IN THIS CHAPTER

- Understanding what virtual and augmented reality are
- Explaining some other related terms
- Reviewing the history of virtual and augmented reality
- Understanding the technology hype cycle and the fourth wave

Chapter 1

Defining Virtual and Augmented Reality

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When you picture "technology of the future," what are the first things that come to mind? In ten years, how will technology be affecting your life differently than it does today?

Some people may picture self-driving electric cars that at a word automatically whisk them off to their desired destinations. Others no doubt envision an artificial intelligence (AI) utopia in which robots perform the menial labor tasks humans have had to do in the past, freeing people up to tackle life's tougher problems.

Finally, many people may foresee a future where they're able to create their own realities. They could be sitting on a couch at home but put on a headset and feel as if they're at a soccer stadium thousands of miles away. They could put on a pair of high-tech glasses and have a fully realized holographic avatar of a friend appear to chat with them. They may even picture an entire room they could step into and dial up an environmental simulation as if they were actually there.

The average person may not have had a chance to experience this just yet, but nearly everyone can envision virtual reality (VR) and augmented reality (AR) as part of humanity's future. And with good reason. For years, entertainment such as movies, TV shows, and books have been selling us on the promise of VR — the VR OASIS of *Ready Player One*, the VR real-world simulations of *The Matrix*, the

full-blown environmental re-creation of the holodeck from *Star Trek*. . . . All types of entertainment have their take on what has, up until very recently, been the stuff of magic and imagination.

The ideas of VR and AR themselves seem outlandish. Within the comforts of my own home, I can put on a headset and be anywhere? Experience anything? Be anyone? Attend live concerts or sporting events as if I were there? Fly across the sea and explore other countries? Travel through entire solar systems in minutes, jumping from planet to planet? These are the kinds of VR and AR that the public has long been promised. But until recently, that promise has fallen short of, well, *reality.*

Within the past few years, however, computing and manufacturing technologies have begun to catch up with the promises of VR and AR. What was once the purview of science-fiction has been brought to life. Science-fiction writer Arthur C. Clarke once claimed, regarding the wonders of new technology, "Any sufficiently advanced technology is indistinguishable from magic." If you were to travel back in time and show an iPhone to a medieval peasant, he would think you were a wizard with a magical picture box. And today, many first-time users of high-end consumer VR headsets often describe the experience as nothing less than "magical."

Within the next decade, we can expect massive changes in how we work, how we're entertained, and how we communicate, all due to VR and AR. These technologies will fundamentally change where we're headed as a society. But in order to do so, they need creators — dreamers, innovators, and magic makers — to help them reach their potential.

Before you dive into all the details of VR and AR, you need a basic overview of these technologies. This chapter helps you recognize the different types of VR and AR and provides you with some basic vocabulary for differentiating and discussing them. This chapter also provides a brief historical overview, so you can understand how we arrived at this current place in technological history. Finally, it explains the Gartner Hype Cycle, a way of understanding how technological innovations tend to grow and change, and how the Gartner Hype Cycle applies to emerging technologies such as VR and AR.

Introducing Virtual Reality and Augmented Reality

Virtual reality is often used as an umbrella term for all manner of immersive experiences, including many related terms such as *augmented reality, mixed reality,* and *extended reality.* In this book, however, when I refer to *virtual reality,* I generally

mean an immersive computer-simulated reality that creates a physical environment that does not exist. VR environments are typically closed off from the physical world in the sense that the environments they creates are wholly new. Although the digital environments could be based on real places (such as the top of Mount Everest) or imagined ones (such as the underwater city of Atlantis), they exist apart from the current physical reality.

Figure 1-1 shows an example of a VR environment. It's a screen shot of Wevr's VR experience, *The Blu,* which allows users to explore undersea coral reefs and ocean depths, including an encounter with an 80-foot whale.

