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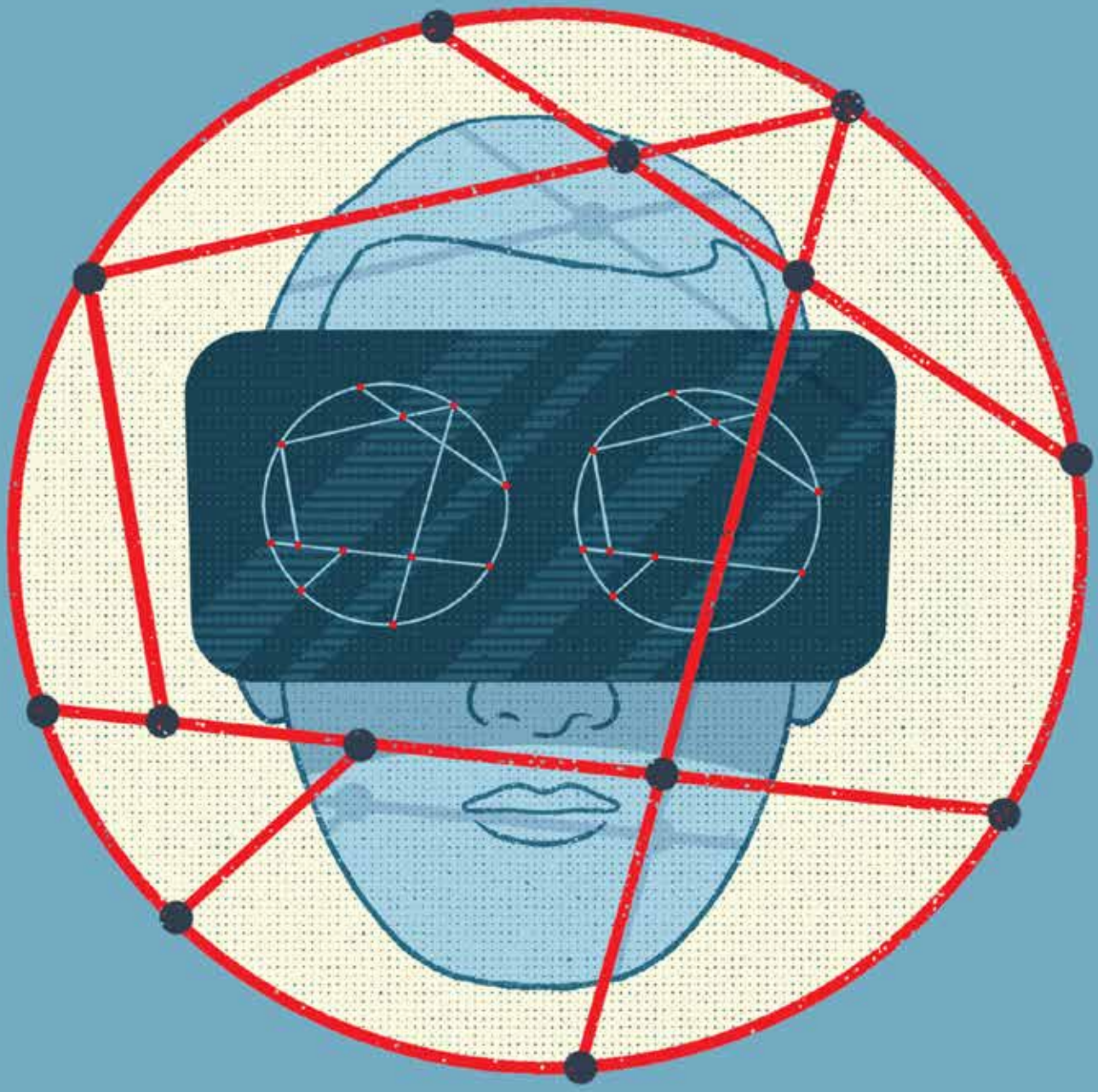
Part of a Deloitte series on digital reality



Real learning in a virtual world

How VR can improve learning and training outcomes

Digital reality, which consists of augmented reality (AR), virtual reality (VR), mixed reality (MR), 360º video, and immersive technologies, is rapidly gaining traction in the marketplace. The proliferation of these tools, applications, and solutions will permeate throughout everyday life and work in just a few years and will be as impactful as the PC, web, and mobile. This has led to digital reality's reputation as the next technology transformation in the way people interact and use data. Companies around the world are applying these technologies to create revenue-generating and cost-saving solutions as well as wholesale changes to the way they work. Please reach out to any of the contacts listed in this article for more information.

