

# Current and Potential Future Applications of Virtual Reality in Academia, Business, and Public Policy

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**Abstract:** I describe current and potential use cases of virtual reality (VR), which made a commercial comeback in 2014 after failing to gain traction in 1995. I discuss VR's ability to provide standardized, identical experiences. I analyze Walmart's implementation of VR to improve employee readiness for 'holiday rush.' Through VR, Walmart cut training costs, and employee knowledge retention increased by 10% and contributed to Walmart's 2016-2017 4.09% growth in revenue. I analyze the relationship between VR and tourism on Monhegan Island, Maine and its implications for financial planning. I examine increased museum ticket sales by differentiation through VR adoption.<sup>2</sup>

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<sup>2</sup> Abstract is 98 words.

## 1.) Introduction

Virtual reality (VR) is defined as the experience a head-mounted display provides through screens, tracking sensors, and a rendering of a virtual environment. Commercial virtual reality was primarily introduced in 1995 as a gaming device (Edwards 2015). However, since Palmer Luckey revealed his Oculus Rift VR prototype in 2014, corporations, economists, and communities across the world have adopted VR to provide new insight into business, research, and communication (Izzo 2017; Innocenti 2017). A range of industries currently utilize this technology (Figure 1). Through VR, organizations can achieve innovations in employee training, customer retention, and evaluating product and service appeal.

First, I provide background on the revival of VR technology in 2014 and the formation of the new VR headset market. Second, I describe VR's ability to isolate participants and focus their attention on specific environmental stimuli to increase research standardization. Lastly, I find that VR has significant capacity to improve fiscal performance and community engagement. Through VR visualizations of proposed community-altering decisions, such as the construction of a new windmill, and challenging retail scenarios like Black Friday, stakeholders can better prepare for the future. My approach synthesizes peer-reviewed sources while employing VR adoption and market data and Walmart Inc.'s financial documents to provide new insight into VR.

This paper examines economics research in VR. Teisl et al. (2018) study the effects of offshore wind turbines on the tourism economy of Monhegan Island, Maine through VR and 2D experiences. Yoo and Drumwright (2018) evaluate the relationship between non-profit fundraising and VR and find that on average, participants who experience a Syrian refugee camp in VR are more likely to make larger donations than those who watch a 2D video. Mol (2019)

describes economic experiment applications of virtual reality, highlighting the concept that VR provides detailed head tracking data compared to real life experiments. Izzo (2017) examines the first mover advantage that interactive VR exhibits endow an Italian museum by increasing consumer appeal. Innocenti (2017) explores virtual reality game theory and discovers that VR can provide valuable insight into people's behavior in high-risk situations. Through the existing framework that these works provide and the incorporation of financial data and real-world scenarios, I create unique arguments and suggest VR use case recommendations.

## **2.) Background**

Although commercial VR existed in 1995 with the release of Nintendo's Virtual Boy, its high price, failure to attract game developers, and lackluster immersion dissuaded consumers from investing in VR (Edwards 2015). Technology entrepreneur Palmer Luckey ignited a resurgence in attention for VR devices with Oculus, a VR headset manufacturer (Clark 2014). The Oculus head-mounted display debuted on Kickstarter in 2012 (Clark 2014). Whereas the Virtual Boy was unable to generate lasting demand, Oculus' efforts resulted in a multimillion-dollar VR market (Figure 1; Clark 2014).

The Oculus Rift "[packs] a wealth of cutting-edge tech" (Nield 2016). Two lenses magnify a single high-resolution display, encompassing the wearer's field of view (Nield 2016). Inside the headset itself is a custom motherboard, an ARM processor, and an 'Adjacent Reality Tracker' comprised of a magnetometer, gyroscope, and accelerometer to track head movement (Nield 2016). Positional tracking sensors, handheld controllers, and 3D audio technology are also essential to the Oculus Rift's immersion (Nield 2016).

To create a market, Oculus first had to incentivize software creation; Oculus Rift Development Kit 1, the first prototype, was sent to early Kickstarter backers and software

developers (“Oculus Rift” 2016). Sony, HTC, Google, and Samsung subsequently entered the VR market with PC, console, and smartphone-based headsets in a race to dominate the emerging industry. Unlike the previous generation of VR in 1995, these companies have created immersive, content-rich headsets at competing price points.

