Designing Simulation Training to Foster Transfer: The Role of Deep Imprinting, Digital Skill Adaptability, Constructivism, and Fidelity

September 9, 2010

Research & Evaluation Team

research_eval@adlnet.gov

When designing training to prepare today's warfighter for the realities of what he or she will be required to do on the job, the issue of transfer is of utmost importance. No matter how much learning occurs, if training does not result in an ability to perform in real life, then the training has not accomplished its goal: to equip warfighters with the tools they need to carry out their mission.

This white paper will highlight ways in which transfer is fostered or improved in general, and how simulations are particularly suited to catalyze transfer from training. It will also give recommendations on how to design simulation training to maximize the potential for transfer.

Fostering Transfer: Deep Imprinting

Early advocates of formal schooling were well aware of the concept of transfer, and used it as the basis of their curriculum design. The pervading view amongst those advocating a "classical education" was that the content of a pupil's first introduction to learning did not matter as much as the degree to which they exercised and developed their mind in learning it (Barnett & Ceci, 2002). Young students memorized long sets of numbers under the theory that it improved memory in general; they learned the dead languages of Latin and Greek to bolster their language and grammar skills in general. In essence, as Alfred Binet and Theodore Simon wrote, it was believed that they "must learn how to learn" (1916, p. 257) before being taught more specific knowledge. This was all under the assumption that their foundational comprehension and skills would transfer to all other areas of learning.

While this view is not held as dogmatically today, its underlying tenets remain true. Transfer is improved when there is a causal understanding of the events of training. When the trainee understands the underlying relationships and dynamics that *cause* the facts they learn to be true, they form a cognitive schema of the nature of this knowledge and how it exists and interacts within the framework of the world. This can be referred to as a "deep imprinting" (as opposed to a surface imprinting) of the material. It allows trainees to adapt the skills they've learned and apply them successfully in different or changing environments.

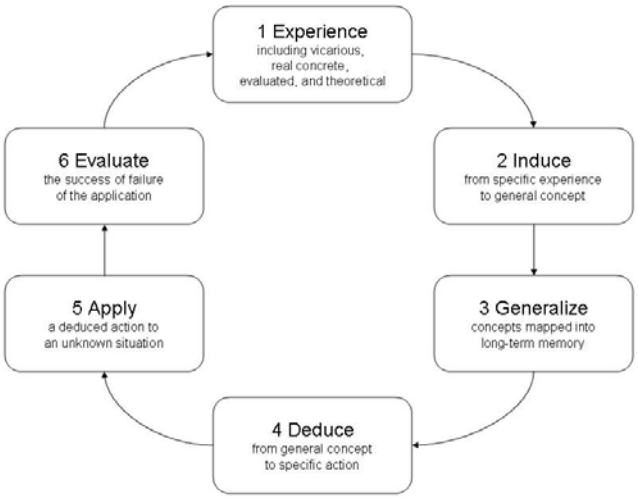
Why Simulations Foster Deep Imprinting and Transfer

Research has shown that simulation training results in transfer to real-life job situations. A recent review of the literature by Hahn (2010) found that in 22 out of 26 studies comparing simulation training to another form of training, simulations resulted in equal or superior transfer to the control group. The remaining four studies yielded mixed results, but in no study did a simulation result in transfer outcomes that were wholly negative (Hahn, 2010).

One explanation for this is in keeping with Reed and Saavedra's (1986) study that showed the discovery method of learning to improve transfer more than completing a passive task or learning abstract concepts. Presumably, this is because the discovery method encourages causal understanding and deep imprinting.

