

March 18, 2019

UCLA Information Technology Planning Board
Charles E Young Drive E.
Los Angeles, CA 90024

RE: Virtual Reality on the UCLA Campus

Dear Members of the UCLA Information Technology Planning Board,

Thank you for taking time to review the enclosed business intelligence report regarding the integration of Virtual Reality (VR) devices as a pedagogical tool into workspaces and classrooms on the UCLA campus.

Contained in this report is a background description of VR, its technical elements and advantages, an overview and examination of key challenges, and future trends in the mainstream use.

The objective of this report is to assess both the advantages and disadvantages of VR, while addressing the ISP Board's topics of interest including budget, policy matters, and strategic opportunities when investing and deploying information technology. As the board considers the facets of VR, it will be important to keep in mind the emergent and unpredictable nature of the VR market.

I hope you find this report to be thorough and informative. If you have any questions regarding this report, please do not hesitate to contact me via email. I appreciate your time and consideration.

Sincerely,

A handwritten signature in cursive script that reads "Marisa Purcell".

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Insights into Virtual Reality's Pedagogical Future

Overview:

- The reach of Virtual Reality (VR) is extensive, with mainstream industries such as education recognizing the potential benefits of VR integration.
- There is a large variety of choices in the VR market and companies are hiking up price for top of the line architecture and design, ultimately forcing buyers to give up quality for affordability.
- Many companies are sharing their VR software and hardware designs with the public in hopes to create quality content across platforms. While this push for open source VR brings great strides to the industry, it also creates security threats and instability in regulation.
- Companies in the VR industry are focusing more and more on the user's wants and needs, yet the lack of interoperability and modularity across VR inhibits the purchaser from swapping hardware and software once the purchase is made.
- The volatility of the VR market makes it difficult to predict, meaning popular brands and standards could be left behind in an instant

Introduction:

Virtual Reality's future is currently at a crucial point. Society is getting a glimpse into the unique opportunities VR offers, and industries are beginning to understand how VR can benefit their advancement. Though, a complicated balance of VR's architecture, lack of regulation, and the shortfalls in considering the user's need for versatility can be potentially fatal to the future prosperity of VR.

Background:

Virtual reality is expanding across society, permeating multiple industries, and has the potential to change the landscape of higher education. As of 2018, there was an estimated 171

virtual reality users, and the VR hardware and software market is expected to reach \$40.4 billion by 2020.¹ With the growth of VR, industries including healthcare, education, finance, marketing, and manufacturing are considering new applications and are building new tools to enhance user experience and bringing convenient and practical training experiences to the consumer.² The objective of virtual reality is to place users in an immersive environment that simulates reality through head mounted devices.³ There are three categories of classification for virtual reality headsets: tethered VR headsets, standalone VR headsets, and smartphone or handheld VR viewers.⁴ In order for users to have a high-quality immersive experience, companies consider movement tracking, low latency, and high resolution.⁵

Technical Description:

The communication of VR systems is depended on the coordination between the VR headset, internet connection, and VR company servers.⁶ Virtual reality relies on Virtual Reality Modeling Language (VRML) which creates “an interactive sequence of audio, animations, videos and URLs that can be fetched by a web browser to simulate virtual environments.”⁷ Different VR devices require different amounts of bandwidth dependent on the quality of the stream and whether 3D imaging is in high or standard definition.

- a. Tethered VR: To operate a Tethered VR headset, the device needs to be connected to a computer using HDMI and/or USB cables.⁸
- b. Standalone VR: Standalone headsets are considered the all-in-one VR device, in which no cables are needed to access content other than a charger for the battery. Standalone VR has “built-in processors, sensors, battery, storage memory, and displays” so it is not

¹ “BOSS Magazine | INFOGRAPHIC: Virtual Reality Stats Everyone Should See,” *BOSS Magazine* (blog), March 2, 2018, <https://thebossmagazine.com/virtual-reality-statistics-infographic/>.

² Danny Bradbury, “How 5 Industries Are Already Using Virtual Reality,” *Forbes*, accessed January 14, 2019, <https://www.forbes.com/sites/centurylink/2017/09/29/how-5-industries-are-already-using-virtual-reality/>.