According to Grand View Research’s market forecast, VR is projected to grow considerably between 2019 and 2025 (Figure 1). The US virtual reality market created \$220 million in revenue in 2016 and is projected to reach \$9.31 billion by 2025 (Figure 1). One of the largest VR firms is Facebook, which bought Oculus in 2014 for \$2 billion (Solomon 2014). As a social media platform, Facebook could increase VR headset sales considerably through its network. Through Oculus, Facebook users will populate virtual reality ‘worlds’ where they can interact with Facebook friends (“Introducing Facebook Horizon” 2019). These early adopters may become a driving force behind VR adoption for mainstream consumers. There were 15.7 million VR headset users in 2018, but eMarketer projects that number to grow to 26.5 million by 2021 (Figure 2). Moreover, in a Facebook statement, Mark Zuckerberg asserted that VR is a “new communication platform” because it places global users in face-to-face VR environments and that “Oculus has the chance to create the most social platform ever” (Solomon 2014).

Since its revival in 2012, VR has impacted several different industries, from manufacturing to education, through ‘presence’ and ‘co-presence’ factors (Yoo and Drumwright 2018; Mol 2019). Presence is the sense of ‘being there,’ or feeling a life-like immersion in an alternate space (Yoo and Drumwright 2018). Co-presence—sometimes referred to as social presence—describes feeling “presence together with other virtual humans” (Mol 2019, p. 1) and establishes intimate relationships between these virtual users (Yoo and Drumwright 2018). Facebook’s approach to capitalizing on the co-presence potential of its Oculus acquisition, for

example, is the launch of Facebook Horizon, a VR world in which Facebook users interact virtually (“Introducing Facebook Horizon” 2019). Through the means of [co-]presence, VR can simulate social and solitary real-life environments for experimentation purposes, enabling researchers to uncover trends and biases inaccessible through conventional experimentation. A VR experiment in which participants in a burning building heard multiple cries for help, for instance, found that participants were less likely to respond to those from African Americans than those from other races (Innocenti 2017). While VR is being employed in multi-national firms, students and professors can also harness its abilities to strengthen research, decision-making, and institutional and college missions. Strong differentiation from traditional forms of media transforms VR into a source of unique perspectives with implications for economic research, business optimization, and consumer retention.

Virtual reality’s ability to enable ‘otherworldly’ and ‘out-of-body’ experiences creates a differentiation effect compared to other forms of media. To create believability and active immersion in the environment (Izzo 2017), VR tracks head and hand movement through multiple feedback sensors (Yoo and Drumwright 2018; Innocenti 2017). This creates a “Proteus effect” in which a user conforms to a virtual body (Mol 2019). VR further isolates users from the real world through the elimination of environmental and temporal variations in sound, smell, and weather (Mol 2019).

### **3.) Applications of Virtual Reality in Economics**

While real world experiments have real world limitations and are vulnerable to inexact replication, VR environments provide static experiences with otherwise-inaccessible resources. Cost and management challenges make some real-life experiments infeasible, but VR can place a participant on a stage before a heckling audience or on an island with limited resources to gauge

behavior. It provides strict control over the environment, allowing researchers to customize their simulations as needed without worrying about outside interference (Innocenti 2017). This ensures a high level of focus and experience standardization, thereby improving the accuracy of experiments utilizing VR (Innocenti 2017). These abilities provide a foundation on which economists and companies can explore a new way to conduct experiments.

