Training Using VR In Industrial Applications: pitfalls due to limited knowledge of human skill acquisition

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Training in virtual environments (VEs) gives new, exciting and cost-effective ways of learning, but several critical issues on human learning in VEs have to be resolved. An underestimated issue concerns the limited transfer of skills acquired in a VE to the real world. Research is required to determine in detail (a) what we can expect from VE-based training (and what not), (b) how VEs need to be designed in order to maximize such transfer, and (c) how training programmes should be designed to optimize transfer.

1 What is the added value of virtual reality over other methods of training e.g. instructor-led, computer-based training (CBT), etc.?

The main asset of virtual reality (VR) systems, used to create a virtual environments (VE), is obviously the high degree of immersion, that is, the experience of people they are inside a virtual environment. With VE-based training, one can distinguish between primary and secondary advantages. With primary advantages I mean the possibility to train in situations that are otherwise *not possible*. This entails training in locations and situations where training is usually impossible due to environmental hazards or costs, such as with astronaut training, emergency training for pilots, training in adverse weather conditions, and training on specific railroad tracks that are always in use.

Secondary advantages are those that make training more *cost-efficient*. Cost-efficiency may occur for many reasons: high hourly rates in the real task due to fuel, wear and tear of actual equipment (aircrafts, tanks), and high instructor rates (in case the instructor tasks are automated). Furthermore, the available training time can be used more efficiently because the training simulator can be adapted (automatically or manually) to the needs of a particular trainee. For example, particular tasks (like drivers negotiating a roundabout) can be repeated until satisfactory performance, without the need to each time go back to that particular situation. Feedback information can be augmented to the type of support needed by the trainee (e.g., with artificial cues). Furthermore, performance can be stored and used for automatic trainee grading as well as for determining what additional training is needed, and what training is no longer needed.

2 What degree of complexity is required in virtual environments in order to provide effective training?

This is a tricky one. It all depends on what you intend the trainee to learn. High level (automatically executed) cognitive and motor skills appear highly dependent on seemingly unimportant cues in the training situation (like the illumination, the feel of controls, presence of other people), while learning at a conscious, explicit level (i.e., knowing what to do next) depends much less on such cues. Currently, virtual environments (VE) provide situations that are similar to the real situation, but *not* identical. It is critical that training in VE does not yield skills that depend on the VE itself, in order to prevent that performance in the real world depends on conscious control again without being able to properly use the skill that developed in VR.

From psychological research we know that performance often deteriorates when tasks are executed in another environment. This may be caused, not only by task relevant aspects such as changed visual, auditory or haptic interaction properties, but even by seemingly irrelevant aspects such as illumination and positions at which simulated displays in the VE are located. We do *not* know yet how bad it is when feedback in a particular sensory modality is different or absent, and to what extent human performance and motivation will be reduced. Currently we are investigating this issue at our department at the University of Twente. So, until we know in detail what aspects of simulators are paramount for skill training, we might be wasting money when we build complex simulators for training as simpler systems may yield the same result.

3 What are the perceived barriers for implementation in industry, and how can we overcome these?

There certainly is an interest in industry to apply simulators for training albeit only because of the potential cost effectiveness, but the main barrier for implementation is the limited knowledge we have on when exactly VR training leads to improved performance in reality. We simply do not know what the efficiency will be of training in a VR training simulator. In addition, for simulators involving movement in the environment, nausea is a problem. We know that a substantial part of all people is susceptible to nausea in simulators. Please note, these are not just academic issues. We are talking about big money here. The big question, obviously, is how we can make industry understand the importance of extending our knowledge of human learning, and how we can persuade them to invest in the development of such knowledge. As said, the main barrier for implementation of VR training systems in industry is the current lack of knowledge on human skill acquisition. Poorly designed systems will yield limited results of VE based training, and will cause industry to turn away from this promising technology.

4 What is your vision for the future of virtual reality for training?

Like many researchers I feel that there is great future for VR for training. Yet, further research is required before these training devices will be able to live up to expectations. This will allow us to determine which tasks can be trained properly in a VR simulator, and which ones will not. The assumption that a more expensive and complex VR system is better for training is simply wrong. We have to learn to predict in advance when VR training will be beneficial and when it will not. What the characteristics are of useful scenarios, and how people interact in VR. We have to develop better hardware systems to make haptic and kinaesthetic stimulation more realistic, and more intelligent software that allow the implementation of more realistic scenarios. We also need to do something about nausea in persons moving in VEs as this may reduce the cost effectiveness substantially. I do not know how long it will take to solve these issues. I do know that if we take certain limitations into account, a widespread development of VE systems for training is inevitable. The question is not whether the application of VR for training will be a success, but when.