³ “Explained: How Does VR Actually Work?,” *Wareable*, December 26, 2017, <https://www.wareable.com/vr/how-does-vr-work-explained>.

⁴ “Types of VR Headsets - PC VR, Standalone VR, and Smartphone VR,” *Aniwaa* (blog), accessed January 29, 2019, <https://www.aniwaa.com/guide/vr-ar/types-of-vr-headsets/>.

⁵ Ryan Bushey, “Advancements in Virtual Reality Device Development,” *Research & Development*, August 29, 2017, <https://www.rdmag.com/article/2017/08/advancements-virtual-reality-device-development>.

⁶ “System Architecture of the VR Demonstrator • Visual: The 3D,” *ResearchGate*, accessed January 29, 2019, https://www.researchgate.net/figure/System-architecture-of-the-VR-demonstrator-Visual-The-3D-representation-of-the-virtual_fig1_221909807.

⁷ “Bandwidth Requirements for Virtual Reality (VR) & Augmented Reality (AR) (Infographic),” accessed January 29, 2019, <https://www.mushroomnetworks.com/infographics/bandwidth-requirements-for-virtual-reality-vr-and-augmented-reality-ar-infographic/>.

⁸ *Ibid.*

required to connect to any external device, and it is almost immediately ready to use when it comes out of the box.⁹ Standalone VR headsets are typically paired to a smartphone via Bluetooth and need to be connected to a Wi-Fi network.¹⁰

- c. Smartphone VR: This device requires users to have a smart phone in which they slide into the headset and access content through VR apps and websites.¹¹

Key Challenges:

1. VR's Architectural Fight Between Quality and Affordability

The greater the computational power the more immersed the user will be. Typically, tethered VR headsets give users the highest quality experience through high-resolution imaging and fast processing speeds, because of the cables that are used to directly connect to a PC or gaming console.¹² High-end headsets are costly and sell between \$600 and \$800.¹³

Standalone headsets are considered to be mid-range in quality and cost. Consumers pay \$75 to \$125 for “software optimization, a better control system than [smartphone headsets, and]... a dedicated app store.”¹⁴ Lastly, there are smartphone headsets/viewers which is the low-cost option. Smartphone VR like the popular Google Cardboard has a price tag of \$15.00.¹⁵ These low-cost products make VR more accessible to a wide-range of people because of their affordability and because 77% of Americans own a smartphone.¹⁶ Though the high-end VR headsets mainly attract gamers, the immersive experience cannot be compared especially to that of the low-cost headsets.

a. Bandwidth

The higher resolution VR headsets require an internet connection with a larger bandwidth, leaving some users without the capability to support immersive VR. Access to a larger bandwidth connection means faster transfer rates and low latency, which is important for VR headsets because 3D scenes are being, “structured into small parts for

⁹ Ibid.

¹⁰ The Android Guy, *How Does Virtual-Reality Work - The VR Experience !!*, accessed January 29, 2019, <https://www.youtube.com/watch?v=-0R1xTq32cw>.

¹¹ “Types of VR Headsets - PC VR, Standalone VR, and Smartphone VR,” *Aniwaa* (blog), accessed January 28, 2019, <https://www.aniwaa.com/guide/vr-ar/types-of-vr-headsets/>.

¹² Ibid.

¹³ “The Ultimate VR Headset Buyer’s Guide,” *TheVerge.com*, accessed February 18, 2019, <http://www.theverge.com/a/best-vr-headset-oculus-rift-samsung-gear-htc-vive-virtual-reality>.

¹⁴ Ibid.

¹⁵ “Get Cardboard – Google VR,” accessed February 25, 2019, <https://vr.google.com/cardboard/get-cardboard/>.