One economic application of virtual reality is in experiments involving game theory. Through manipulation of virtual environments and avatars, researchers can influence participants' behavior. In games in which dishonesty and cheating are blatant but create higher payoffs, experimenters can create actively justice-seeking or passive avatars that attempt to influence participant behavior accordingly (Innocenti 2017). Mol (2019) demonstrates that a participant's distance from static avatars directly correlates with dishonest behavior in a game scenario. Another experiment included one visibly cheating and one fair avatar and a task in which dishonesty correlated with a higher reward, but participants could come up to avatars and punish them by taking away rewards. The experimenters found that participants who sought justice and removed an avatar's rewards gravitated towards and lingered by those unfair avatars, exemplifying aggression, compared to more indifferent participants (Mol 2019). While such an experiment is possible in real life, variations in fair and unfair opponents' behavior, for example, may decrease the scenario's homogeneity and skew results. The combination of VR's isolating and focusing capabilities with its ability to create convincing environments grants experimenters a unique perspective on the intersection between social and economic behavior. In conjunction with the experimental consistency VR provides, these advantages could make VR a viable platform for research at universities around the world. Researchers can create unique game scenarios through VR, transporting participants to a myriad of possible virtual settings and

establishing game conditions that wouldn't be possible to create otherwise, such as playing chicken in VR.

#### **4.) Financial Applications of Virtual Reality**

Virtual reality may become essential to financial performance through workplace simulation and visualization of the future. In one experimental model, researchers had participants work on a virtual conveyor belt alongside a productivity-varying virtual avatar and discovered that participants were more efficient when placed next to highly efficient avatars than less efficient avatars (Mol 2019). Similarly, multi-national corporations have adopted VR as a means through which employees can become more productive in new environments and situations, which could endow them with a competitive advantage over competitors (Mol 2019). As of 2017, 52.8% of mid-market company executives reported utilizing mixed reality—which includes VR—for employee training (Figure 3). On May 31<sup>st</sup>, 2017, Walmart announced a company-wide VR integration in Walmart Academy, a training program for Walmart employees (Harris 2017). The VR initiative would simulate the upcoming 'holiday rush' to help employees acclimate to the large crowds and improve efficiency under pressure (Rao 2017), and investors may have agreed; according to calculations, from May 31<sup>st</sup> to June 2<sup>nd</sup>, Walmart stock price WMT increased by 8.87% from \$62.95 to \$68.18 (Figure 4). Through intensive employee training modules employed during Q2 and Q3 which increased store productivity ("How Walmart" 2017), VR may have helped enable Walmart to generate more revenue in Q4; Walmart's Q4 revenue was \$5.4 billion higher in 2017 than in 2016 and constituted a 4.09% increase from 2016 (Table 1). As Table 1 demonstrates, Q4 2017 was Walmart Inc.'s best-performing quarter for total revenue in several years, and that success could be partly attributed to VR; employees employing VR for training retained 10 to 15% more knowledge than before

VR integration (“How Walmart” 2017). Walmart’s utilization of VR to train associates, then, is a distinct competitive advantage over companies like Target, which lack VR programs and fail to harness the potential efficiency such programs provide. In addition, companies with traditional training programs can easily rack up expenses on training coaches traveling between store locations and may endure reduced productivity due to ‘training days,’ as VR allowed Walmart to reduce training time per employee from 8 hours to 15 minutes (“How Walmart” 2017).

Virtual reality’s role as an informant can also influence investors’ decisions to exit a market. At Monhegan Island, Maine, potential wind turbine investors were dissuaded from committing to their project after they realized the extent of the potential development’s negative externalities through VR; virtual reality provided investors with otherwise unobtainable insight concerning the potential community reaction and the effect on Monhegan Island’s tourism industry (Teisl et al. 2018). In the future, it may be likely that VR could be a highly effective method to screen community opinions. Municipalities with strict regulations such as Claremont, California could employ VR surveys to ensure investment security, preventing new developments from becoming sources of contempt and disputes. Colleges and universities could also employ VR experiences to gauge student reactions to administrative decision-making concerning the allocation of donations, endowment, and manpower into campus resources. One point of contention at universities, for example, is funding for athletics centers. A comprehensive architectural model of an upcoming athletics center could be designed for students to ‘experience’ through VR. Student responses in VR may sway opinions, persuade administrators to adjust the athletic center’s budget, and create a sense of meaningful collaboration in campus decision-making.



