

## How Simulation-Like Questions Can Replace Expensive Multimedia Simulations

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Simulations are widely touted in practitioner circles as the pinnacle of instructional design, and though a few recent research reviews have been generally supportive of the effectiveness of simulations as learning tools (Klein & Fleck, 1990; Jentsch & Bowers, 1998; Bell & Waag, 1998; VanSickle, 1986) additional research is needed. One important omission is the lack of causal analyses. What is it that causes simulations to be effective? Simulations are not likely to be effective only because they “simulate,” but also because of other attributes that are inherent in their design.

This paper draws its conclusions from an extensive research review of the general learning literature. It is argued that simulations produce learning effects because they utilize five basic learning factors. It is not the purpose of this paper to test this proposal but to explore its practical ramifications and spur future research by generating this hypothesis. Specifically, it is argued that if simulations are effective because they utilize these five learning factors, other learning interventions that utilize these same factors to the same extent will be equally effective.

### Results of Exploratory Literature Review

Simulations and simulation-like questions produce benefits because they utilize the following five learning factors:

1. *Aligning Contexts*

*By providing realistic decisions set in realistic situations simulations align the learning-and-performance contexts. This makes it more likely that learners will remember what they've learned when they enter their on-the-job performance situations. Learning improvements range from 10 to 55%.*

Psychologists have found that learners will retrieve more information from memory if they try to retrieve that information when they are in the same context in which they learned the information—as opposed to being in a different context. This has been found for many contextual stimuli, for example learners remember more if they have to perform in the same room they learned in (e.g., Smith, Glenborg, and Bjork, 1978). Similarly, when scuba divers learn underwater, they recall more underwater than nearby on land, and vice versa (e.g., Godden and Baddeley, 1975). When people learn during a time when they are sad, they'll remember more when they're sad, and vice versa (e.g., Bower, Monteiro, and Gilligan, 1978; Eich, 1995; Smith, 1995). When people learn under the influence of alcohol or marijuana, they recall more when tested under the influence, and vice versa (e.g., see studies reviewed by Eich, 1980). When people learn while smelling peppermint, they retrieve more information when smelling peppermint than when smelling osmanthus, and vice versa (Herz, 1997). When college students learn with loud noise as a background they do better on tests when those tests are accompanied by loud noise; silent studying improves performance during silent test taking, as well (Grant, Bredahl, Clay, Ferrie, Groves, McDorman, & Dark, 1998). If people have learned while listening to Mozart, they retrieve more of the learned information while listening to Mozart than they do listening to jazz (Smith, 1985). These varied results show that context—whether it is environmental, emotional, or physiological—can provide cues that aid future retrieval of learned information. In other words, returning to the same context facilitates retrieval of information learned

in that context (for reviews see Bjork & Richardson-Klavehn, 1989; Smith, 1988; Smith & Vela, in preparation; Eich, 1980; Roediger & Guynn, 1996; Davies, 1986).

## 2. Retrieval Practice

*By prompting learners to make decisions and hence to retrieve information from memory, simulations provide retrieval practice and testing. This type of practice helps learners strengthen their ability to retrieve information in the future. This effect produces learning improvements ranging from 30 to 100%.*

Researchers have found that such retrieval practice, even when learners get no feedback, prevents forgetting, but does not increase learning (Izawa, 1992; Rose, 1992; Allen, Mahler, & Estes, 1969; Runquist, 1983, 1986). As stated before, decreasing forgetting can be just as important as increasing learning. This is especially critical because forgetting occurs just as rapidly for information well learned as information learned less well (Rose, 1992; Runquist, 1983, 1986), so that even information well learned may not be accessible when it is required for performance, unless forgetting can be stemmed.

