Industrial manufacturing companies stand to lose their most experienced workers — and the knowledge of these workers — as they age out. But augmented reality (AR) can help preserve that expertise and pass it on to a new generation of workers.

How Augmented Reality Expedites Training and Knowledge Transfer for Frontline Workers

November 2019

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Introduction

Industrial manufacturing is nearing a tipping point, wherein the workforce — having amassed years of valuable experience and knowledge — is preparing to age out. This is critical for several reasons. First, traditionally, these experts act as mentors to novices and apprentices, demonstrating not only the proper workflow methods but also identifying shortcuts and tips. This includes all the tacit knowledge and shortcuts that have been accumulated through years of experience and aren't written down anywhere. Second, these workers also understand the importance of safety and how it aligns with industry and government standards, which is equally valuable to new workers and to the company. Third, these mentor relationships take place in real time and in person on the job, keeping the learning experience as close to the actual tasks as possible. However, as experts leave, they take their years of valuable expertise with them. Collectively, this situation represents an opportunity — which sometimes ends up lost — to capture that knowledge and leverage it for training new or redeployed workers.

According to the Bureau of Labor Statistics, the profile of the U.S. workforce is changing, going from 162.1 million in 2018 to as many as 171 million in 2028. From an aging perspective, the 55+ age segment is growing the most, from 23.1% to 25.2% of the total workforce in that same time span. However, even as that segment grows in size, older workers will age out over time, decreasing the number of experts that a company can rely on.

Meanwhile, the younger generations are changing. Within the same research from the Bureau of Labor Statistics, the younger talent pool (ages 25–34) will shrink from 22.7% in 2018 to 21.6% in 2028, leaving companies scrambling to find employees. Moreover, the way the younger generations — specifically Millennials and Generation Zers — learn how to work is likewise changing. Their learning style incorporates video, audio, and hands-on approaches, presented in a variety of brief delivery formats. Unsurprisingly, they also show a high level of comfort with technology as digital natives and

AT A GLANCE

WHAT'S IMPORTANT

» Industrial manufacturers stand to lose valuable insight and expertise as older workers age out.

» Novice workers look to experts for their insight and experience but also use multiple learning styles — video, simulations, and hands-on training — to master their work.

KEY TAKEAWAY

Augmented reality solves this problem by capturing expert know-how and turning it into step-by-step videos for novice workers to follow, pointing out methods, shortcuts, and safety tips.

have been instructed to work collaboratively. This has allowed them to practice in work simulations without the pressure of making costly mistakes. At the same time, younger workers get bored more easily and have higher expectations and turnover rates if they do not find their work stimulating enough. This stands in stark contrast with Baby Boomers and older Generation X workers who learned through individualized approaches and more traditional means of coursework, lectures, and training seminars.

Technology's Role in Knowledge Transfer and Training

Augmented reality overlays digital content onto your field of view of the physical world. This can include charts, data, tables, diagrams, images, and video in addition to 3D content. The key here is that the wearer of an AR head-mounted display (HMD) or a user of a tablet or mobile device have clear sight of the physical world around them while they are doing their work. This differs from AR's cousin, virtual reality (VR), in which the physical world is completely obscured by the digital content. Furthermore, AR can be classified into basic and advanced AR.

Basic AR refers to those AR experiences in which content is shown in the user's field of view but cannot be manipulated (e.g. stretched, rotated, spun, or moved around). By contrast, advanced AR allows the wearer to manipulate content within the field of view. By way of example for advanced AR, a virtual motor engine can be taken apart with different pieces moved around, stretched out, rotated around, or placed in another area within the field of view. This contrasts with basic AR, in which the same virtual motor engine can come up within the field of view, but the user cannot manipulate it in the same way. This is a critical distinction for knowledge transfer and training, yet both are important.

With advanced AR, users get a 3D view of the content that anchors itself to the real-world environment, providing nearly seamless viewing between the physical and the digital. This becomes especially helpful when a worker has multiple steps and multiple locations to work on a machine. With basic AR, users get a 2D view of the content, similar to having a tablet close to one's eyes. This results in a look-up/look-down user experience, good for those situations in which the user can consume short pieces of information on the display while completing a task.