Virtual reality experiences may allow institutions to secure long-term appeal from a technology-savvy new generation. In 2018, VR received demand from 2% of organizations in the travel and leisure industry (Figure 5). Therefore, a first-mover VR strategy for traditionally less technologically competitive industries such as museums could be quite effective to attract customers. Palazzo Ducale, an art museum in Venice, Italy became an early mover in VR. Palazzo offers permanent VR stations in which users experience a painting first-hand (Izzo 2017). According to Izzo, this incorporation of technology endowed the museum with a differentiation strategy and competitive advantage over competing museums due to VR's ability to entertain and interact with users (Izzo 2017). Although attendance in the museum industry is largely decreasing, attendance at Tate Modern Museum in London, England has increased by one million visitors, and the recent addition of VR exhibits has contributed to this success (Geronikolakis 2018). Tate Modern and Palazzo's VR approaches attempt to appeal to and retain younger, technology-focused audiences and donors through the innovation of the gallery experience, and other institutions in the museum industry and beyond may benefit from adopting similar VR programs. Through the efforts of institutions seeking to educate underserved and disabled communities, for example, multiple experiences have already been made available online to eliminate the need to travel to physical galleries, including 'The VR Museum of Fine Art,' and have received thousands of virtual visitors.

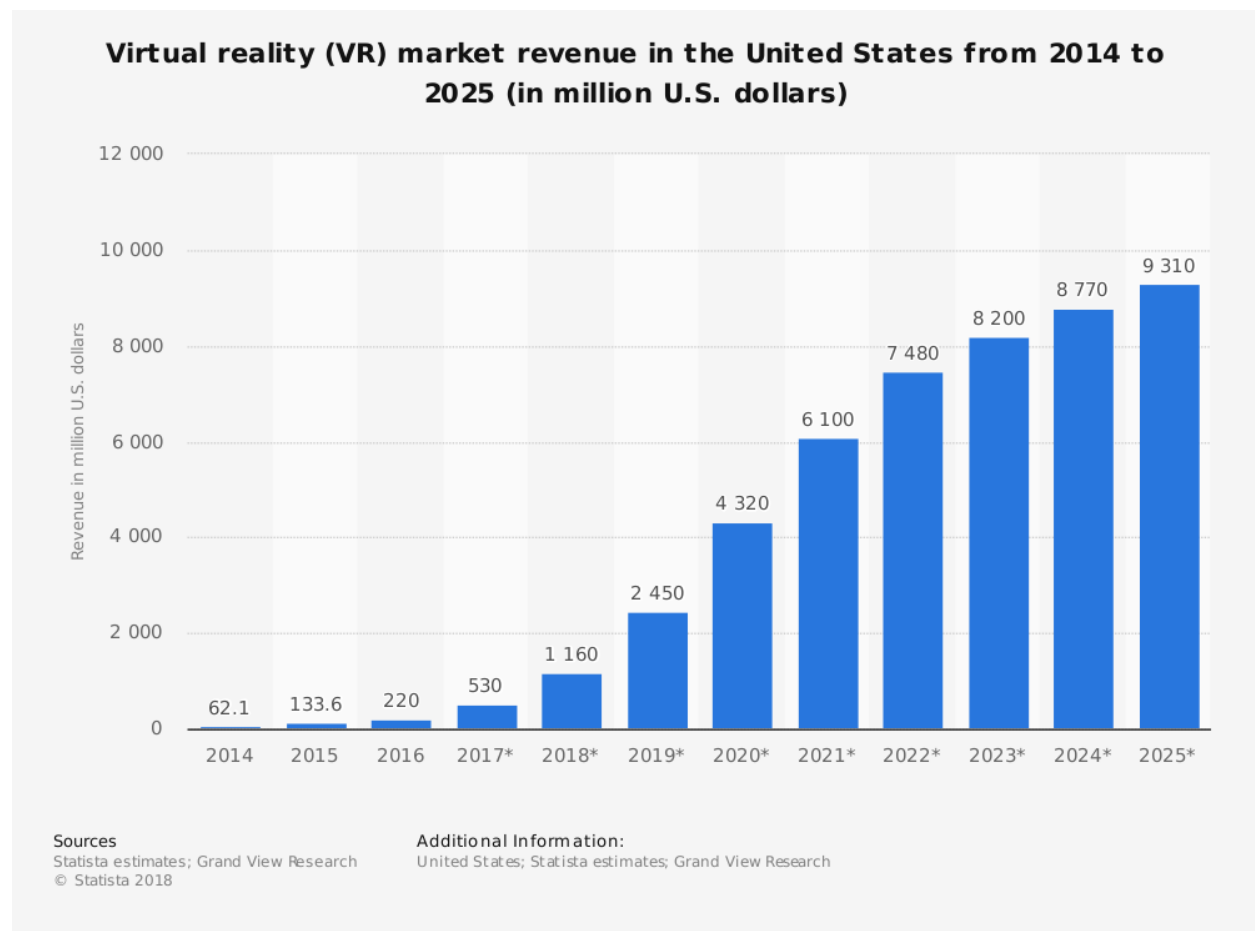
## **5.) Conclusion**

I conclude that VR has the potential to be useful in several industries and communities. Research universities and brick and mortar retail currently employ VR to test and inform economic theory and conduct business optimization. Walmart's VR employee training helped workers adapt to intensive shopping scenarios such as Black Friday, improving employees'