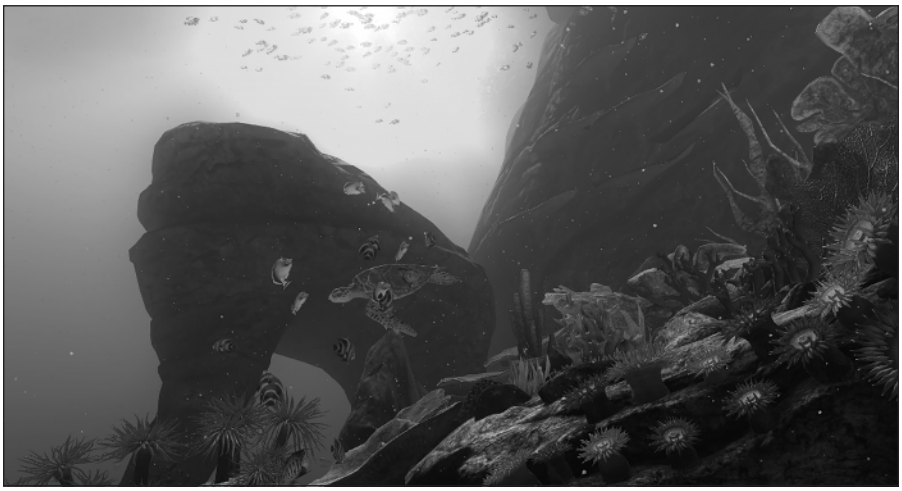

FIGURE 1-1: A VR screen shot of *The Blu* by Wevr.

Augmented reality is a way of viewing the real world (either directly or via a device such as a camera creating a visual of the real world) and "augmenting" that real-world visual with computer-generated input such as still graphics, audio, or videos. AR is different from VR in that AR *augments* (adds to) a real-world or existing scene instead of creating something new from scratch.

By strict definition, in AR, the computer-generated content is an overlay on top of the real-world content. The two environments have no way of communicating with or responding to one another. However, AR's definition has been somewhat co-opted in recent years to also include a more blended hybrid called *mixed reality,* in which interaction can occur between the real world and digitally augmented content.

REMEMBER

In this book, when I refer to *augmented reality*, I use it as a blanket term that includes mixed reality as well. The two terms are often used synonymously within the industry as well, with *mixed reality* rapidly gaining favor as the more descriptive term for the combination of analog and digital realities.

Figure 1-2 shows an example of one of the most popular recent examples of AR, Pokémon Go, which places a digital Pokémon character within your real-world environment.

THE THIN YELLOW LINE

For the past 20 years, millions of people have been exposed to a flavor of AR every Saturday and Sunday, although they may not realize it. In 1998, the 1st & Ten line was introduced by a company called Sportvision to digitally visualize the first-down line for the casual football fan.

In order to achieve this effect, Sportvision creates a virtual 3D model of the football field. While capturing video of the game, each real-world camera also transmits its location, tilt, pan, and zoom values to powerful networked computers. Using these values, the computers can determine exactly where each camera sits within the virtual 3D model of the field and can use a specialized graphics program to draw the line on top of the video feed.

Drawing that line is more complicated than you may think. If the line were simply overlaid on top of the video feed, any time a player, referee, or ball passed over where the line was overlaid, the person or object would appear "under" the digital representation of the line. This would lead to a very poor viewing experience.

In order to make the digital line appear to display under various people and objects, the software uses one color palette for colors that should appear as part of the field and another color palette for colors that should appear on top of the line. When it draws the digital line onto the video feed, the field color palette colors are converted to yellow where the line should appear, whereas colors in the other color palette are not converted, leading the people and objects to appear on top of the digital line.

This encompasses AR in a nutshell — a real environment (the football field) has been augmented with digital information (the yellow line) to enhance users' viewing experience in a way that feels natural to the viewers.

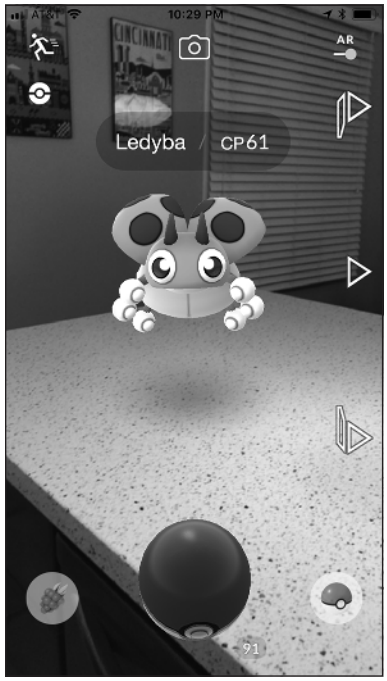

FIGURE 1-2: AR Pokémon Go being played on an iPhone.

