Evaluating Virtual Reality as a Tool for Equity in Education

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Abstract

Two simultaneous forces may have opened the education system to disruption: the COVID-19 pandemic and developments in virtual reality, augmented reality, and mixed reality technology (XR). The shift to online learning triggered by COVID-19 comes at a time when XR advancements have reached a tipping point in quality and affordability that will permit the education system to feasibly adopt the technology. Within the industry, there is a budding amount of research-backed content specifically for educational purposes that raises learning outcomes, but the majority is not verified by scientifically verified studies. Furthermore, in the context of an American education system with policies, bureaucracies, and complex forces that reinforce inequities, XR's ability to "equalize" educational opportunity as a standalone technology is limited. Nevertheless, the benefits offered by XR – delivering experiential learning; saving time, money, and physical resources; and producing an emotional response amongst learners – can supplement policy initiatives in order to secure a promising future for the education system and its students.

I. Introduction

1. An Overview of the Current XR Technology

In an annual virtual reality conference called Facebook Connect, Mark Zuckerberg described why he believes that virtual and augmented reality* will be the next frontier of the computer revolution[1]. Unlike 2-dimensional screens that are visibly adjunct to reality, and can often become distractions, virtual reality can "deliver a sense of presence" that is fully immersive and nearly indistinguishable from reality. Furthermore, augmented reality makes the digital world much more cheap and interactable, as screens and monitors are no longer needed – only a tiny digital screen and holograms that appear on a small glass window pain. With more intuitive gestures and a user-centric design, AR and VR present a less intrusive interface that can be augmented by AI to produce an unparalleled user experience.

Note: Throughout this paper, I will often use the term "XR" as an umbrella term to refer to all virtual (VR), augmented (AR), and mixed reality (MR). While each technology encompasses different advantages, challenges, and companies, in the scope of this paper it is useful to refer to their collective impact as together they will radically alter the educational and workforce training industries. When specificity is necessary, I will refer to the individual technologies as either VR, AR, or MR.

Facebook, with the leadership of Zuckerberg, has pioneered many of the advancements in the quality of virtual reality hardware and software, employing hundreds of talented cognitive scientists and computer programmers in their Facebook Reality Lab. However, their most important innovation to date might be the way they have shaved off the cost of the consumer technology by considerable margins in the past decade. As little as 10 years ago, fully immersive VR headsets had each cost a hefty $1000 minimum, not to mention the need of additional hardware, software, wiring, and accessories in order to deliver a truly immersive experience. But with the release of the Oculus Quest 2 last year, Facebook has made a fully immersive technology for only $300, without any additional components required.

Google, on its part, has played a major role in reducing the cost of cheaper consumer products such as the Google Cardboard, that allow people to place their smartphones into small head-mounted displays (HMD's) which they can then strap onto their heads. The inertial measurement units (IMU's) of many smartphones allow the user to move freely, with the visual display monitoring their position and orientation to correspond to the 360° video display from the smartphone.

And in the wake of COVID-19, XR may penetrate more of the global market than ever before, as companies begin to shift entire swaths of their employees into remote work, and education

[1] Zuckerberg, M. (2020, October 12). *Facebook Connect | Keynote 2020.* Youtube.com. https://www.youtube.com/watch?v=-cRxT32G7y4

systems begin to realize that digital, remote delivery of instruction is much cheaper than providing infrastructure and facilities to thousands of students. The global pandemic may have accelerated the time horizon for the dominance of digital work and digital education, and therefore the market seems prepped for more disruptive technologies, as the natural disruption of the coronavirus has scraped away many of the resistance and doubts that remote interaction was somehow unfeasible.

The culmination of these two trends – the massive innovations that made virtual reality much more accessible and the natural disaster that steamrolled most resistance to new technology – have paved the way for the entrance of virtual reality in the education and corporate training industries.