knowledge retention and general store productivity. Thus, VR likely contributed to Walmart's increased financial performance in Q4 2017, granting them a competitive advantage over companies with traditional, resource intensive training programs by employing more effective and efficient solutions. I also suggest that VR may improve the democratic aspect of decision-making in tight-knit communities. Experiments that compare VR and 2D reactions to potential future projects, such as the wind turbines at Monhegan Island, can help uncover significant bias against those projects and prevent investors from enduring losses. In addition, as early movers in the VR space, museums can both increase consumer satisfaction and gain a competitive advantage over others by appealing to new generations of consumers and donors.

I lack sufficient information to calculate specific values for VR's effects on the companies discussed. Walmart's stock increased after its VR integration announcement, but there were likely other factors that influenced the stock market or WMT stock specifically. Thus, it is reasonable to infer that VR increases Walmart's store productivity, but I cannot calculate the magnitude of its improvement. The same limitation applies to attendance at Palazzo Ducale and Tate Modern. Another limitation is that SuperData Research does not specifically categorize museums as 'travel and leisure' as opposed to education. Since 2% of the travel and leisure industry and 46% of the education industry have demand for VR, inclusion in the education industry could imply that VR integration no longer grants museums a first-mover advantage. Further work could entail creating and executing unique VR experiments in the workplace setting to analyze the corporate performance benefits of virtual reality. In addition, quantitative research could be conducted at universities through VR.

