires while working under the close supervision of experienced personnel who guided their performance through day to day operations and applications of case studies and "war stories" that added the more tacit knowledge that turns a novice into a journeyman. From another angle a recent Gallup poll shows that for the first time the percentage reporting themselves as socially liberal is equal to the number reporting as social conservative, at 31%. As the society has shifted the issues of often negative reaction to police and emergency responders has become more intense as seen in the initial reaction to FEMA's response to Katrina in New Orleans. Likewise the reaction to the Gulf Oil spill with the explosion on the Deepwater Horizon and the international publicity has opened the entire question as to training of the oil crews and their supervisors. (Insurance Journal 2007)

Given that the personnel who are available to work in these communities are already out of public school, the industry is being required to look at their current training methods and the abilities of the candidate population that is applying. In many cases the entry level workforce as described above is lacking in the fundamental skills that their older workforce members had when they were entry level and the training has not changed significantly from the paradigm of basic training on the procedures and safety followed by mentoring by supervisors in an on the job approach. With the exception that the basic training now uses PowerPoint, the changes needed to remediate the lack of cognitive and communications or other "soft skills" has not been addressed. Clearly with the changes in the entry level population and the lack of documentation on the details of the experts knowledge that is leaving daily through retirement, the outcome can only be a less well equipped workforce at a time when they are more closely observed and often criticized.

5 Job Performance Details and Systematic Blended Training Design

5.1 The Emergency Management Community

There have been many discussion over the years about the ultimate role of education in our country ranging from making good citizens, to good workers, to good family members but some believe that the purpose of education is to teach people how to think (Dewey 1933). However much of our education in the recent past has shifted to teach content or facts as it is much more straight forward and easier to test (Marzano & Toth 2014). Teaching someone how to think is much more complex but it is really what is needed for our workforce of today and the future, especially for those working in the communities of Emergency

Management and First Responders. Followers of Dewey and his theory of reflexive thinking believe that the 5 step process of Defining the problem, Analyzing the Problem, Design and Test various solutions, implement a solution and evaluate its effectiveness has great utility in education (Hermanowicz 1961) and in fact in a later work by Dewey (1916), *Democracy and Education*, Dewey says, "While we speak, without error, of the method of thought, the important thing is that thinking is the method of an educational experience. The essentials of method are therefore identical with the essentials of reflection." He later (Dewey 1938) in *Experience and Education* expanded that thought and translated the five steps of reflective thought into a more prescriptive set of methodology described below:

1. That the pupil have a genuine situation of experience that there be continuous activity in which he is interested for its own sake
2. That a genuine develop within this situation as a stimulus to thought
3. That he (the learner) possess the information and make the observations needed to deal with it.
4. That suggested solutions occur to him which he shall be responsible for developing in an orderly way.
5. That he have the opportunity and occasion to test his ideas by application, to make their meaning clear and to discover for himself their validity.

Although there are some to include Hermanowicz who believe Dewey's process is restrictive, especially for teaching children, it appears to have significant relevance to the problems with training adults, especially for those who must face critical problems and develop skills to solve them with significant time constraints. The challenge facing this community is the same one facing the entire society, which is the departing experts whose knowledge is leaving with them.

5.2   Loss of Knowledge Through Retirement and Turnover

Historically retirement has occurred with much less concern for two newly occurring problem; first, the sheer number of Baby Boomers who are scheduled to reach retirement age over the next 14 years; and second, the gap and experience of replacements, which is a function of the reduced amount of children Boomers had and the flattening of organization based on technology (PC and Internet) and financial impacts of the Crash of 1987. Companies shifted from typing pools to PCs on managers desks and large numbers of clerical workers and their supervisors were downsized. These jobs which existed between entry level personnel and managers/executives would have been learning the important middle level skills and under earlier eras would have been the next generation of managers/executives. This came at a time when the Millennials had been on the job for a few years but lacked the experience of the middle managers who were ousted but felt ready and eager to take on the new and better paying senior management positions. The retiring Boomers when possible explained their job, but the communications and experience gap was too great and often they felt that the younger folks should know more and were not really interested in how the seniors did it.

This highlights another problem, cited by Klein (1991) that understanding how experts and experienced people make decisions and deal with complex situations is not best

accomplished by applying theoretical decision making models or by asking SMEs to describe what they do or to teach others how to do it. His work began focused on fire-fighting of wild fires in the Western states, in which situations are dynamic, conditions constantly change, real time reaction is needed for these changes and communications, teamwork and decision making are critical and can cause severe negative results if not done correctly. He explains that theoretical decision making included analytical and systematic procedures to weigh evidence and select optimal course of action. This process was often tested in academic surroundings in which the subjects were focused on a specific problem and controlled setting to allow clean data collection. The challenge was that the SMEs didn't solve problems like that and it was ineffective to try to train novices to employ those methods as they were not effective in the chaos of a wild fire. Classical strategies fail under time pressure and even without time pressure they require significant work and are not flexible enough to deal with the changing conditions.