¹⁶ “Demographics of Mobile Device Ownership and Adoption in the United States,” accessed February 25, 2019, <http://www.pewinternet.org/fact-sheet/mobile/>.

rapid delivery over the Internet.”¹⁷ Lower to mid-range cost VR will have a lower resolution and may require somewhere around 25Mbit/s for streaming, whereas the high-quality VR headsets require at least 600Mbit/s.¹⁸ For context, a 720p (below Full HD) VR video stream takes at least 50 Mbps to connect.¹⁹

b. Browsers:

Browser viewing is used with smartphone compatible VR headsets. Browser VR is accessible and affordable but can be unpredictable, “due to the range of devices it can be experienced on... [O]lder generation phones struggle[e] to render scenes and caus[e] a drop-in frame rate. It also requires a good internet connection due to the weight of the experiences. All of these factors can easily break the immersion of a VR experience.”²⁰

2. Regulatory Instability Within VR

a. Lack of Regulation

The rapid evolution of VR has outpaced the establishment of regulatory bodies, therefore eliminating attempts of oversight or regulation. Instead companies are self-regulating based on profit margins with “economics and market forces provid[ing] the primary influences on how we use and develop VR.”²¹ Furthermore, it is likely there has not been a rush to create VR regulations because VR has yet to pose a great risk. Though, experts believe that VR is set to become far more realistic in the next ten years, which in turn can make it more dangerous.²²

b. The Law’s Impact on VR

There is a void in the legal system as it pertains to VR, but the existing legal regulations on VR comes from the case *Zenimax v. Oculus*.²³ Though *Zenimax v. Oculus* was a step in the right direction, the law has yet to firmly create regulation in six hotly contested areas: ownership of VR intellectual property, what can and cannot be included in VR content, what can be brought

¹⁷ Mario A. Gutiérrez Alonso, Frédéric Vexo, and Daniel Thalmann, *Stepping into Virtual Reality* (London: Springer, 2008), 174.

¹⁸ “Bandwidth Requirements for Virtual Reality (VR) & Augmented Reality (AR) (Infographic),” accessed January 28, 2019, <https://www.mushroomnetworks.com/infographics/bandwidth-requirements-for-virtual-reality-vr-and-augmented-reality-ar-infographic/>.

¹⁹ “The Bandwidth Problem: 5 Issues the VR Industry Must Resolve,” *VentureBeat* (blog), May 6, 2017, <https://venturebeat.com/2017/05/06/the-bandwidth-problem-5-issues-the-vr-industry-must-resolve/>.

²⁰ Ibid.

²¹ Matt Sparks, “VR Ethics Codes Need a Boost,” *Learning Solutions Magazine*, August 30, 2018, <https://www.learningsolutionsmag.com/articles/vr-ethics-codes-need-a-boost>.

²² Ibid.

²³ Schuyler Moore, “The Legal Reality Of Virtual Reality,” *Forbes*, accessed February 26, 2019, <https://www.forbes.com/sites/schuylermoore/2017/03/10/the-legal-reality-of-virtual-reality/>.

claims by users against VR companies, what claims third parties can bring against VR companies, what claims VR companies can bring against users, and what claims users can bring against other users.²⁴

c. Data Sharing

Several VR companies choose to share user data with third-party companies without regulation. Data is collected about a user's location, age, name, email address, IP address, and a user's data is also used to target marketing of other products on users.²⁵ Some companies have created their own regulatory data policies like Google and Sony allowing users to opt out of the sharing of aggregated data with third-party sources.²⁶

d. Open Source

Posting source code or allowing users to create their own VR software has the potential to deposit an assortment of unregulated, unsecure, and hard to control VR software and hardware into society. Major companies like Samsung, Google, and Mozilla post their source code and hardware designs, and sponsor workshops in hopes to improve their VR products with the public's help.²⁷ Companies like Open Source Virtual Reality (OSVR) and OpenVR give users VR Software and Hardware Development Kits, allowing users to read the documentation and look at samples of the software, to design their own VR compatible software.²⁸ OSVR has the potential to change the landscape of VR and was founded to address the lack of modularity within VR and has the goal to create, "a universal open source VR ecosystem for technologies across different brands and companies."²⁹ With large companies like Oculus, HTC Vive, and Windows supporting sites like OpenVR, there will be an open-ended absence of regulation on almost all VR devices.³⁰

3. Where the User Stands in the VR World

a. The Downside of VR's Lock-In Business Structure

²⁴ Ibid.

²⁵ Ibid.

²⁶ Ibid.

²⁷ "W3C Workshop on Web & Virtual Reality," accessed March 2, 2019, <https://www.w3.org/2016/06/vr-workshop/>.