Looking at Some Other Types of Virtual and Augmented Reality

VR and AR are still in their relative infancy, so it's difficult to know which terms will fall out of favor over time and which terms will stick around. The terms *virtual reality* and *augmented reality* may have staying power, but you should also be aware of some of the other terms out there.

Mixed reality

Mixed reality (MR) may take your view of the real world and integrate computer-generated content that can interact with that view of the real world. Or it may take a fully digital environment and connect it to real-world objects. In this way, MR can sometimes function similarly to VR and sometimes function similarly to AR.

In AR-based MR, the content of the digital world is no longer passively laid on top of the real world; instead, it can act as if it were a *part* of the real world. Digital objects appear as if they existed in the physical space, and you can even interact with some digital objects as if they were actually there. For example, you might be able to drop a digital rocket onto your coffee table and watch it blast off, or bounce a digital soccer ball off the real-world walls and floor.

TECHNICAL STUFF

A ROSE BY ANY OTHER NAME . . .

You may hear terms used in ways that seem misaligned with the rest of the industry. Sometimes it's because terminology has changed since the naming occurred — which does happen, because the technologies are still very young. However, it can also be due to branding.

For example, Microsoft recently released a line of Windows Mixed Reality headsets. But by nearly any current metric, the headsets would more properly be referred to as *virtual* reality headsets, because they allow only a closed-off virtual environment similar to other VR headsets. Many people believe that Microsoft intends to merge its current batch of VR headsets with AR interaction, but the current naming can make things confusing for consumers.

As long as you understand the definitions described in this section, you should be able to evaluate products according to their actual feature set, and not necessarily how they're marketed.

Apple's ARKit and Google's ARCore, while described as AR, actually straddle the line between AR and MR and reveal the naming discrepancy occurring within the industry. Although they project a digital layer on top of the physical world, they're also able to scan the environment and track surfaces within the real world. This enables users to place digital objects in the real world, cast digital shadows on real-world items, affect digital lighting according to the real world's lighting conditions, and so on — all things that lean more toward the definition of MR.

Another example of a current AR-based MR headset is the Microsoft HoloLens (shown in Figure 1-3), a headset that scans the physical environment to mix in digital objects. This technology, which is also found in Microsoft's Meta 2, takes things a step further than the current tablet-based offerings from Apple and Google. It projects the digital environment onto translucent visors and enables your hands to interact with those digital objects as if they were physically there.

FIGURE 1-3: Microsoft HoloLens headset hardware.

Used with permission from Microsoft

In other MR instances, you may only see a completely digital environment with no view of the real world, but that digital environment is connected to real-world objects around you. In your virtual world, real-world tables or chairs may digitally appear as rocks or trees. Real-world office walls may appear as moss-covered cave walls. This is VR-based MR, sometimes called *augmented virtuality.*

REMEMBER

Following their strict definitions, AR provides no interaction with the augmented digital world, whereas MR does allow such interaction. However, these strict definitions are becoming blended in the industry. Often *mixed reality* and *augmented reality* are used as synonyms within the industry. Their meaning over time will likely grow and change. In this book, I use AR and MR synonymously, unless otherwise noted.

Augmented virtuality

A term that has yet to gain much traction within the industry, *augmented virtuality* (AV), also sometimes called *merged reality,* is essentially the inverse of typical AR. Whereas AR refers to predominantly real-world environments that have been augmented with digital objects, AV refers to predominantly digital environments in which there is some integration of real-world objects. Some examples of AV include streaming video from the physical environment and placing that video within the virtual space or creating a 3D digital representation of an existing physical object.