2. XR in the Educational Landscape

Several features of virtual reality present advantages for usage in education and workforce development. The first feature echoes Zuckerberg's conviction towards "delivering a sense of presence," as VR is capable of giving its users an experience that can arouse the human brain's affective (emotional) response. By giving realistic visual experiences to the largely visually oriented creatures that humans are, virtual reality can deliver digital content in a much more immersive and impactful way.

A second, closely related feature of virtual reality is its ability to provide a true experience. As educational researchers highlight the importance of experiential and project-based learning (PBL), virtual reality offers an affordable means of delivering experiences to learners by using digital programs and scenarios that are safe and easily manipulated by both the learner and the administrator of the content.

Thirdly, thanks to companies such as Apple, Facebook, Google, virtual reality is much more affordable and accessible to educational actors. Motivated by a unique intersection of corporate social responsibility and profit optimization, these two major technology companies are the most recent in a long line of industry giants who view education as a chance to induce brand loyalty amongst young people while also supplementing struggling education systems around the world with technology that reduces the price of content and its delivery[2]. The two most recent examples include iPads in schools (~$400 each) and Google Chromebooks (~$150 each). With the Oculus Quest 2 sitting squarely at $300 each, education systems could potentially consider the technology as a sensible and affordable supplement.

[2]Rim, C. (2018, October 31). iPads Are Not The Future Of Education. Forbes. Retrieved April 18, 2021, from https://www.forbes.com/sites/christopherrim/2018/10/31/ipads-are-not-the-future-of-education/

3. XR and Ed Tech as Tools for Equity

These major technological and societal trends, taken in sum, make virtual reality an inextricably disruptive technology in many major industries. The scope of this paper, however, centers the potential revolution of the education and workforce development industries. My central concern in this paper is more than just a prediction of the likelihood that virtual reality will alter the industries, but rather, in what timescale, and with what overarching societal impacts?

According to Horace Mann, the famous early 20th century pioneer of American public education, education has the potential to be "the great equalizer" in society. He described the intermingling of young people of all backgrounds, each engaged in schools that engaged them under one shared roof. Evidently, the spirit of education as a "great equalizer" has been compromised due to a myriad of different factors, including *de jure* and *de facto* segregation, income inequality, and pre-existing societal injustices. Despite these difficulties, countless thought leaders, politicians, and business leaders have championed technology as a "silver bullet" to truly democratize education and realize the vision of Horace Mann. These trends have included the One Laptop Per Child (OLPC) movement, Massively Open Online Courses (MOOC's), education platforms such as Canvas and Blackboard, and fully virtual educational institutions such as University of Phoenix, DeVry University, and Southern New Hampshire University (SNHU).

Yet despite these technologies, education remains unequal – at least in the United States. In light of these past efforts to fully democratize education through the private sector's technologies, virtual reality presents very stark differences and very clear advantages to their predecessors. But education equality has remained an elusive wish, mired in a nebulous mesh of bureaucracy, policy, and centuries of societal injustices.

While virtual reality is far from a silver bullet, with an understanding of policies and the specialized advantages of virtual reality, the technology may be able to bring the United States closer to the true democratization of education paired with equal opportunity and access.

II. The Technology

Currently, the hardware and operating systems of virtual reality are leaps and bounds ahead of the actual content that is available. The quality of the digital screens, the interactivity of the user interface, and the potential to deliver immersive experiences are not matched by an equivalent amount of deliverable experiences – especially in the education space. While the gaming industry has seen an uptick in the past year of 12 to 35 companies pulling in revenue over $1M, the same cannot be said for the amount of educational content on the market currently.

1. Hardware

The hardware exists along a wide spectrum, with the most recent endeavors into the classroom coming from companies such as Google Cardboard, which are cheap viewing devices that are compatible with most smartphones. With these headsets, the smartphone is merely inserted into the viewing compartment, and a slit separates the viewing port of the right and left eyes. The smartphone plays two separate iterations of the same video, from slightly different angles as to simulate the slightly different perspectives of the right and left eyes. The video display on the smartphone is curved, so that when images are seen through the viewing port, it appears to be properly dimensional and immersive. The smartphone registers its own position in 3D space, and adjusts the video display as the user tilts or rotates their head.