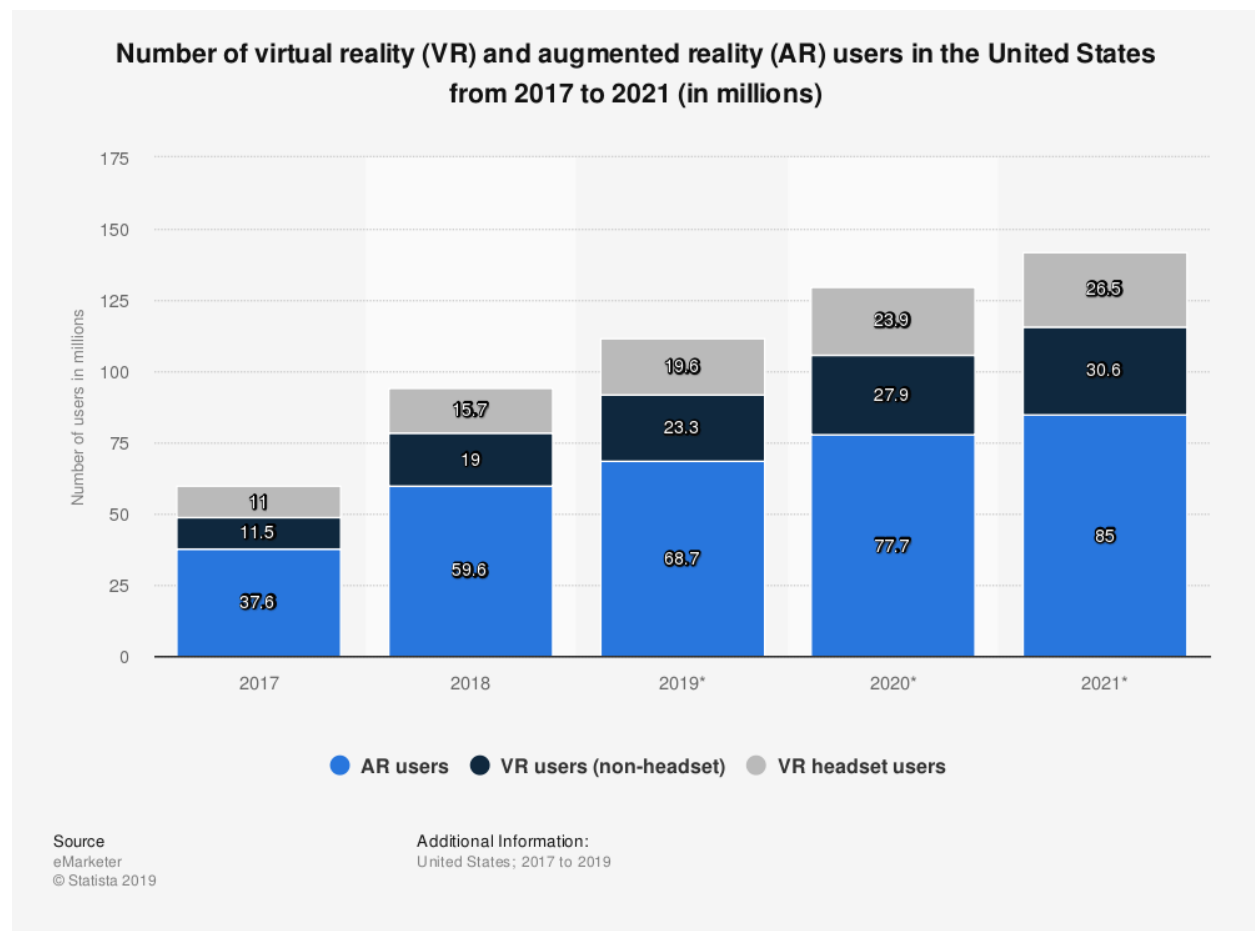
**Figure 1: Virtual reality (VR) market revenue in the United States from 2014 to 2025 (in million US dollars)<sup>3</sup>**



**Source:** Statista. "Virtual Reality Market Revenue in The United States from 2014 to 2025 (in Million U.S. Dollars)." *Statista*, Statista Inc., 1 Mar 2018, <https://www-statista-com.ccl.idm.oclc.org/statistics/784139/virtual-reality-market-size-in-the-us/>.

<sup>3</sup> Data is forecasted from 2017 to 2025.