Augmented reality has been gaining ground as a teaching and training tool within industrial manufacturing. It started out as see-what-I-see and expert-in-your-ear shared experiences, as well as visualizing hidden components inside products. It's a strong step forward compared with the traditional approach of spending countless hours of classroom training with PowerPoint slides and training manuals, logging time shadowing or under the watchful eye of a mentor, or looking up information in a manual or inviting managers and coworkers to examine your work. These use cases still hold, but the experience has expanded so that users can retrieve information about machinery from a company's back-end servers and share annotations on the content to provide additional training and insight. As a result of incorporating augmented reality into a company's training program, managers of frontline workers can:

» Speed up the training process

» Update digital content and adjust training programs as needed

» Offer more effective training and new skills development to employees

» Lower training costs

» Teach safety requirements and increase compliance to standard operating procedures

The consequences of an AR-based training program then begin to emerge — organizations can reduce or even eliminate costly mistakes; improve first-time fix rates, quality, and throughput; and move novice workers into more complex tasks with greater efficiency.

Augmented reality, while still a relatively new technology, continues to evolve and gain traction in the industrial market. For training and skills development, capturing the deep knowledge of experienced workers and subject matter experts and then transforming it into AR content that can be used to empower new and redeployed workers have become faster and easier than previously thought possible. This solves the challenge of saving and preserving expertise before it leaves the company, keeps it always on-demand, and presents it in a way that novice workers can quickly learn and use that knowledge. The result is an on-demand AR experience featuring step-by-step expert instruction and digital content designed to help workers successfully operate, set up and maintain machinery, complete product assembly, and perform maintenance and service tasks accurately and safely.

The Benefits of AR

By capturing expert insight, procedures, and know-how and transferring that knowledge into AR experiences that can be quickly and easily scaled to frontline workers across the organization, companies realize several benefits. First, consider how this approach aligns well with how novice workers learn from seasoned veterans: They can learn how to safely operate a piece of equipment, how standard procedures should be performed, and how to avoid safety hazards and costly mistakes. This goes above and beyond book-based instruction, reducing the lengthy process that requires experts to spend time on bringing new workers up to speed instead of working on high-value tasks. It also presents the information in a technology-rich, highly visual format that feeds directly into their nature as digital natives to learn and retain information.

Second, it gives managers the flexibility they need to successfully instruct novices. Content can be created with the insight from multiple experts as they go about their work and be updated as the workflow evolves – especially as new machines come online and new workflow methods are developed. Learning can take place on the job without the need to take down equipment or shut down high-volume production lines.

Third, not only does AR-based knowledge transfer flatten the learning curve and reduce the amount of time needed for training but it plays a vital role in helping trainees retain knowledge. Novices can more easily recall what they saw and heard compared with remembering what they read in a manual. This also helps with employee satisfaction and retention. Research has shown that it is more cost-beneficial to train and retain an employee than seeing them leave the company. According to estimates from the Association for Talent Development, the average training cost per employee is $1,252. Meanwhile, turnover costs can run as high as $15,000 (source: Work Institute's 2017 Retention Report). Turnover can cost a manufacturing organization money as it has lost any investment in training it has made and now needs to spend additional money to train someone new.

AR-based knowledge transfer and training benefit companies by giving trainees access to expertise in a way that aligns with their learning style to perform and complete their work and gives managers and subject matter experts the flexibility to create highly effective training materials, when and where they are needed most, while reducing costs.
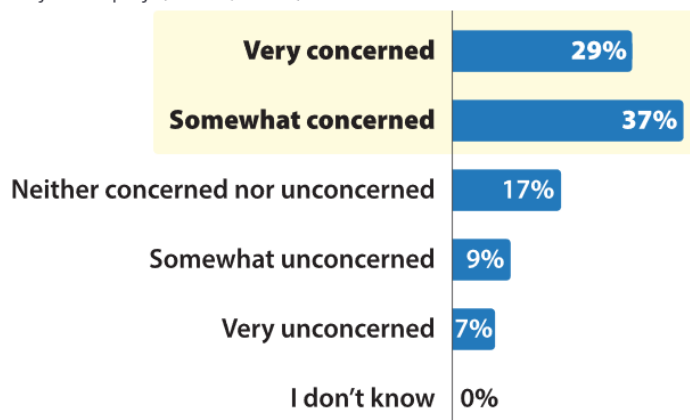
Key Trends

Recent IDC surveys have pointed to a growing trend among companies to deploy AR, specifically for knowledge capture. Earlier this year, IDC fielded a survey to 183 enterprise users of augmented reality, asking several questions on the use of AR with respect to knowledge capture. The first data point IDC collected shows how much of a concern companies have about losing their most knowledgeable workers due to retirement (see Figure 1). An impressive 67% reported themselves as concerned, with 37% saying they were somewhat concerned and another 30% saying they were very concerned. This highlights that companies are aware of the situation and sense a level of urgency about it. At the same time, of those participants who said knowledge loss is a concern for their company, a whopping 87% believe AR can help their companies address this concern today or in the future. Similarly, 29% believe that AR's greatest benefit for business has been knowledge capture and transfer, second only to increased worker efficiency (38%).