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Introduction

Total immersion

At the oil refinery, emergency sirens begin to wail. A shift supervisor races to the scene of the emergency and sees smoke already billowing from the roof of a distillation unit. He needs to get the fire under control, but when he opens the door to the control room, a wall of flame greets him. The situation is worse than anything in his training manual. How can he locate the shut-off button when he can't see through the flames? He hesitates—and in that moment, the pressure built up in the distillation tower releases in a massive explosion, ripping apart the building and scattering debris across the whole refinery.

A RED MESSAGE FLASHES before the supervisor's eyes: Simulation failed. A voice comes over the intercom and says, "All right—let's take two minutes, and then we'll reset from the beginning." He is covered in sweat as he takes off the headset. It had been a virtual reality (VR) simulation, but the stress was real; more importantly, the lessons on how to respond to a crisis had been real.

For decades, trainers have faced a difficult trade-off: How can you adequately prepare learners to make good decisions when facing dangerous or extraordinary situations? You can provide simple learning materials like books and classes, but these are likely inadequate preparation for stressful and highly complex situations. Or you can expose the learners to those situations in live training, but this can be extremely costly—not to mention hazardous. For many jobs and situations, training has long offered an unappealing choice between easy but ineffective, or effective but expensive and risky.

VR promises a third way: a method of training that can break this trade-off of learning and provide effective training in a safe, cost-effective environment.[1] Certainly, the technology is not optimal for every learning activity. But VR has been shown to offer measurable improvement in a wide array of immersive learning outcomes, in tasks that range from flying advanced jets to making a chicken sandwich to handling dangerous chemicals.[2]

This article is intended to help trainers identify whether VR is right for their particular learning needs and chart a path toward successful adoption of the technology. Ultimately, learning-focused VR can turn novices into experts more swiftly, effectively, and smoothly than ever before.

It's all about expertise

SUCCESS IN BUSINESS often rests on having the right expertise in the right places: having the IT expert on hand when the system goes down, or the best shift manager on duty when a huge order comes in. The more experts in an organization, the more likely an expert will be around when needed.

Of course, expertise can be purchased by hiring established experts. But their numbers are finite, and with needs constantly shifting, training often makes far more sense. Corporate learning, then, aims to create expertise as quickly and effectively as possible. We want people to learn better and more quickly. This begs a question: What exactly is expertise? Just what is it that we want people to be able to do after training?

Expertise is easiest to define in terms of what it is not. Expertise is not merely the number of years one has studied or how many academic degrees—or corporate training certificates—one has earned or even the results one has achieved. For example, simply tabulating wins and losses in tennis turns out to be a poor way of ranking the best players.[3] And notwithstanding some popular theories, thousands of hours of practice don't always generate expertise. For example, deliberate practice accounts for only 29.9 percent of the variance in expertise in music.[4]

Experts are not only better at executing particular tasks—they tend to think about things fundamentally differently than amateurs. In fact, they can execute better *precisely because* they think about things differently. Experts typically see more when looking at a situation than an amateur. Research comparing a world champion chess player with amateurs showed that the champion was better not only at playing chess but at knowing the game. The champion had a better understanding of a chessboard setup after viewing it for five seconds than a skilled amateur did after 15 minutes of studying the board.[5]

That result came about not because the chess champion was any smarter or had faster visual acuity than his amateur opponents—it was a product of expertise itself. Experts are able to recognize patterns behind the data we all see. Academic research has found a similar pattern-recognition story in nearly every industry from medicine to chess.[6] Experts in diverse domains are better able to reorganize and make sense of scrambled information.[7] Where knowledgeable amateurs rely on rules and guidelines to make decisions, experts are able to quickly read and react to situations by recognizing indicators that signal how a situation is behaving.[8] A key to creating experts, it seems, is not the memorization of facts or knowledge but, rather, instilling flexible mental models that help explain why systems act the way they do.