## 3. Feedback

*By providing realistic or didactic feedback, simulations enable learners to correct their misconceptions. Feedback typically improves learning by 15 to 50%. When simulation feedback is delayed, as is natural in some topic areas, additional improvements of 10 to 25% can be achieved.*

Studies that compare feedback to not giving feedback generally find fairly sizable improvements with feedback (Karraker, 1967; Kulhavy & Anderson, 1972; Kulhavy, Yekovich, & Dyer, 1976; Surber & Anderson, 1975; Sturges, 1978; Clariana, Ross, & Morrison, 1991; Webb, Stock, & McCarthy, 1992). Similarly, studies that compare giving corrective feedback (giving learners the right answer) to giving only feedback about whether an answer was right or wrong, show advantages for corrective feedback (Phye, 1991; Phye & Sanders, 1994). How does feedback work? It was once believed that feedback reinforced correct responses, but research has shown that feedback works by correcting errors. Guthrie (1971) found that feedback had almost no effect on correct answers (improving results by 8 percent over a no-feedback condition, a statistically non-significant difference), but produced major improvements when provided for incorrect answers (improving results by a whopping 474 percent!!). Surber and Anderson (1975) obtained similar results, finding that different feedback conditions (no feedback vs. immediate feedback vs. delayed feedback) had no effect on answers that were correct on the initial test, but had a significant effect on answers that were incorrect (.388 for no feedback, .536 for immediate, and .654 for delayed feedback).

Although feedback helps correct errors, it can also prepare learners for future retrieval situations by enabling them to practice correct retrievals. Phye and Andre (1989) found that when learners re-responded to test questions after getting corrective feedback, they improved their later retrievals by 26% (when they received delayed-feedback) and 97% (when they received immediate feedback) over conditions where they got feedback but didn't re-respond to the test questions. These results show the power of retrieval practice. Similar results have been found by Sturges (1972) who found that testing after feedback improved long-term retention on a recall test by about 95% and on a recognition test by about 20%. That recall tests are more susceptible to retrieval practice is expected because recall tests require unassisted retrieval whereas recognition tests provide alternatives that enable learners to assess the cognitive connection between the question and each alternative.

## 4.

### Repetition

*Simulations and simulation-like questions that provide multiple scenarios covering the same learning points can improve learning as well. Repetition typically improves learning outcomes by 30 to 110% or more.*

Although today's researchers assume repetitions produce learning, in the late 1800's there was at least one researcher who thought it was important to authenticate the effects of repetition. In 1885 Hermann Ebbinghaus (English translation in 1913) published his classic book on memory, which showed, among other things, that repetition strengthened learning and decreased the amount of time needed to relearn what had been forgotten. Since then, researchers have continued to find that repetition helps learning (for reviews of the verbal learning research see Crowder, 1976; Hall, 1971; Hintzman, 1976; for reviews on the role of practice in the development of expertise see Ericsson, Krampe, & Tesch-Römer, 1993; Ericsson & Charness, 1994).

To illustrate with a list of examples, repetition improved the performance of Morse-code telegraphers (Bryan & Harter, 1897), typists (Fendrich, Healy & Bourne, 1991), computer game players (Shebilske, Goettl, Corrington, & Day, 1999), and people using arm movements to track targets (Wulf & Schmidt, 1997). Reading something twice improved learning (Rothkopf, 1968; Barnett & Seefeldt, 1989; Bromage & Mayer, 1986; Krug, Davis, & Glover, 1990). Restudying a list of words improved retention (Waugh, 1962; Roediger & Challis, 1992; Madigan, 1969). Repeating musical melodies helped listeners remember those melodies (Gardiner, Kaminska, Dixon, & Java, 1996). Repetition of television commercials increased viewers' familiarity with the commercial, the product, and the viewers' recall of the advertising content (Rethans, Swasy, & Marks, 1986; Singh, Mishra, Bendapudi, & Linville, 1994). When learners take notes and review those notes after a lecture or other learning event, the repetition inherent in such a review improves retention (Kiewra, 1989).

### 5. Spacing

*Simulations and simulation-like questions that provide repetitions usually provide spaced repetitions. Spacing typically improves learning by 5 to 40%.*

Over 300 studies were done on the spacing effect in the 20<sup>th</sup> Century (Bruce and Bahrick, 1992), and at regular intervals some experimental psychologist reviews the research on the spacing effect and announces that it is one of the most robust findings in all of psychology (e.g., Ruch, 1928; Cain & Willey, 1939; Melton, 1970; Crowder, 1976; Hintzman, 1974; Glenberg, 1979; Dempster, 1988, 1989; 1996; Rea & Modigliani, 1988).