Figure 1-4 shows an example screenshot of AV through Intel's recently defunct Project Alloy. Using 3D cameras, Intel was able to bring in interactive imagery of physical real-world objects (such as your hands) into its virtual environments.

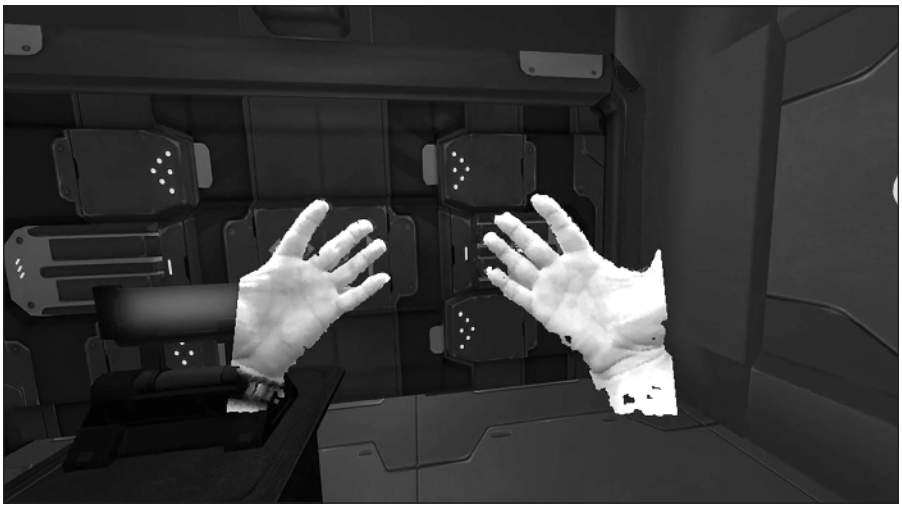

FIGURE 1-4: An example of AV from Project Alloy.

Extended reality

Extended reality (XR) is the umbrella term for the entire spectrum of technologies discussed thus far (including VR, AR, and AV).

The *virtuality continuum* is a scale used to measure a technology's amount of realness or virtualness. On one end of the scale is the completely virtual, and on the other end is the completely real. XR spans the full spectrum of this scale, from end to end.

Figure 1-5 shows where these terms fall on this scale developed by technology researcher Paul Milgram in the 1990s. Remember, though, that MR and AR, while separated in this chart for definition's sake, are often used synonymously to refer to the spectrum that MR is shown covering here.

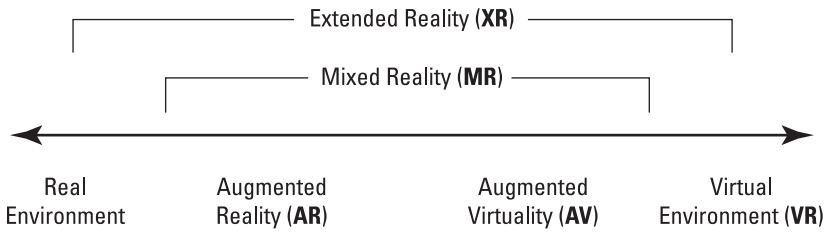

FIGURE 1-5: Paul Milgram's reality–virtuality continuum.

In this book, I mainly focus on two terms — *virtual reality* and *augmented reality* — and the technological areas that they cover. Those two terms encompass most scenarios. I use *virtual reality* to refer to any hardware/software combination that creates a mostly or entirely digital experience. I use *augmented reality* to refer to any real/physical environment to which digital elements have been added (which may or may not interact with the real environment).

Taking a Quick History Tour

In 1935, a short story called "Pygmalion's Spectacles" by American science-fiction writer Stanley G. Weinbaum told the tale of a professor who invented a pair of goggles that enabled a user to trigger "a movie that gives one sight and sound . . . taste, smell, and touch. . . . You are in the story, you speak to the shadows (characters) and they reply, and instead of being on a screen, the story is all about you, and you are in it." Weinbaum's writing predates computers and nearly predates the invention of television. If Weinbaum were to travel to the present and see just how closely his vision of VR resembles that of the emerging technology of today, he would probably be shocked.