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How can we learn better?

IN HINDSIGHT, TRAINERS may have had it easy in offering certifications based on hours of study. Creating deeper expertise can be far more challenging. How can we train people to see deeper patterns in data? How do we know whether they are using flexible mental models?

For most people, experiences that expose trainees to tough or atypical cases force them to create more refined or specialized reasoning than that found in a book or procedure manual.[9] The most effective learning may come from unexpected scenarios, a challenge to present in a book or classroom.[10] But unpredictable, experience-based learning has obvious limitations: It is easy to learn from experience when failure simply means losing a chess match, but what about fighting a fire, unloading hazardous chemicals, or configuring a wind turbine—all tasks for which failure means huge costs or even death? The problem facing trainers is how to create the benefits of learning from experience without incurring the costs of facing rare or dangerous experiences. The answer is to re-create those experiences.

Take medical training, for example. A cardiologist may practice for years, continually training, before reaching the peak of her profession. One reason: Many of the most serious medical problems are extremely rare, meaning that a doctor must often work for years before encountering them and building expertise in how to recognize and treat them. With some procedures requiring doctors to practice on 100 patients before reaching a critical level of skill, this means that some doctors may retire before even having the opportunity to become an expert in treating certain rare conditions.[11]

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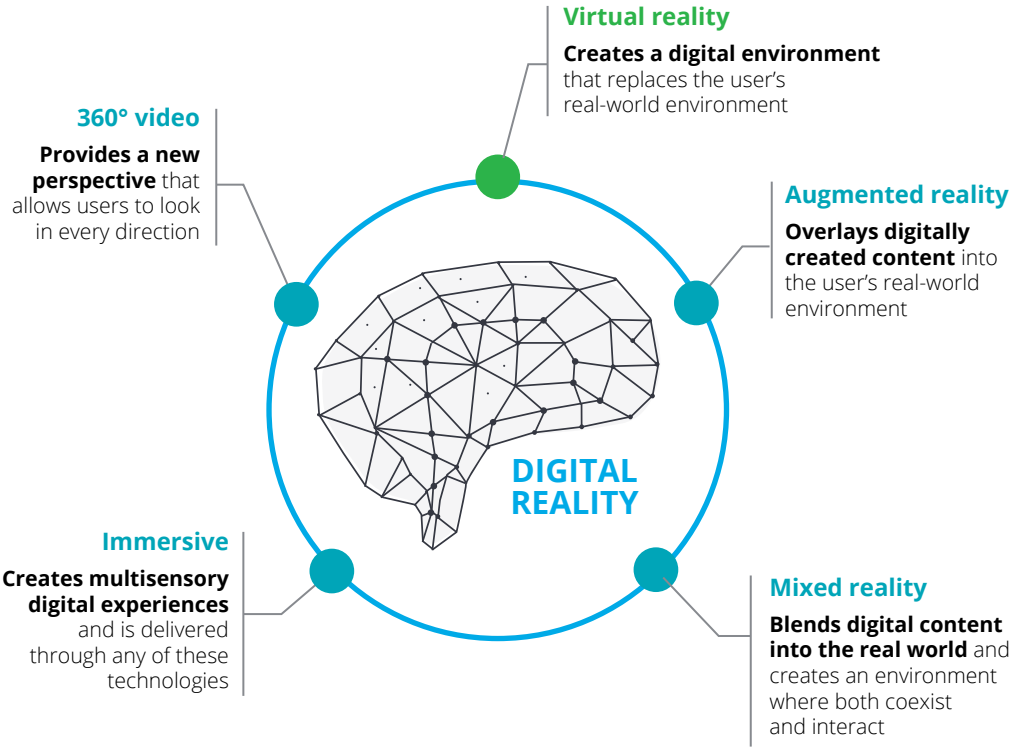
VR training offers a shortcut. Given its ability to present immersive, realistic situations over and over again, the technology can give doctors the opportunity to potentially build expertise on conditions before they see them for the first time in real patients (see figure 1). VR can also offer the ability to learn in new ways—not only simulating what a doctor might see but presenting it in 3D or in more detail. For example, a cardiologist could see a heart defect, not just from symptoms or test results but as a 3D model, allowing her to peek inside the heart and understand the problem more deeply and how to treat it more accurately.[12]

FIGURE 1

Virtual reality is one technological component of digital reality that can help solve real-world business problems and create competitive advantage



Source: Deloitte analysis.