The Google Cardboard (left), starting at $15, and the Oculus Quest 2 (right), starting at $299.

For VR, HMD's which can exist as stand-alone consoles, Oculus is a viable option for mass distribution in the education setting while delivering a high end immersive experience (two market competitors to mention are the HTC Vive and Playstation VR, but both are more expensive). The Oculus Quest 2 was released this past year at $299 USD, with a custom Qualcomm Snapdragon XR 2 chip, a single LCD panel display, and cameras that can sense external surroundings while you are immersed. It is an all-in-one system that does not require any other console or components aside from the head strap and hand controllers which provide feedback and a wide range of controls. It also offers beta features such as hand gesture controls that do not require a hand-held controller.

2. The Current Market

i. The XR and EdTech Markets

In 2019, the global VR market alone was valued at $3.2bn and is projected to reach $57.5bn by 2027, according to Fortune Business Insights[3]. Needless to say, the AR and MR markets showcase similarly exponential growth. These trends are motivated by the rapid advancements in hardware and software, and more countries and major corporations dedicating vast amounts of human and financial resources to more R&D.

As for the EdTech market, the analyst firm HolonIQ has estimated that in the 2020's global EdTech venture capital will reach $87bn+, up from $32bn in the 2010's (Figure 1)[4]. This projected near-three-fold increase will be clustered primarily in XR, AI, and cloud computing. China dominates the VC realm of EdTech, making up over half of the global amount invested, with the US following with 33%, followed by the EU, then India, then the rest of the world.