### Figure 1 *Majority Concerned Over Knowledge Loss See AR as Help*

Enterprise Concern Over Losing Knowledge

Q: One of the biggest challenges facing many companies is that many of their most knowledgeable workers are reaching retirement age, and as they leave the workforce, much of their knowledge is lost. How concerned or unconcerned are you about this for your company? (Base: all; n = 200)

- **Very concerned** — 29%
- **Somewhat concerned** — 37%
- Neither concerned nor unconcerned — 17%
- Somewhat unconcerned — 9%
- Very unconcerned — 7%
- I don't know — 0%

Ability for AR to Help with Knowledge Loss

Q: You said knowledge loss is a concern for your company. Do you believe AR can help your company address this concern today or in the future? (Base: those very concerned or somewhat concerned about losing knowledge; n = 136)
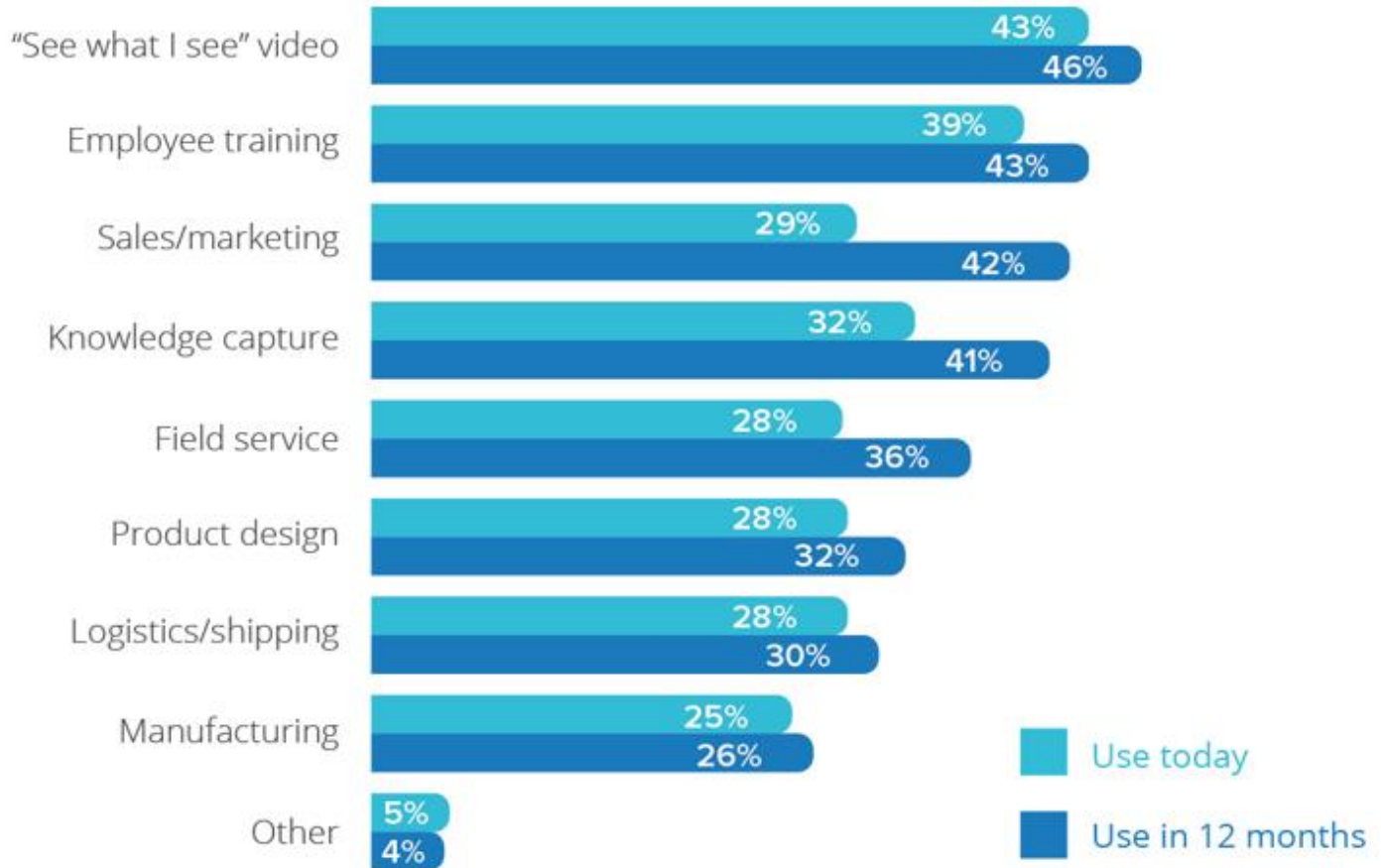
- Don't know 11%
- No 2%
- Yes 87%
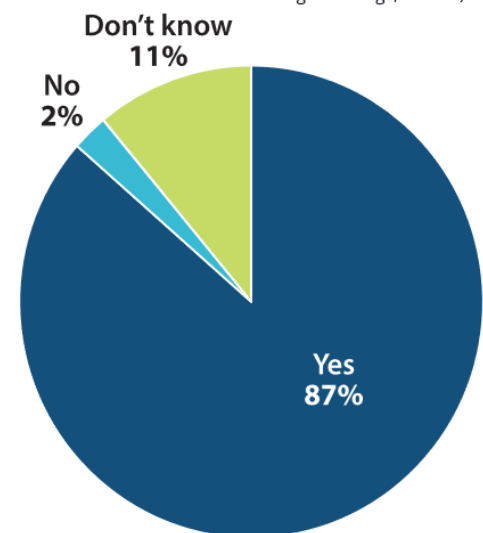
Source: IDC's Commercial AR/VR Survey, 2019