Both VR and AR have an incredibly rich and diverse history, far too deep to fully cover here. However, a general overview of some of the various incarnations of these technologies may provide some insight into where the technologies may be headed in the future.

The father of virtual reality

In 1955, a cinematographer named Morton Heilig, considered the father of VR, imagined a multisensory theater called "The Cinema of the Future." Heilig created the Sensorama (see Figure 1-6), an arcade-style mechanical cabinet built to stimulate the senses, for which he then developed a number of short films. It included many of the features prevalent in modern-day VR headsets, such as a stereoscopic 3D display, stereo speakers, and haptic feedback through vibrations in the user's chair.

FIGURE 1-6: The Sensorama.

Courtesy of Minecraftpsycho (https://en.wikipedia.org/wiki/Sensorama#/media/File:Sensorama-morton-heilig-virtual-reality-headset.jpg) under a Creative Commons license (https://creativecommons.org/licenses/by-sa/4.0/)

Shortly after inventing the Sensorama, Heilig also patented the Telesphere Mask, the first-ever head-mounted display (HMD), which provided stereoscopic 3D visuals and stereo sound. This (relatively) small HMD more closely resembles today's consumer VR headsets than the bulky seated form factor of the Sensorama.

The patent image shown in Figure 1-7 bears a striking resemblance to many of the headsets available today.

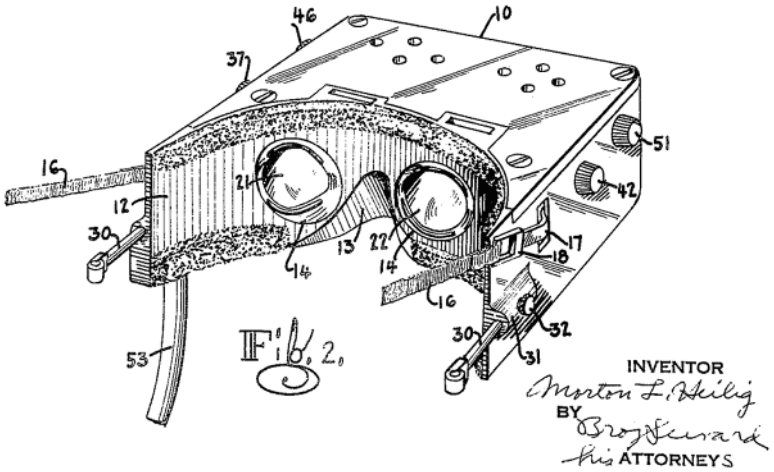

FIGURE 1-7: The Telesphere Mask patent.

Source: https://patents.google.com/patent/US2955156A/en

Augmented reality gets a name

In 1990, Tom Caudell, an employee at Boeing Computer Services Research, was asked to create a replacement for Boeing's current system of large plywood boards with wiring instructions for each aircraft being built. Caudell and his co-worker David Mizell proposed a head-mounted display for construction workers that superimposed the position of cables through the eyewear and projected them onto multipurpose, reusable boards. Instead of having to use different boards for each aircraft, the custom wiring instructions could instead be worn by the workers themselves. Caudell and Mizell coined the term *augmented reality* for this technology.

Early virtual reality failures

In 1993, Sega, a videogame company riding high on the release of its massively popular Sega Genesis, announced the Sega VR headset for the Sega Genesis at the Consumer Electronics Show (CES). Sega originally intended to deliver the device for $200 in the fall of 1993, a moderately affordable price point at the time. However, the system was plagued by development difficulties and was never released to the public. Sega's CEO at the time, Tom Kalinske, said that the Sega VR was shelved due to testers developing painful headaches and motion sickness — an unfortunate first foray into consumer gaming VR.

INDUSTRIAL-STRENGTH AR

Tom Caudell and David Mizell not only coined the term *augmented reality,* but also kicked off the use of AR in an industrial setting.

Industrial manufacturing is poised to be one of the most significant areas of AR expansion in the near future. Whereas companies developing consumer-facing AR applications must deal with a number of complications (including an unknown user base and unknown environments to perform in), those variables can be managed or even removed within the tightly controlled environment of an industrial manufacturing workspace. Manufacturers can develop targeted hardware and applications that can help their workforce train more quickly, work faster, access data more easily, and help avoid errors. All these benefits can lead to massive improvements in a company's bottom line, making AR usage within industrial settings a match made in heaven.