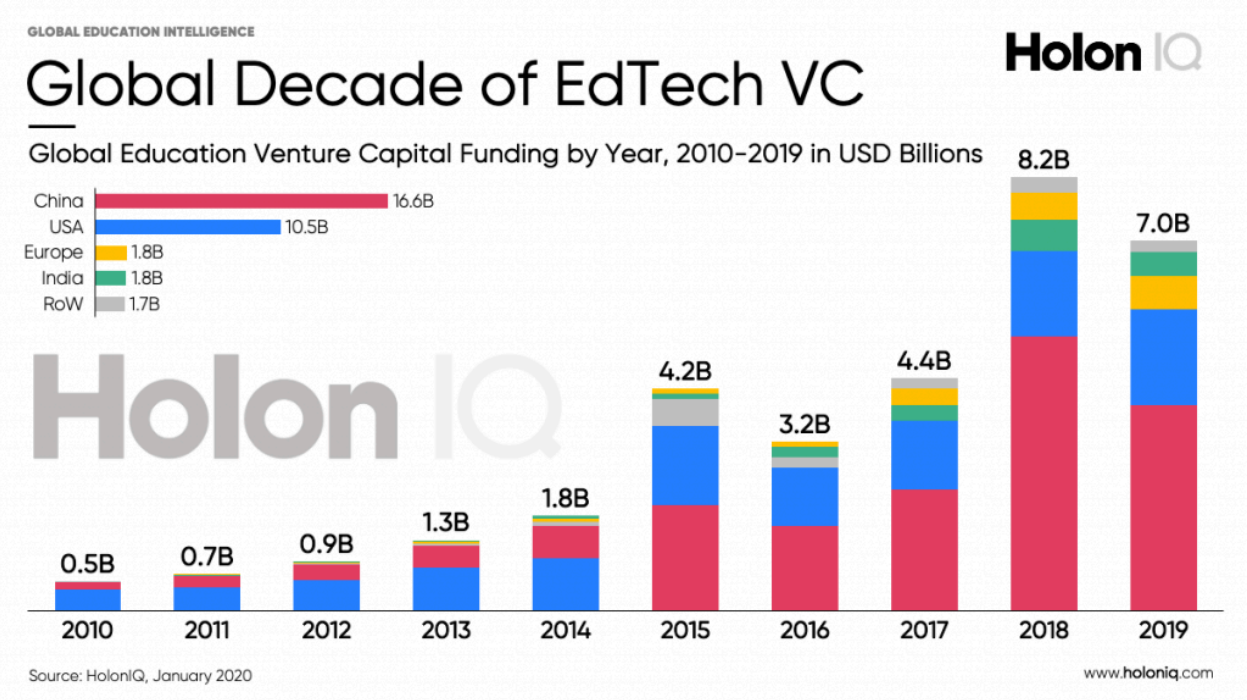

Figure 1: The 2010's Global VC in EdTech, showcased by year and by country.

[3] Fortune Business Insights. (2021, June 1). Virtual Reality [VR] Market Size, Growth, Share | Report, 2030. Fortune Business Insights. Retrieved April 18, 2024, from https://www.fortunebusinessinsights.com/industry-reports/virtual-reality-market-101378

[4] Holon IQ. (2020, January 28). $87bn+ of Global EdTech funding predicted through 2030. $32bn last decade. HolonIQ. Retrieved April 18, 2024, from https://www.holoniq.com/notes/87bn-of-global-edtech-funding-predicted-to-2030/

ii. Educational Surveys[5]

As of 2016, the usage of virtual reality technology sat at 5% among teachers, with computer science teachers (11%) and science teachers (9%) using the technology at the highest rates. For students, about 9% of middle schoolers (grades 6-8) and 8% of high schoolers (grades 9-12) have used VR or AR in the classroom.

Only 13% of teachers and 12% of principals expressed that they would like to see AR in their "ultimate school," and 23% of teachers and 29% of principals said the same for VR. 13% of teachers indicated that they would like to undergo professional development (PD) to learn how to introduce VR or AR into the classroom. In sum, these results indicated that pre-COVID, the technology had not reached widespread adoption, and there was considerable resistance to behavior change on the parts of faculty and administration.

However, culture is shifting. According to Steven Sato, a business developer I spoke with at Immersive VR Education, teacher conferences such as ISTE may be the first signs that educators are amassing collective buy-in for XR technologies[6]. In the wake of COVID-19, the number of educators and schools interested in Immersive VR Education's offerings shot up, as reflected by an increase in requests for speaking and product introductions and demonstrations.

Data is not yet available about how COVID-19 has affected the adoption of XR across the education system, but as digital learning gains popularity and legitimacy, it is highly likely that XR will form a central part of the conversation.

3. Research and Applications (2017 and 2014)

According to a 2014 review of the current educational content available, "virtual reality-based instruction is an effective means of enhance (*sic*) learning outcomes.[7]" The authors give a call to action, stating that "educational institutions planning to invest time and financial resources are likely to see the learning benefits in their students." The specific details of their report indicate that the most strong findings of enhanced learning outcomes come from games and short simulations. These highly interactive lessons leverage the advantages of VR's natural engagement and experiential learning. However, the authors call for more rigorous studies of the actual learning outcomes, and suggest that current research has a shortage of methodological rigor.

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[5] Speak Up Research Project for Digital Learning. (2017, November 9). Augmented and Virtual Reality in K-12 Education: Current Status and Aspirations. Tomorrow.org. Retrieved April 18, 2021, from https://www.tomorrow.org/speakup/speak-up-2016-augmented-and-virtual-reality-in-k12-education-april-2017.html

[6] Interview with Steven Sato.