Virtual reality

Better training faster, safer, and at less cost

VR TECHNOLOGY CAN enable more effective learning at a lower cost and in less time than many traditional learning methods. This is because VR can allow for more training repetitions, especially when dealing with costly, rare, or dangerous environments. For example, the skills of aviation maintenance personnel can degrade when budget constraints limit flying hours; if jets are not in the air, there is nothing to be fixed. But without that practice, critical maintenance skills can slip, leading to increased accidents.[13] VR can allow maintenance staffers to keep up their skills by learning from experience, at a fraction of the cost of putting an actual jet in the sky.

VR is not just about saving money—it can provide better outcomes than many traditional learning methods. Most research examining the technology's effectiveness have found that it reduces the time taken to learn, decreases the number of trainee errors, increases the amount learned, and helps learners retain knowledge longer than traditional methods.[14] These effects apply to the general population as well as specialists training for unique tasks. One experiment compared how prepared airline passengers were for an emergency from reading the ubiquitous seatback safety card versus completing a brief immersive game. Passengers who used the game seemed to learn more and retain their knowledge longer than those who merely read the safety card. These better outcomes are almost certainly linked to the fact that the game was more successful than the card at engaging passengers and arousing fear, both incentivizing participants to learn and providing the neurological surprise to support that learning.[15]

Beyond simply improving how well learners retain information, VR-based training can help learners when they get it wrong. The ability to track all of a trainee's actions and inputs as he or she moves through a scenario can reduce the cost of providing individual feedback and giving tailored feedback. Experts need not sift through all the data and tell a trainee where he or she went wrong—the system itself may be able to determine likely causes of error and best strategies for avoiding those errors in the future.[16]

All of these capabilities mean that VR can be a valuable learning tool for a variety of tasks in any industry—and some real-world applications are already catching up to predictions that academic research has suggested:

- **Better learning.** Some major retailers have begun training workers using VR simulations. Staff are able to repeatedly take on new tasks

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such as managing the produce department or annual challenges such as dealing with Black Friday.[17] Working through these challenges is designed to help people directly see the impact of their actions on customer experience. And simulations can even allow staff to virtually travel to other stores to see how operations are managed there, spreading good ideas and offering paths to improvement.[18] As a result, some companies have found that not only do people seem to retain more compared to traditional methods—they appear to *learn* more as well.[19]

- **Faster learning.** In 2017, KFC debuted a VR training simulation to help trainees learn the chain's "secret recipe" for preparing chicken. Using the simulation, trainees were able to master the five steps of making fried chicken in 10 minutes, compared with 25 minutes for conventional instruction.[20]

Linde's experience with VR-based training illustrates the technology's potential benefits. One of the world's largest suppliers of industrial gases, Linde delivers hazardous chemicals to thousands of locations daily, meaning that truck drivers must handle materials that may be explosive or, at -320° F, cold enough to instantly freeze hands solid. When one slip-up can mean injury or death, how can new drivers build their skills and expertise? For Linde, VR-based training provides an answer. In the virtual environment, new drivers can get dozens of repetitions, building safe habits before stepping out on their first delivery.[21] VR can even give drivers an X-ray view of what is happening inside the tanks as they work. Not only are drivers practicing the right skills—they are learning the underlying concepts of why they *are* the right skills. That is what can create expertise—allowing drivers to react to unexpected situations quickly and with confidence.

Linde is experimenting with more ambitious VR training environments as well. The company used CAD files for a plant currently under construction to create an immersive VR environment, aiming to train the operators who will eventually manage that plant.[22] As with the earlier oil-refinery example, operators can practice emergency procedures or dangerous tasks, but they can also explore the environment, understand how all systems fit together, and even peek inside operating machinery to have a better view of the plant for which they will soon be responsible.[23]

When can VR enhance training?