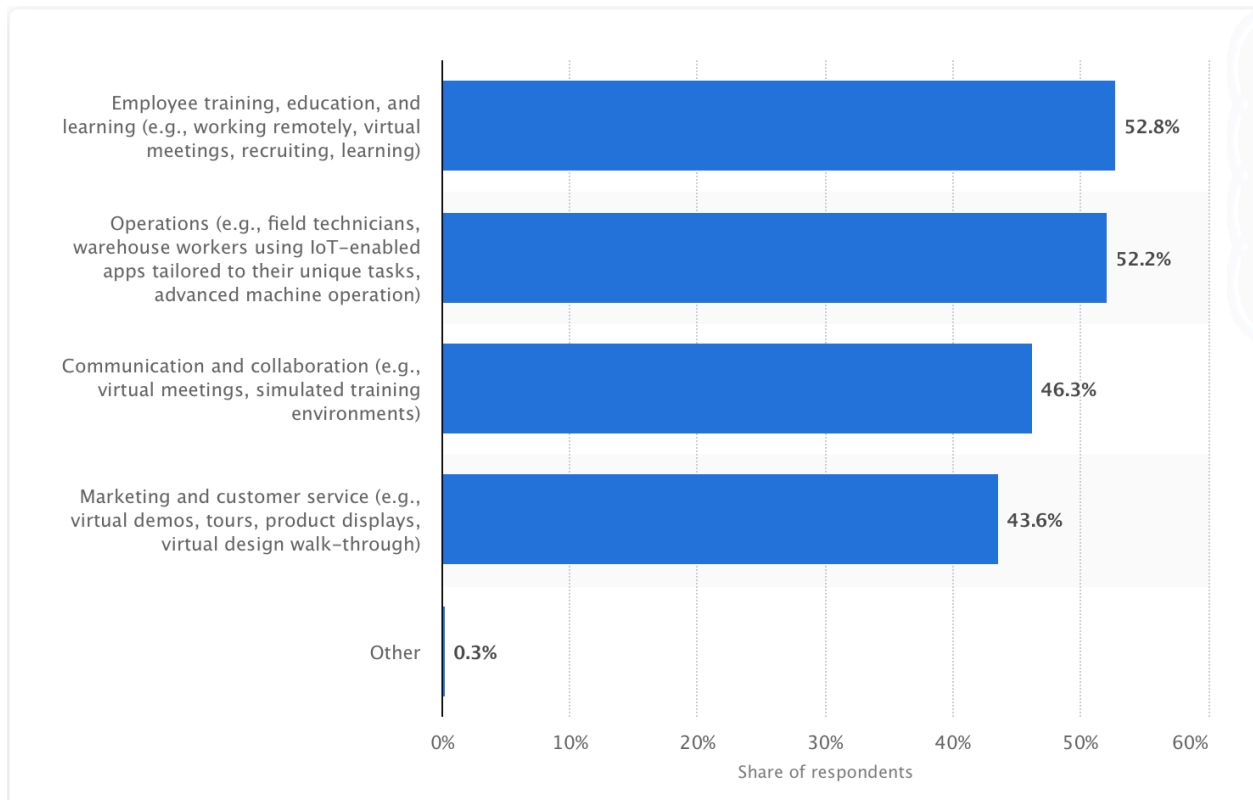
**Figure 2: Number of virtual reality (VR) and augmented reality (AR) users in the United States from 2017 to 2021 (in millions)<sup>4</sup>**



**Source:** eMarketer. "Number of Virtual Reality and Augmented Reality Users in The United States from 2017 to 2021 (in Millions)." *Statista*, Statista Inc., 27 Mar 2019, <https://www-statista-com.ccl.idm.oclc.org/statistics/1017008/united-states-vr-ar-users/>.

<sup>4</sup> Data is forecasted from 2019 to 2021.

**Figure 3: Mixed reality usage in support of business goals among mid-market enterprises in the United States, as of July 2017**



**Source:** Deloitte. “Mixed reality usage in support of business goals among mid-market enterprises in the United States, as of July 2017.” *Statista*, Statista Inc., 24 July 2017.

<https://www.statista.com/statistics/785517/us-mixed-reality-mid-market-usage/>.

**Figure 4: Walmart Stock Price from 5/22/17 to 6/2/17<sup>5</sup>**



**Source:** Walmart Inc. (WMT). Stock price data, June 2, 2017. *Yahoo! Finance*.

<https://finance.yahoo.com/quote/W/history?period1=1495263600&period2=1496386800&interval=1d&filter=history&frequency=1d>.

<sup>5</sup> Stock market was closed from 5/27/17 to 5/29/17 (Memorial Day)