Some of the five learning factors are straightforward and easy to grasp. Others challenge long-held paradigms about how learning works to create performance. In my conference presentation, I'll describe these factors in depth. These principles are also outlined in the Work-Learning Research white paper, *Simulation-Like Questions: How and Why to Use Them*, available at [www.work-learning.com](http://www.work-learning.com).

### **Practical Implications**

The five learning factors are crucial for designers of simulations. Simulations that follow the five learning principles are more likely to produce beneficial learning results than those that don't.

Similarly, if another learning intervention utilizes the five learning factors available to simulations, it should be able to produce the same beneficial results. Simulation-like questions, for at least some content areas, can utilize the same factors to the same extent as more expensive multimedia simulations.

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## Simulation-Like Questions

A simulation-like question is one that:

1. Presents a brief realistic scenario.
2. Highlights one or more key learning points (inclusive of its alternative answer choices, correct answer, and feedback).
3. Shows how the world works, or should work, by outlining a real-world cause-and-effect relationship.
4. Asks the learner to respond in a manner that shows he or she understands the key learning point.

Simulation-like questions are especially valuable when the content area is easily verbalizable and the demands of the real-world performance situation are not too time-constrained. For example, simulation-like questions are valuable for teaching management skills, instructional design, and other competencies where the rules of performance can be communicated clearly and concisely and where performers have time to think through their real-world actions. On the other hand, simulation-like questions are not likely to have value for fight simulation, sports performance, and other situations that are not verbalizable. They may also have difficulty providing value for call-center representatives, psychotherapists, and others who have to create immediate responses to ill-formed stimuli.

For content areas in which simulation-like questions are appropriate, they can easily be used to fulfill all five of the learning factors that make simulations effective.

**Aligning Context.** By creating a realistic scenario—and specifically by using some of the same words or images in the scenario that will be encountered in the learner’s performance situation—a simulation-like question can create some of the same advantages in helping learners spontaneously remember what they learned. Full-blown multimedia simulations may have some advantages for this variable, though they are also more likely to use images that can distract learners from the main points of the learning.

**Retrieval Practice.** All questions prompt retrieval practice. Simulation-like questions, if well written, can prompt appropriate practice retrieving meaningful information from memory, and they can do this to the same extent as multimedia simulations.

**Feedback.** Feedback can be easily delivered after each simulation-like question, just like it is done after each simulation scenario. Simulations may have a slight advantage in providing realistic “within fiction” feedback, though feedback for simulation-like questions can be tailored to create similar effects.

**Repetition.** Simulation-like questions can either be repeated verbatim or can be revised to cover the same learning point with different background settings. Because of a much cheaper cost of development, simulation-like questions can be more easily repeated than scenarios within an expensive multimedia simulation. Of course, simulation-like questions can augment full-blown simulations by repeating core concepts more cheaply than additional multimedia scenarios.

**Spacing.** Spacing repetitions apart in time is easily done with simulation-like questions. The ease of spacing simulation-like questions is partly due to the reduced cost of development of each spaced question. And because spacing often involves distance-learning methodologies that as of yet are still subject to bandwidth concerns, they also have some advantages over more resource-heavy multimedia.

Although some may argue that simulation-like questions have a disadvantage in comparison with full-blown multimedia simulations in terms of having a lack of an immersive experience, recent research suggest that such an environment provides no learning benefits (Moreno & Mayer, 2002).

### References

Because this paper presents a literature review, there is not enough space to include the references here. They are available at [www.work-learning.com/reference\\_list.htm](http://www.work-learning.com/reference_list.htm).

### Biographical Sketch

**Will Thalheimer, Ph.D.**, of Work-Learning Research is a researcher and instructional-design consultant. He founded Work-Learning Research in 1998 to create a closer relationship between researchers and practitioners and to bring research-based knowledge to the learning-and-performance field. He compiles research on learning and disseminates practical recommendations through his consulting services, publications, workshops, and the Work-Learning Research website to help instructional designers, e-learning developers, trainers, and performance consultants build effective learning-and-performance solutions.

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