AS WITH ANY technology, VR is a tool, not a magic bullet. Incorporating VR into a training program hardly guarantees quality improvements; indeed, the coming years will doubtless bring anecdotes of VR disappointments along with successes. Trainers should bring the same careful planning in program design and learning goals to VR as to any other training effort—including focusing programs around understanding the knowledge that an organization needs learners to acquire and what they should then do with that knowledge.

The knowledge that learners must acquire can cover a wide range, but several factors are particularly relevant to VR technology: how rare the knowledge is, how observable, and how easily it can be replicated physically. A cardiologist may struggle to learn about uncommon heart defects exactly because they are rare, limiting learning opportunities. Many find organic chemistry challenging to learn partly because one can't directly observe molecular bonds with human senses; landing on an aircraft carrier is tricky to perfect because repetitions are both costly and dangerous.

Trainers should bring the same careful planning in program design and learning goals to VR as to any other training effort.

Another attribute to consider: what trainers expect learners to do with the knowledge once they have it. Do people simply need to recognize and apply it, as with reading the defense in football, or do they need to perform complicated actions such as synthesizing it with other knowledge and adjusting to context? All of these factors play into how best to present knowledge to learners.

By understanding the different factors that go into learning, a trainer can make informed decisions about when VR is appropriate and design the best training possible to maximize performance (see figure 2). For example, if learners need only acquire relatively simple information—that is, information that is common, obvious, or easy to represent—VR may be superfluous and no more effective than books, classroom instruction, or job aids.

Similarly, if learners need to do more complex tasks involving simple information, VR may help, but there may be easier, cheaper ways to accomplish the learning. Take the simple knowledge of a workflow: Workers need to understand the workflow and apply it in different contexts. VR might certainly help in learning such workflows, but it may not always be necessary. If the various contexts of the work are not rare, dangerous, or costly to recreate, using case studies or job aids may be cost-effective alternatives.

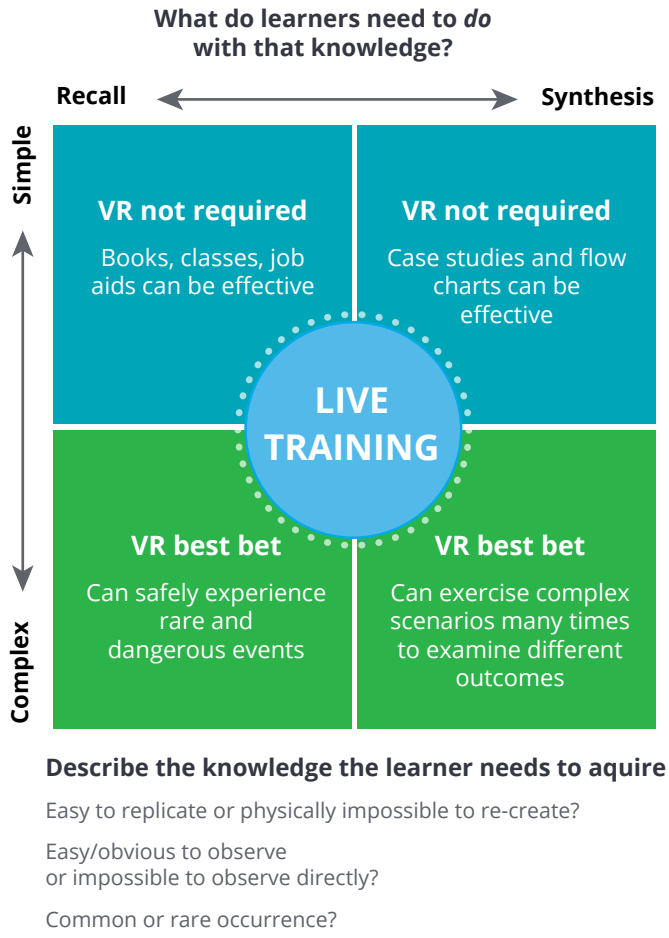
Where VR moves into a class of its own is when the knowledge that learners must acquire is complex: where trainees must try to grapple with difficult-to-observe phenomena that occur rarely or in dangerous situations. In these cases, VR-based training may well be an effective choice, offering the advantages of faster and better learning at lower cost.