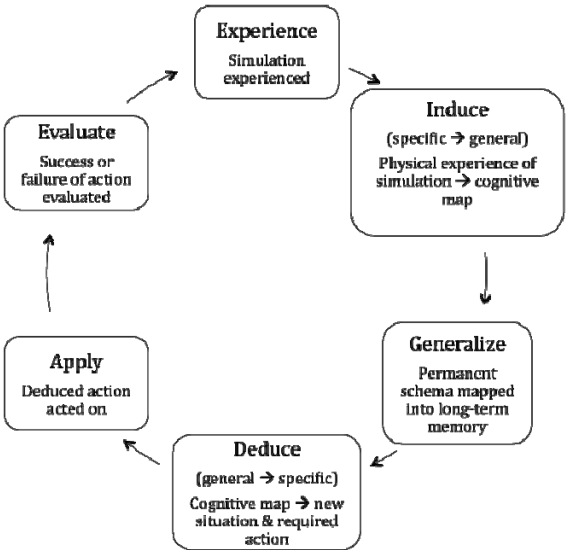
Priest and Gass' (1997) Experiential Learning and Judgment Paradigm is a six-part cycle that explains how experiential learning results in such deep and flexible comprehension of knowledge (see Figure 1).

Figure 1. Priest and Gass' (1997) Experiential Learning and Judgment Paradigm.



The six parts of Priest and Gass' model—Experience, Induce, Generalize, Deduce, Apply, and Evaluate—can easily be applied to simulations, as in Hahn's (2010) cycle of experiential learning and transfer from simulations (see Figure 2).

Figure 2. Hahn's (2010) cycle of experiential learning and transfer from simulations.



The trainee *experiences* the simulation when using it. The trainee then *induces* a cognitive template of what the actual experience he/she is training for is like from his/her physical and psychological experiences with the simulator. He/she next *generalizes* the cognitive template into a schema that is imprinted into the long-term memory (a process which I refer to here as "deep imprinting"). Post-training, he/she *deduces* from that schema what specific action is needed for the situation (and thus adapts the training to the current environment), *applies* that action, and *evaluates* the outcome (Hahn, 2010). Since simulations incorporate large amounts of discovery learning, it is not a far stretch to conceive of how they would foster the same kind of transfer shown in Reed and Saavedra's study.

The formation of a cognitive template and schema referenced in these models supports the conclusion that Dennis and Harris (1998) propose: that the ability to transfer a task from a simulation to real life is not the result of any specific psychomotor skills honed from the simulation, but the cognitive template of the *experience* of performing the job that is formed. Dennis and Harris claim that directly practicing, experiencing, and applying in the simulation the steps that the mind goes through when performing a task creates a deep understanding or imprinting of the material, and thus results in transfer.

Recommendation #1: Design simulation training to teach digital skill adaptability

Early advocates of formal schooling were well aware that it is crucial to instill in students a foundational understanding of the underlying mechanics and dynamics that drive the specific skills they are taught. Trainees must develop a deeply-imprinted cognitive schema of these mechanics and dynamics in order to apply and adapt these skills.

In recent years, this idea has come to be applied to training the use of (and often by means of) advanced technology—a skill set becoming more and more important to the warfighter. As applied to the teaching of and by technology, this concept is referred to as teaching *digital skill adaptability* (Hess, Alliger, Littleton, MacMillan, & Titus, 2001; Hess et al., 2003). Hess et al. (2003) assert that while teaching digital skill adaptability is important, it cannot be done in a vacuum. It must be taught through the teaching of specific tasks and the

operation of specific devices—but in a way that allows trainees to transfer and adapt those skills to an environment where technology is constantly evolving.

Aptima, Inc. and the Group for Organizational Effectiveness have created a program of instruction to do this which shows promising results. Their computer-based (non-simulation) training program is engineered to increase basic computer knowledge through device-specific training on using the Advanced Field Artillery Tactical Data System (AFATDS). Their program has resulted in higher scores on measures of transfer and an 88% satisfaction rate among trainees, who claimed it improved their understanding of AFATDS (Hess et al., 2001; Hess et al., 2003).

Though this program was conducted on non-simulation training, Schaab and Dressel (2001) have shown that using constructivist methods of training to teach digital skills resulted in equivalent learning outcomes and superior transfer of digital skills compared to traditional training. Designed with digital skill adaptability in mind, simulations would have the potential to not only transfer specific tasks to the job environment, but also to equip the warfighter with a deeply-imprinted cognitive template of the dynamics of digital technology. The trainee would thus be able to adapt and apply this understanding to an ever-changing environment. That is why it is recommended that simulation training be designed to teach digital skill adaptability through the teaching of specific skills.