[7] Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014, January). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. Computers & Education, 70(1), 29-40. ScienceDirect. https://doi.org/10.1016/j.compedu.2013.07.033

According to a second review, in 2017, VR in education provides real improvements only along a limited scope of skills. These skills include "cognitive skills related to remembering and understanding spatial and visual information and knowledge; psychomotor skills related to head-movement, such as visual scanning or observational skills; and affective skills related to controlling your emotional response to stressful or difficult situations."[8]

A third study, published by Dr. Muller Queiroz, lead education and VR researcher at the Stanford Virtual Human Interaction Lab (VHIL), confirms several of the prior studies' findings, and offers broader implications for how VR can impact the education system as a whole[9].

> *"Research studies in education [demonstrate] that the use of technology can help improve students' scores on standardized tests, their inventive thinking, and their self-concept and motivation. In addition, Dede states that the educational usage of technology can help to foster fundamental skills for the twenty-first century, such as information literacy, communication skills, global awareness, creativity, and collaboration."*

Queiroz echoed the concern that many content developers and researchers have not reached a level of methodological rigor[10].

4. Select Educational XR Companies

Immersive VR Education's ENGAGE Platform

One of the most exciting companies in the VR-Education industry is Immersive VR Education. Founded in 2014, one of the company's primary offerings is ENGAGE, which is a fully immersive platform that allows students to feel an in-person experience such as a lecture all through the headset. ENGAGE is also an all-in-one, "motion capture studio in a box," as Steven Sato, Business Developer at the company described it in an interview. The platform allows a student to take a recording of oneself completing a task, giving a tour, or delivering a lecture, and translating those movements into the VR platform.

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[8] Jensen, L., Konradsen, F. A review of the use of virtual reality head-mounted displays in education and training. Educ Inf Technol 23, 1515–1529 (2018). https://doi.org/10.1007/s10639-017-9676-0

[9] Queiroz, A. C. M., Nascimento, A. M., Tori, R., & da Silva Leme, M. I. (2018, June 16). Using HMD-Based Immersive Virtual Environments in Primary/K-12 Education. Immersive Learning Research Network 4th International Conference, 4, 177-190. https://link.springer.com/chapter/10.1007/978-3-319-93596-6_11

[10] Interview with Dr. Queiroz

Content Creators[11]

The hardware and software in the VR industry is well-developed, and the industry is waiting for an influx of content for all purposes – from gaming and entertainment to education. A high number of startups have been arriving to fill the gaps in content, and a few of them are discussed

1. Immersive VR Education

In addition to their platform, they offer several content options, such as the Apollo 11 HD, an experience transporting users into the historic space mission; Shuttle Commander, a tour of the galaxies through the Hubble Telescope; RCSI Medical, a jarring and intense scenario of a car accident and the medical response to save a life; and on the horizon is an immersion that will place users into the heart of the 1920's Jazz era of Harlem, providing a firsthand glimpse of segregation and discrimination in America.

2. Neo Bear

Founded in 2009, this company has received about $56M in funding to date, and it specializes in AR content for children to learn words and language, using flashcards, painting, and a cartoon video series. It's based in Shanghai, and major investors include Qualcomm, Kaishi Capital, and Jiangsu Huaxi Group.

3. Strivr

Founded in 2015, this company specializes in providing training modules for major corporations, including Walmart, VISA, Fidelity, Bank of America, and Google, to name a few. They have received $52M in funding, and investors include Prologis, Franklin Templeton Investments, National Football League. They are headquartered in Menlo Park.

4. Talespin

Another competitor in employee training, this company was founded in 2015, is located in Los Angeles, and has received $20M in funding from investors such as Farmers Insurance, Cornerstone, and HTC Corporation. Their clients include Stanford University, COX, Google, Jaunt, and Workplace.

5. Labster[12]

This Danish startup is leading the way in making realistic STEM lab experiences at a low cost.