The process of eliciting knowledge and what works in such situations is the key to both analyzing the performance requirements and tacit knowledge that SMEs actually use and the process that needs to occur before that expertise retires or moves on to other communities. Without a plan or formal program to capture this knowledge organizations face a severe challenge with continuity of business or mission. And at this time it is becoming critical with the Baby Boomers retiring and multigenerational make up of the workforce. (Pena 2013) This loss of knowledge has a secondary impact and one potentially greater with the advent of new training technologies such as simulation, in that without the details of job knowledge and skills available for the training community the required information to design appropriate learning outcomes and training strategies that are the basis for training and simulation interventions are not available to train the less experienced and new employees. Managers see the new training technologies as a quicker way to train and increase employee's ability, but without the critical and detailed expert knowledge of actual required job performance the technology is like a race car with no fuel. It demonstrates great potential but can only deliver when the right learning outcomes are used to design the training interventions that achieve the performance requirements in the new personnel.

6   Case Studies

Over the last 5 years, this author has been privileged to be involved to two major efforts in which advanced learning technologies were used to help solve the challenge of knowledge loss and training of the next generation of personnel working in emergency management and first responder situations. In both these cases the initial intent was on implementing the technology to modernize and enhance the existing training and in both cases it was recognized much greater level of information on the actual details of job performance by experts was critical to achieve the goals of the organizations.

6.1   Transportation Emergency Response Application (TERA)

The first program, TERA, is sponsored by the National Academy of Science, Transit Cooperative Research Program, guided by an advisory panel of which this author is a member as

an expert in training and simulation and contracted through the Engineering & Computer Simulations, Inc. (ECS). Initiated based on the perceived need for Transit managers to improve their readiness for dealing with catastrophic events, a more modern methodology was sought after and one approach selected which had been implemented by the National Guard for their similar needs. As the National Guard has the mission of assisting in times of natural disasters like flood, tornados and other situations it appeared to be a good fit. However as the project began it became very clear that the mission of the NG and Transit managers is very different; not at the overall goal level but in the actual job performance details. This became especially evident as they looked at what the experts do in response to a terrorist incident like the gas attack of the Metro in Washington, DC. (The Police Policy Studies Council 2004). In addition, the target audiences was quite different as well as Transit personnel were quite inexperienced with emergency management and they used different job terminology and were organized very differently. The real difference became obvious as the analysis identified detailed cues and decisions that made up the actual needs for this community of Transit managers, who historically focus on getting the trains running again after a disturbance but for some new situations that is the last thing that is needed. The Objective and Scope for this project taken from the first report by the ECS contractor to the Transit Cooperative Research Program office that was sponsoring the work states:

> The objective of this research is to develop the Transit Emergency Response Application (TERA) to provide interactive training and exercise for transit agency command-level decision makers. ECS will leverage the Emergency Manager Staff Trainer (EMST), a government-owned simulation training and exercise system. EMST allows individuals or teams to make decisions and mitigate the incident by responding to the messages, communicating with teammates and giving commands to simulated entities. (TCRP Quarterly Report on Project A-36; ECS, dtd 14 Jan 2011, Orlando, FL.)

The initial 3 month plus period of the project was spent on analyzing and describing the needs of transit command level personnel, specifically the cognitive and behavioral tasks and prerequisite knowledge required to respond to a variety of catastrophic events. To accomplish this they employed Cognitive Task Analysis (CTA) with a large pool of SMEs from both local and regional transit agencies. In addition, they conducted reviews of existing literature, best practices and reports as well as existing training. They found that most training was a combination of FEMA sponsored classroom training and live exercises. The program over the next 2 years developed and tested with SME and novice subjects to ensure that not only the performance and tacit knowledge was right but the translation of that into experiences that target audience personnel could understand and learn from. As the program moved to field test, other ground Transportation communities became interested and the scope was expanded from Transit to Transportation, which has just recently expanded into Aviation portion of Transportation. To ensure the detailed process of knowledge elicitation is not lost with the expansion a spreadsheet tool and workshop have been developed for Transportation trainers who plan to use the TERA as a portion of their training, and will be able to extract relevant cues as input for the scenarios that they will use in the expanded program.