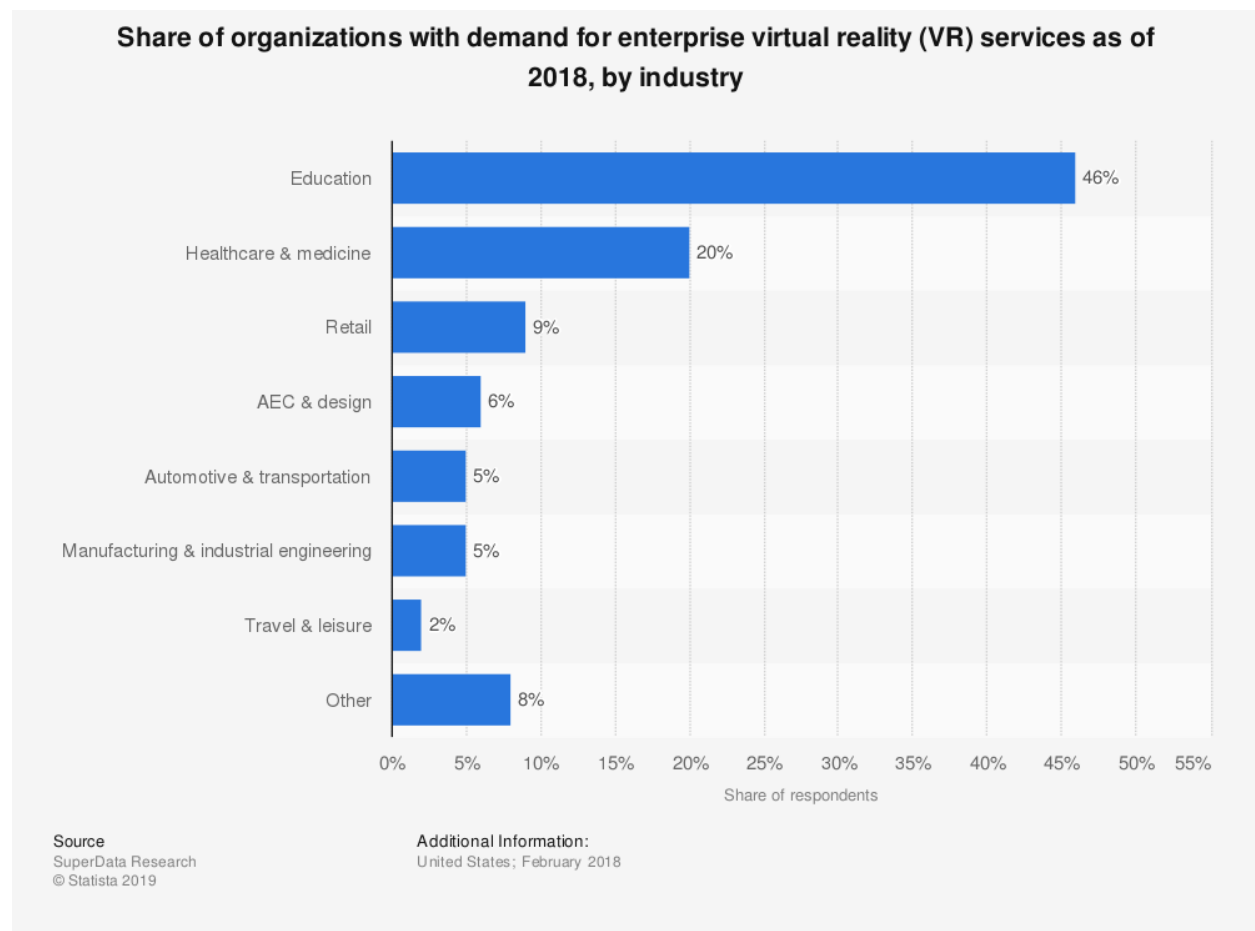
**Table 1: Walmart Inc. Q4 Total Revenue from 2013 to 2017**

<b>Calculation</b>	<b>Q4 2017</b>	<b>Q4 2016</b>	<b>Q4 2015</b>	<b>Q4 2014</b>	<b>Q4 2013</b>
<b>Revenue (Billions USD\$)</b>	\$ 136.30	\$ 130.94	\$129.67	\$131.60	\$128.80
<b>Percent Change in Revenue from Previous Year</b>	4.096658	0.9786607	-1.4688	2.17391	N/A

**Source:** Walmart, Inc., 2018 Q4 Quarterly Results, Feb. 20, 2018, pp. 1.,

[https://s2.q4cdn.com/056532643/files/doc\\_financials/2018/q4/Q4FY18-Earnings-Release-final.pdf](https://s2.q4cdn.com/056532643/files/doc_financials/2018/q4/Q4FY18-Earnings-Release-final.pdf).

**Figure 5: Share of organizations with demand for enterprise virtual reality (VR) services as of 2018, by industry**



**Source:** SuperData Research. "Share of Organizations with Demand for Enterprise Virtual Reality (VR) Services as of 2018, by Industry." *Statista*, Statista Inc., 22 Feb 2018, <https://www-statista-com.ccl.idm.oclc.org/statistics/860822/worldwide-share-of-organizations-demanding-enterprise-vr-services-by-industry/>.



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