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[11] Top 825+ companies in AR VR in Education. (2021). Tracxn. Retrieved April 18, 2021, from https://tracxn.com/d/sectors/ar-vr-in-education/__NJg9lCPD-fsOjB_huuOEu_ytoO4c8Pi-YKJGTIiLpzc/companies

[12] O'Hear, S. (2019, April 25). Labster scores $21M Series B to bring VR to STEM education. TechCrunch. Retrieved April 18, 2021, from https://techcrunch.com/2019/04/25/labster-series-b/

6. Lifeliqe: Digital Science VR

Lifeliqe has created a multiple platform, NGSS and Common Core aligned curriculum that presents a model for teaching and learning that highlights AR as a supplement to learning

7. Oculus

Last but not least is Oculus, which is the well-known subsidiary of Facebook that produces the Oculus HMD – a fully contained unit that does not require any wires, consoles, or PC. Oculus may also disrupt the education industry directly, however, through the creation of a software called Infinite Office. This system aims to eliminate the browser by allowing individuals to view a 360 office without the need of a monitor, keyboard, mouse or trackpad. Through sensory detectors, the Oculus headset can detect gestures on a flat surface to replicate mouse and keyboard motions, and use hand motions to change screens, scroll, zoom, etc.

III. The Education System

1. History of Inequality

i. Education as the Great Equalizer?

The model of education put forth by Horace Mann posited public schools as "the great equalizer," but despite this strong vision, the policies of segregation in antebellum America which were built upon the ruling of *Plessy v. Ferguson*, education achievement and social mobility remained strictly dictated by racial and socioeconomic lines[13]. After *Brown v. Board of Education,* as well as the executive orders and Supreme Court rulings that upheld affirmative action throughout the 60's [14]. In the decades that followed, the education system has seen a gradual increase of inequalities and *de facto* segregation, due to the dual trend of housing in American cities becoming more stratified by race and income paired with most states having education funding by pulling from property taxes [15]. In 2020, the COVID-19 pandemic shined a light on the income inequality facing school systems, as the vast majority of students without access to proper wifi or continued instruction were clustered in locations with high levels of racial minorities and low socioeconomic resources[16].

ii.Separate, not Equal

Education equality has been a pipe dream for many years, not just along race but also in socioeconomic status (Hechinger)[17]. According to education policy research Michael Seelig, four policies have intersected to make schools more unequal: gentrification, housing, standardized testing, and school choice[18]. As these networks of policies create a system of inequality, many advocates of school equity such as educational researcher and author Alfie Kohn argue that the nation must reform the most basic premises of the education system, including testing, homework, "achievement," and competition[19].

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[13] Darling-Hammond, L. (1998, March 1). Unequal Opportunity: Race and Education | Brookings. Brookings Institution. Retrieved April 18, 2021, from https://www.brookings.edu/articles/unequal-opportunity-race-and-education/

[14] Brunner, B., & Rowen, B. (2020). Affirmative Action History – Office of Equal Opportunity. The University of Rhode Island. Retrieved April 18, 2021, from https://web.uri.edu/equal-opportunity/affirmative-action/affirmative-action-history/

[15] Seelig, M. A., O'Day, J., & Smith, M. S. (2020, June 18). How 20 Years of Education Reform Has Created Greater Inequality. Stanford Social Innovation Review. Retrieved April 18, 2021, from https://ssir.org/articles/entry/how_20_years_of_education_reform_has_created_greater_inequality

[16] Wen, L., Strauss, V., & Schneider, J. (2020, April 14). Perspective | How covid-19 has laid bare the vast inequities in U.S. public education. Washington Post. Retrieved April 18, 2021, from https://www.washingtonpost.com/education/2020/04/14/how-covid-19-has-laid-bare-vast-inequities-us-public-education/

[17] https://hechingerreport.org/a-decade-of-research-on-the-rich-poor-divide-in-education/

[18] Seelig, M. A., O'Day, J., & Smith, M. S. (2020, June 18). How 20 Years of Education Reform Has Created Greater Inequality. Stanford Social Innovation Review. Retrieved April 18, 2021, from https://ssir.org/articles/entry/how_20_years_of_education_reform_has_created_greater_inequality