²⁸ Ibid.

²⁹ Ibid.

³⁰ Matias Nassi, "Introduction to OpenVR 101 Series: What Is OpenVR and How to Get Started with Its APIs," *The Ghost Howls* (blog), March 15, 2018, <https://skarredghost.com/2018/03/15/introduction-to-openvr-101-series-what-is-openvr-and-how-to-get-started-with-its-apis/>.

Once a consumer purchases a VR device, that consumer will be constrained by the software and hardware that the company offers, and switching suppliers essentially means buying new VR. Tethered and standalone devices are setup to minimize modularity and interoperability across companies, for example, the tethered Oculus Rift headset makes a user download the Oculus Rift software, gives the user access to Oculus apps, and comes with specialized Oculus controllers.³¹ Also with smartphone VR, users must have a phone that is compatible with a headset.³² This gives few options to the consumer if the market changes or a company doesn't offer a certain app/product the consumer needs, meaning users need to know what they want and what devices they already own.

b. Standards are Hindering User's Agency

Top companies are making great strides in creating industry standards, cornering the VR market, and doing their best to push out competition through the creation of standards. W3C is an international community that brings tech professionals and the public together to develop web standards for technology like VR.³³ The W3C VR group is comprised of industry professionals but is run by co-chairs from Samsung and Google.³⁴ It is likely Google and Samsung are trying to control the market by creating standards that focus less on the users and more on their profit and partnership.

c. The User's Agency: Kits and Customizability

As addressed above, companies are giving users the ability to create their own VR software and hardware through development kits. These kits are giving users more control over their VR, but they require a fair amount of computational understanding and experience, giving a large number of users no agency or ability to customize their device.

Future Trends:

The VR market is tumultuous, unpredictable, and rife with competition. VR technologies are constantly changing and even the most popular brands could be left behind in an instant. Yet, the Nielsen Company estimates that 44 percent of individuals interested in purchasing VR are

³¹ Sim UK, *Oculus Rift + Touch | Unboxing & Installation + Day 1 FIRST VR Experience*, accessed February 18, 2019, <https://www.youtube.com/watch?v=bmGNkImQ9VA>.

³² "Mobile VR - What Smartphones Work with Virtual Reality?," accessed February 4, 2019, <https://3g.co.uk/guides/what-smartphones-work-with-virtual-reality>.

³³ "World Wide Web Consortium (W3C)," accessed February 8, 2019, <https://www.w3.org/>.

³⁴ "W3C Immersive Web Working Group," accessed February 8, 2019, <https://www.w3.org/immersive-web/>.

Millennials between the ages of 18 and 34.³⁵ This means VR may not be as difficult to integrate and attract users in a university setting. Secondly, the International Data Corporation has found VR will continue to grow and estimates over 1 billion people will regularly access VR and AR content by 2020.³⁶

One major change in the VR world that may be seen is the move away from the lock-in business structure. Though in the beginning stages, subscription services are proving to be successful. Vive headset sales have increased because of the growing popularity of Viveport, a subscription service allowing users, “to experience up to five titles at a time, starting with a free 14-day trial, and continuing after for \$8.99/month. There are almost 500 curated Vive titles to choose from at any given time [, and] subscribers can exchange titles once a month.”³⁷ Vive has also added applications to their app store that can support the Oculus Rift, which potentially doubles Viveports consumer base and shows potential advancements towards a future of VR interoperability. Lastly, Virtual Reality’s fate may be dependent on the popularity and advances in Augmented Reality and Mixed Reality, both of which pose a threat in taking over VR’s current consumer base.

³⁵ “Virtual Reality Has Real Appeal Among U.S. Gamers,” accessed March 16, 2019, <http://www.nielsen.com/us/en/insights/news/2017/virtual-reality-has-real-appeal-among-us-gamers>.

³⁶ Ibid.

³⁷ Charlie Fink, “Viveport VR Subscription Platform Opening To Rift Users,” Forbes, accessed February 18, 2019, <https://www.forbes.com/sites/charliefink/2018/08/16/viveport-vr-subscription-platform-opening-to-rift-users/>.

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