Indeed, VR's ability to allow for collaboration and for repeated simulation opens up entirely new learning possibilities:

- **Shared scenarios.** Consider a military squad that needs its members not only to individually do the right thing but to coordinate and work to-

FIGURE 2

The decision framework can help determine when and how to use VR in learning



Source: Deloitte analysis.

gether. Shared scenarios can allow members to practice individual actions and communication within the squad in a variety of combat situations they could not normally face.

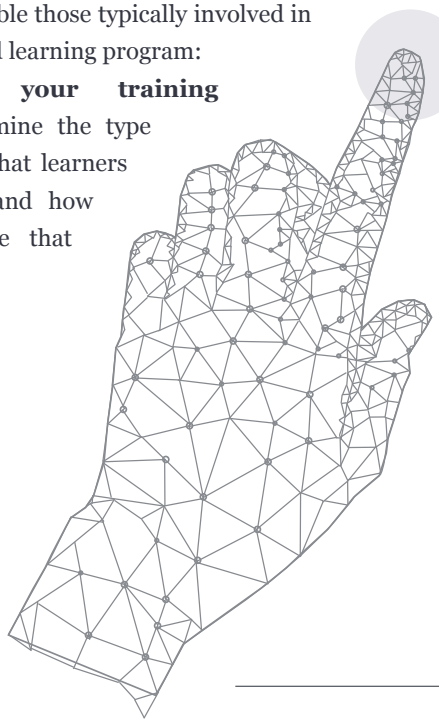
- **Seeing the unseen.** VR may be even more helpful for research scientists. Not only do they often need to collaborate within teams—they regularly struggle with concepts not easily visualized. But imagine if a team of scientists could share ideas while all looking at a 3D model of the molecules they are studying. They could come up with new ideas inspired by finally seeing the previously unseen—and they could then easily share those ideas with their colleagues.
- **Test and re-test.** VR technology allows trainees to test ideas as well as share them. Many Formula 1 auto racing teams use VR extensively in preparation for races, going far beyond drivers simply learning the track—after all, they already know it by heart. Instead, the teams use simulations to test different setups for their car and different race strategies.[24] The aim is to prepare team members for any eventuality during the race, helping them react swiftly. This type of virtual testing represents a deeper form of learning, one in which the drivers and the teams are using VR to see into the future and discover the deeper patterns in what is likely to happen. In short, they are building expertise.

Getting started is less daunting than it may seem

MANY TRAINERS NO doubt find exciting the description of VR as a new technology that can bring revolutionary benefits, though CFOs and CTOs—worried about complex technical integration, high up-front costs, and years of headlines about VR hype—may express less initial enthusiasm. The good news: Implementing VR technology may be far less daunting than it might seem. With standardized development kits, training design and technical integration have never been easier, as the costs of hardware, computing power, and storage continue to fall. As a result, many will find the cost of VR-based training applications increasingly reasonable. Especially when companies consider the increases in performance and the cost savings from time lost to longer, traditional training methods, VR can show a rapid return on investment.

With technology improving and prices dropping, the major steps to consider for creating successful VR learning resemble those typically involved in designing any good learning program:

- **Understand your training needs.** Determine the type of knowledge that learners must absorb and how they must use that knowledge during the job to help understand whether VR is right for your need and how it should be used.
- **Create your business case.** Quantify the expected benefit from the training in terms of increased performance, decreased errors, and productivity gains from fewer days lost to training. Array those benefits against expected costs to understand the ROI for the project.
- **Pilot the training.** Start small. Begin with a pilot program to evaluate the effectiveness of the VR training and its adoption within the organization.
- **Quantify the benefit and scale the program.** Use the results of the pilot program to validate initial estimates of ROI, modify the program based on what worked and what did not, and scale in scope or size of deployment.



Following these steps, companies adopting VR should get more than a shiny new technology—they can get better learning at lower cost than other options. Ultimately, the applications of VR and its ROI are limited not by dollars or technology but purely by imagination.

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