When it comes to how these survey participants are currently using AR, 32% indicated that they use it specifically for knowledge capture (see Figure 2). This ranked behind see-what-I-see videoconferencing (43%), and employee training (39%), but still ahead of sales and marketing (29%), field service (28%), logistics (28%), and product design (28%). That both knowledge capture and employee training emerged as two of the top key use cases is significant, underscoring AR's value as an educational tool. Within the next 12 months of taking this survey, 41% said that they will be using AR for knowledge capture. This highlights the importance of collecting and curating expert insight before it leaves the workplace altogether, something that will increase as workers age.

Figure 2 *How Companies Will Use AR in the Next 12 Months*

Q *How does your company use AR today? How do you expect your company to be using AR in the next 12 months?*

"See what I see" video — 43% (Use today), 46% (Use in 12 months)
Employee training — 39% (Use today), 43% (Use in 12 months)
Sales/marketing — 29% (Use today), 42% (Use in 12 months)
Knowledge capture — 32% (Use today), 41% (Use in 12 months)
Field service — 28% (Use today), 36% (Use in 12 months)
Product design — 28% (Use today), 32% (Use in 12 months)
Logistics/shipping — 28% (Use today), 30% (Use in 12 months)
Manufacturing — 25% (Use today), 26% (Use in 12 months)
Other — 5% (Use today), 4% (Use in 12 months)

n = 200

Source: IDC's Commercial AR/VR Survey, 2019

By the end of 2019, vendors will ship a total of 268,000 AR HMDs for commercial use into the market worldwide, up a strong 113.4% from the 125,000 units shipped in 2018. Come 2023, total volumes of AR HMDs for commercial use will reach 26.2 million units, resulting in a five-year CAGR of 191.0%.

Considering PTC

PTC has a long history with augmented reality within industrial manufacturing with Vuforia Studio, Vuforia Engine, and Vuforia Chalk. With Vuforia Studio, users need not be proficient programmers to create their own 3D AR experiences. Its drag-and-drop approach allows users to quickly develop their own AR content, pulling from their own 3D and CAD content and combining it with IoT capabilities. Vuforia Engine takes this a step further, enabling customer AR experiences by attaching digital content to a variety of objects, ranging from embedded markers and flat objects to images and 3D

objects. Vuforia Chalk brings smart annotation capabilities to the AR experience, with multiple parties sharing a video environment in real time.