At the same time, another gaming industry veteran decided to release its take on VR gaming. The Nintendo Virtual Boy was released as the first portable unit capable of displaying stereoscopic 3D graphics. With the Virtual Boy, Nintendo had hoped to capture a unique technology and cement Nintendo's reputation as an innovator by encouraging more creativity in game development outside the traditional 2D screen space. However, development issues also plagued the Virtual Boy. Initial tests of color LCDs were said to have caused jumpy images, leading to Nintendo retaining the red LEDs that the Virtual Boy was eventually released with. Additionally, the Virtual Boy started as a head-mounted system including tracking. However, with concerns about motion sickness and the risk of developing lazy-eye conditions in children, Nintendo changed the head-mounted system to a tabletop format. Critics panned the system. It was never able to meet sales targets and disappeared from the market within a year.

These early failures, coupled with other failed attempts at creating mass-consumer VR devices, pushed VR advances back into research laboratories and academia for a few decades.

Virtual reality breaks through

In 2010, a tech entrepreneur named Palmer Luckey was frustrated with the existing VR head-mounted displays on the market. Almost all were expensive, extremely heavy, had a small *field of view* (the total viewing area a user can see), and high *latency* (delays between user interaction and the display refreshing to reflect those interactions) leading to a very poor end-user experience.

Channeling these frustrations, Luckey built a series of prototype HMDs, focusing on creating a low-cost, low-latency, large-field-of-view, and comfortably weighted headset. His sixth-generation unit was named Oculus Rift, and he offered it on the project funding website Kickstarter as Rift Development Kit 1 (DK1), as shown in Figure 1-8.

FIGURE 1-8: The Oculus Rift Development Kit 1 (DK1).

Courtesy of Sebastian Stabinger (https://en.wikipedia.org/wiki/Oculus_Rift#/media/File:Oculus_Rift_-_Developer_Version_-_Front.jpg) under a Creative Commons license (https://creativecommons.org/licenses/by/3.0/)

The Kickstarter campaign was a massive success, raising $2.4 million, almost 980 percent of the original target. More important, the Kickstarter campaign served to propel interest in VR in the consumer market to an all-time high.

Augmented reality hits the mainstream

AR was treated to a surprise surge in popularity from a rather unexpected source: the mobile phone. Similar to VR, AR had trudged along in relative obscurity for a few decades since its inception. Interest had increased slightly with the rise of VR in recent years, and new developments from companies such as Microsoft, Meta, and Magic Leap had shown promise, but nothing was available for mass consumption, and it was unclear when anything would be.

In 2017, AR underwent its largest boost in public awareness since its inception, as both Apple and Google released their own takes on AR for their various handheld mobile devices running either iOS or Android. Though neither has released exact numbers, estimates place the number of users with ARKit- or ARCore-capable devices to have reached over a quarter billion by the end of 2017.

THE FOURTH WAVE

Large-scale technology revolutions rarely occur in linear progressions of innovation and adaptation. Instead, they come in waves. No one can predict how large a wave will be, how fast it will occur, how disruptive the technology will be, or which way the wave will break.

VR and AR are often regarded as the fourth wave of emerging technological change. (The first three waves were the personal computer, the Internet, and mobile devices.) A wave is beginning to crest that could shape the future of humanity. Recognizing where we are in the wave and how we can best be a part of it means that we, too, can help shape the future.

With such a small sample size of life-altering technologies, it can be difficult to make predictions on how these waves will play themselves out. However, evaluating the first three waves and their development can help paint a picture of how the wave of VR and AR might break.

Perhaps the biggest takeaway from the previous waves was that each successive technological wave has been shorter than the last as far as consumer adoption. Internet adoption was quicker than personal computer adoption, and the mass adoption of cellphones was quicker still. Most current predictions for VR have VR ubiquity occurring no later than 2022, with AR coming a few years behind (2025 or so). By that time, experts predict VR and AR will have woven themselves completely into our daily lives, and picturing our lives without them would be akin to picturing our lives today without mobile phones or the Internet.