6.2   Orange County Fire and Rescue Department (OCFRD) Incident Command Program

This program was sponsored under a grant from FEMA to the OCFRD and developed in support of OCFRD by UCFs Institute for Simulation and Training, of which this author was the Principal Investigator. This program was intended to find a more modern and effective way to train new Fire Lieutenants who are the first responder Incident Commanders responsible to manage and lead the response to a wide variety of incidents, ranging from medical incidents, to fires to other emergencies and disasters. The application approach used was an in-house modification of the Instructional System Design Model (ISD) (Branson 1975) called the Advanced Performance Technology Model (APT) (Tarr 2003) which focuses on the details of the job performance requirements and the learning outcomes needed to achieve them through blended training and simulation interventions. Over 4 months was spent in eliciting the expert knowledge required to successfully respond to a wide variety of incidents, using a mix of ethnographic analysis, critical incident interviews and reenactments coupled with several methods of documentation, to include flow charting and narrative outlining. The level of detail needed to identify the tacit knowledge and critical elements can best be described as 3 layers deeper than most job analysis methods in common practice. These results were subjected to cognitive task analysis in coordination with SMEs to uncover the less observable thinking and decision making activities that SMEs had a hard time articulating. These formed the basis of a spreadsheet of behavioral elements which were then converted into learning objectives for both prerequisite training, in class lecture and computer based training, interactive desktop simulation and large screen scenario based simulator training. This training was evaluated in detail by a SME who conducted a detail after action review (AAR) critique so the student would be aware of what they did right and wrong as well as directions on remediation if needed. Overall seven very different scenario situations based on guidance from OCFRD as to situations they felt were most representative of their missions were designed for the training, including 2 single family homes, small apartments, large motel, commercial building, vehicle accident, and wild fire situations. In the year following the delivery of the program over 400 Fire Officers were trained with the new program while at the same time 10 senior Battalion Chiefs left through retirement. The ability to capture their expertise prior to retirement and promulgate it into an operational training program is an example of the kind of complex and complete efforts required to meet the new challenges.

7   Conclusions and Discussion

The purpose of this paper was to highlight the critical need to capture knowledge being lost through retirement of experienced personnel, both to maintain continuity of mission as well as to form the basis of advanced training technology required to train younger, less experienced personnel who are replacing them. As this is a fairly new problem in our society due to the demographics resulting post WWII and the large number of Baby Boomers retiring over the next 14 years, it is not something that is being recognized by many senior managers. Likewise the need for increased detailed definition of the job performance knowledge and cognitive skills of these retiring personnel to properly design such complex

learning systems as simulations is again a new challenge as these systems require considerable more front end time then more traditional training. In most cases the excitement and promise of new technology as the solution for more modern training overshadows the less exciting but great need for well-organized elicitation of deeply held knowledge from SMEs and the careful translation of that into learning outcomes, objectives and training strategies. This is especially true for such fields as emergency management and first responders who are not only dealing with catastrophic events and complex fire and rescue situations but changing expectations of society. The case studies were intended to provide some actual living examples of some programs that have accepted the need for such systematic programmatic efforts and which have had remarkable results in the form of both modern and effective training activities. However they are relatively few such examples and the intent of this paper is to help inform and provide a better understanding of why such additional and systematic efforts are now needed and that the two colliding issues, knowledge loss to an previously unencountered exodus of experienced personnel and the increase in advanced training technology being employed to help with new training challenges caused by younger replacements. As explained this is a significant problem at a time when our society needs serious solutions and a well trained workforce.

References

Branson, et al.: Interservice Model for Instructional System Design (TRADCO Pub 350-30) (1975)

Cohn, D., Taylor, P.: Baby Boomers Approach 65 – Glumly. Pew Research Center, Social & Demographic Trends, Wash (2010)

Dewey, J.: Democracy and Education: An Introduction to the Philosophy of Education. MacMillan, New York (1916)

Dewey, J.: How We Think. D.C. Heath Company, Boston (1933)

Dewey, J.: Experience and Education. MacMillan Company, New York (1938)

Fisk, D.: American Labor in the 20th Century. Bureau of Labor Statistics, Wash, DC (2003)

Hermanowicz, H.J.: Problem solving as teaching method: a critical look. Educational Leadership, February 1961

Kirsch, I.: Adult Literacy in America. U.S. Department of Education, NCES 1993-275, Wash (2002)

Klein, G., Klinger, D.: Naturalistic decision making. Human Systems IAC, GATEWAY, vol. XI, no. 3, Winter 1991

Layton, L.: Metro Set to Initiate Chemical Sensors Use at 2 D.C. Stations a First for Subways. The Police Policy Studies Council Quarterly (2004)

Marzano, R., Toth, M.: Teaching for Rigor: A Call for a Critical Instructional Shift. A Learning Sciences Marzano Center Monograph, West Palm Beach (2014)

Oil Drilling risks rise with novice crews. Insur. J. (2007)

Pena, A.: Institutional Knowledge: When Employees Leave, What Do We Lose? HigherEd Jobs (2013)

Tarr, R.W.: Classroom Lecture Materials, Instructional Simulations Design in Education. University of Central Florida, Orlando (2003)