Vuforia Expert Capture rounds out the suite of products, adding the capability to easily record and share valuable insights of expert technicians. To do this, industrial companies can record step-by-step instructions as needed, to provide procedural guidance or simplify documentation of standard operating procedures, using PTC's easy-to-use capture app and prebuilt templates. A user only needs a head-mounted AR device with a camera; no other preexisting assets are needed to create content. Once completed, companies can publish content for multiple users to Microsoft HoloLens, RealWear HMT-1/1Z1, or other mobile devices (e.g., tablets and smartphones). Vuforia Expert Capture also leverages the location-sensing capabilities of Microsoft HoloLens to create specific instructions for multistep, multilocation tasks.

For example, a user can access digital instructions on how to change over a production line created with Vuforia Expert Capture. She brings up a prerecorded session created by an expert relevant to the specific task she must perform and is guided by a detailed walk-through that also points out safety warnings that she may have not previously considered. If she encounters an unexpected issue, she can access a remote expert in real time through Vuforia Chalk, used in conjunction with Expert Capture, share her work environment via real-time videoconference, and get assistance to help identify the issue and speed problem resolution. AR-enabled instructions and remote expert access help speed line setup and changeover, reduce maintenance time, and keep high-value production lines operating at peak efficiency.

Challenges

Vuforia Expert Capture requires a significant investment in terms of software and hardware, and beyond that, it requires an investment of time into properly creating content. While the end result of Vuforia Expert Capture is a quick step-by-step video for novice workers to follow, getting those desired results can be a longer process of shooting and editing ideal footage for consumption. As such, companies may have to repeat this (e.g., right viewing angles and noise levels, editing for length) until they figure out how it works best for them.

However, repeated usage of Vuforia Expert Capture will clearly flatten out the learning curve, and in the end, the value of having captured expert insight will far outweigh the investment of putting it all together. Moreover, capturing expert insight with Vuforia Expert Capture is much faster — and cheaper — than the traditional method of writing and distributing technical documentation.

Another challenge that companies will face is that currently there is a limited set of hardware to run Vuforia Expert Capture. To date, Microsoft's HoloLens and RealWear's HMT-1/1Z1 are the only compatible HMDs. Devices from both companies have received a warm reception within industrial manufacturing, and it's a smart place for PTC to begin. Over time, other devices will be added to the list. In the meantime, companies can also use their mobile devices to access content.

Conclusion

The value of expert industrial workers goes beyond their immediate productivity. Refining, replicating, and passing on their expertise to the next generation of workers behind them can help industrial companies succeed now and in the future. But as large groups of workers begin to age out and leave, so does all the knowledge that they have accumulated. This presents companies with the unique challenge to preserve, curate, and share that knowledge and to present it in a

way that younger workers — comfortable with using technology for self-education — can easily absorb and learn the necessary skills needed to complete their own work. PTC's Vuforia Expert Capture can solve this challenge.

With Vuforia Expert Capture, companies can reap the benefits of knowledge transfer through augmented reality. Novice workers can reduce their training time and improve the quality of their work, including improved error reduction and first-time fix rates. In addition, they are taught proper safety and compliance procedures. Likewise, companies reduce associated training costs with less waste. But perhaps most importantly, trainees learn and retain knowledge better having seen someone do the work before doing the work themselves. Vuforia Expert Capture is a viable option to keep the workforce trained up and educated as enterprise deployments of AR increase.

About the Analysts

Tom Mainelli, *Group Vice President, Devices and AR/VR*

Tom Mainelli manages IDC's Devices group, which covers a broad range of hardware categories including PCs, tablets, smartphones, wearables, AR/VR, thin clients, and displays. In his role as program vice president, he works closely with company representatives, industry contacts, and other IDC analysts to provide in-depth insight and analysis on the always-evolving market of endpoint devices and their related services. In addition to overseeing the collection of historical shipment data and the forecasting of shipment trends in cooperation with IDC's Tracker organization, he also heads up numerous primary research initiatives at IDC including frequent consumer- and commercial-focused surveys. A frequent public speaker, he travels often and enjoys the opportunity to work with colleagues and clients all over the world.

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Ramon Llamas is a Research Director with IDC's Devices and Displays team, covering wearables, augmented/virtual reality, and smartphones. Mr. Llamas's core research coverage includes tracking and forecasting the United States wearables and augmented/virtual reality for IDC's Worldwide Quarterly Wearables Tracker and AR/VR Tracker respectively, analyzing the evolution of those categories, and the changing strategies of the vendors involved. Based on his expertise in the smartphone market, Mr. Llamas's research also focuses on how these different products interact with each other, and how consumers and enterprise users can integrate them into their daily lives.

IDC Custom Solutions

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