AR, long toiling in relative obscurity, suddenly had an enormous market of consumers to create content for, and developers began racing to create content for that market. Some examples include AR gaming applications, utilities that place 3D objects within a real room for interior decorating planning, map utility applications that overlay the real world with turn-by-turn directions or points of interest, and apps that can translate foreign language signs simply by pointing a mobile device camera at them.

Evaluating the Technology Hype Cycle

Technological waves also go through various peaks and troughs before they reach mass consumer adoption. Information technology research firm Gartner once proposed what it called the *Gartner Hype Cycle*, a representation of how the expectations around transformative technologies play out upon release (`www.gartner.com/technology/research/methodologies/hype-cycle.jsp`). The Gartner Hype

Cycle can help predict how a technology will be adapted (or not) over time. Both the Internet (with the dot-com crash) and mobile pre-2007 went through similar (if not exactly analogous) market curves.

In the beginning, an *Innovation Trigger* kicks off interest in the new technology, triggered by early proof-of-concepts and media interest.

Next is the *Peak of Inflated Expectations.* Buoyed by the early work and media buzz, companies jump in with higher expectations than the technology can yet deliver upon.

What follows is the *Trough of Disillusionment,* where interest in the technology begins to dip as implementations of the technology fail to deliver on the lofty expectations set by the initial Innovation Trigger and media buzz. The Trough of Disillusionment is a difficult space for technology, and some technologies may die out in this space, never fulfilling their initial promise.

Those technologies that are able to weather the storm of the Trough of Disillusionment reach the *Slope of Enlightenment,* as second- and third-generation products begin to appear and the technology and its uses are better understood. Mainstream adoption begins to take off, often paying dividends for the early adopters able to see their way through the trough with their ideas and executions intact.

Finally, we reach the *Plateau of Productivity,* where mass adoption truly begins, and companies able to weather the stormy waters of the hype cycle can see their early adoption profit.

Determining where VR and AR are in this cycle can be useful in making your decisions on how to approach these technologies. Does it make sense for your business to jump into these technologies now? Or are things not ready for prime time, and should you perhaps hold off for a few more years?

Gartner claims that VR is just leaving the Trough of Disillusionment and headed into the Slope of Enlightenment at the end of 2017, with a payoff of mass adoption within two to five years. AR, on the other hand, is listed by Gartner as currently wallowing in the Trough of Disillusionment, putting mass adoption for AR at a more conservative five to ten years out.

REMEMBER

Though the Trough of Disillusionment sounds like an ominous place for AR to be, it's a necessary phase for technology to pass through. Innovative technology, before hitting consumers' hands, needs to go through the grind of establishing an identity and determining where it fits in the world. Manufacturers need to figure out what problems it solves well and what problems it does *not* solve well. That often requires numerous trials and failures to discover.

AR as a mass consumer device is in its adolescence. Manufacturers and developers need time to figure out what form factor it should exist in, what problems it can solve, and how it can best solve them. Rushing a technology to market before these questions can be answered can often cause more problems than it solves, and is something that manufacturers of any emerging technology, including VR and AR, should be wary of.

Further, Gartner released this Hype Cycle report for VR and AR less than one month after Apple's ARKit announcement and a full month ahead of Google's ARCore announcement. An argument could be made that those two releases technically triggered mainstream adoption purely by the install base of ARKit and ARCore. However, that feels slightly disingenuous. Installed base alone does not automatically equal mainstream adoption (though it is a large piece of the puzzle).

When using a technology becomes frictionless and nearly invisible to the end user, when using that technology becomes as second nature as starting up your web browser, checking your email on your mobile device, or texting a friend, *that* is when a technology has truly hit mainstream adoption. Neither technology has yet reached this level of ubiquity, but both are looking to hit their stride. The long run of VR and AR holds the same promise of technological waves as the personal computer and the Internet.

The time for you to take action on these technologies is now, whether it's to simply research what they can do for you, to dive into purchasing a device for your own consumption, or even begin creating content for VR and AR.