Recommendation #2: Design simulation training to include lower-fidelity training tools

The literature review by Hahn (2010) has shown that, somewhat surprisingly, transfer benefits can be had from low-fidelity simulators to an equal or greater degree than high-fidelity simulators—and at a lower cost. Dennis and Harris' (1998) study, discussed above, helps to explain this result: since it is not the physical or psychomotor experience of the simulator that causes transfer, but the cognitive template formed by the mind actually experiencing the steps it will go through when performing a task, it makes sense that lower-fidelity simulators—if designed well—can be just as effective, if not more so, than high-fidelity simulators.

Halpern, Hansen, and Riefer's (1990) Feature Overlap Theory also offers an explanation to this phenomenon. According to Halpern and colleagues, if training is too similar on a surface level to the actual event, when encountering a situation that requires them to use their skills in real life, they reach for superficial surface connections and fail to utilize their deep, causal understanding of the material. Accordingly, if the simulation teaches the trainee a deep, causal understanding of the material but is far enough removed, on a surface level, from an actual replication of reality, it forces trainees to exercise their ability to make deep connections and adapt their knowledge to new situations—and thus will result in a higher likelihood of transfer.

This does not mean that training can't take advantage of the full extent of available simulation technology, or that training needs to be purposefully ambiguous. Rather, it is recommended that simulation training be designed to include opportunities for students to practice skills in a way that obliges them to use their causal understanding of the material to make deep analogies and connections to adapt to unfamiliar situations.

Examples of this may include learning in a low-fidelity simulator then practicing in a higher-fidelity simulator or a real life situation, or presenting trainees with significantly varied training scenarios with no apparent surface connections that require the use of the same underlying schema of knowledge.

Conclusion

Simulations are an important technology for instructional designers to leverage in order to promote transfer from training. Their experiential nature helps to promote a causal understanding of the training material and the development of a deeply imprinted cognitive schema of knowledge that can be adapted and applied to changing situations, such as the constantly evolving realm of digital technology.

The Advanced Distributed Learning (ADL) Research and Evaluation Team recommends that when designing simulation training for the warfighter, instructional designers incorporate digital skill adaptability training and consider taking advantage of both lower-and higher-fidelity tools as part of a training program.

References

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy for far transfer. *Psychological Bulletin, 128*(4), 612-637.

Binet, A., & Simon, T. (1916). *The development of intelligence in children*. Baltimore, MD: William & Wilkins Company.

Dennis, K. A., & Harris, D. (1998). Computer-based simulation as an adjunct to ab initio flight training. *The International Journal of Aviation Psychology, 8*(3), 261-276.

Hahn, S. H. (2010). *Transfer of training from simulations in civilian and military workforces: Perspectives from the current body of literature*. Unpublished manuscript.

Halpern, D. F., Hansen, C., & Riefer, D. (1990). Analogies as an aid to understanding and memory. *Journal of Educational Psychology, 82,* 298-305.

Hess, K. P., Alliger, G., Littleton, E. B., MacMillan, J., & Titus, P. (2001). *Training adaptability in digital skills* (Tech. Rep. No. AP-R-1128). Alexandria, VA: U.S. Army Research Institute, TAPC-ARI-II.

Hess, K. P., Alliger, G., Linegang, M., Meischer, S., Garrity, M. J., Hertel, M., & Bailey, A. (2003). *Training adaptability in digital skills: The Learning Skills Bridge (LBS) learning accelerator* (Tech. Rep. No. 1811). Alexandria, VA: U.S. Army Research Institute for Behavioral and Social Sciences.

Priest, S., & Gass, M. (1997). *Effective leadership in adventure programming*. Champaign, IL: Human Kinetics.

Reed, S. K., & Saavedra, N. C. (1986). A comparison of computation, discovery, and graph procedures for improving students' conception of average speed. *Cognition and Instruction, 3,* 31-62.

Schaab, B. B., & Dressel, J. D. (2001). *Training for adaptability and transfer on digital systems* (Tech. Rep. No. 1782). Alexandria, VA: U.S. Army Research Institute for Behavioral and Social Sciences.