[19] Milnes, J. (2011, August 18). Educational Theory of Alfie Kohn. NewFoundations. Retrieved April 18, 2021, from https://www.newfoundations.com/GALLERY/Kohn.html

iii.The Role of Education in Economic Mobility[20]

The reason this systemic approach is needed, rather than say, abolishing school systems, is the fact that when employed correctly and intentionally, education can be a strong force for racial equity and the reduction of income inequality. According to a report by Georgetown University Center on Education and the Workforce, bachelor's degrees continue to confer a high level of return on investment over a lifetime, and the return on investment of a degree is still an economically sound decision (CEW). The returns continue to increase with more schooling, with 83% of professional degree holders making more than the median bachelor's degree holder.

Furthermore, education has many other positive benefits on society, including the reduction of authoritarian and highly polarized attitudes (CEW). Unfortunately, these benefits are lost to the most disadvantaged members of society, as inequality compounds itself, beginning in early years and stretching along the entire educational landscape, with many minorities and underprivileged students not receiving the opportunities afforded to the majority population and the most economically equipped (CEW). Even after college, the race to find jobs disproportionately benefits white graduates more than their minority counterparts of the same educational backgrounds (CEW).

2. K-12 Education Policy Landscape[21]

It is important to note that the American education system is a complicated web of disconnected parts that together make a relatively coherent whole. This is the case on both the student side – with major differences and incoherencies between pre-K, K-12, and higher education – and the policy side – with vast funding and policy differentials between the local, state, and national levels as well as the public and private sectors and the appointed or elected officials. This highly highly intricate model of education makes policy discussions a nightmare, particularly when discussing changes at the systemic level.

For the purposes of this paper, I will center K-12 policy and give attention to the public and private sectors. I will only briefly discuss the higher education system.

i. Federal Situation

The most overarching impact that the national government can have on education is through budget allocation and appointment power. The president and Congress can have a large impact on the amount of money allocated to each state, and it can enforce several requirements for state's to obey in order to receive those funds. The most famous example of this power is the No Child Left Behind Act during the Bush era, which put in place rigorous testing requirements for

[20] Jackson, M., & Holzman, B. (2020). A century of educational inequality in the United States. In Proceedings of the National Academy of Sciences (Vol. 117, Issue 32, pp. 19108–19115). Proceedings of the National Academy of Sciences. https://doi.org/10.1073/pnas.1907258117

[21] Rippner, J. A. (2015). The American Education Policy Landscape. Taylor & Francis.

states to meet and placed accountability on students to have high achievement levels through test scores. Funding was allocated in order to meet the state's needs and increase their average test scores.

A second remnant of the Bush era, reinforced during the Obama administration, is the provision for school choice – subsidized through school vouchers that allow parents to act as consumers in choosing which schools to enroll their children.

Both of these policies remain in place today, and they signify a shift towards federalism and the free market: students and their parents are given vouchers and the choice of how to approach school enrollment, and states are given individual incentives to ensure that their overall populace meets education testing standards.

These policies are important to note as they signify a more individualistic and privatized approach to education, and therefore the path to implementing XR in schools has become primarily a state and local issue, and in many cases, even an individual school or family issue.

ii. Tech Policy[22]

Budgets for purchasing technology are usually decided at the state level, and input on recommendations for tech adoption comes from The U.S. Department of Education Office of Educational Technology (OET), which puts forth guidelines to closing the digital divide, implementing technology use and skills into the classroom, and works closely with the private sector in developing technologies alongside curriculums. While this office does not have significant implementation power, it can exercise influence on state and national policies in education technology.

iii. State Level

At the state and local level, the majority of state and national policies are actually implemented and produce the most direct impact on young people's lives. The funding distribution lies at around 45.2% from states, 44.6% from local governments, and 10.2% from the federal government, with a total of $600 billion in K-12 in the 2011-2012 school year. States are responsible for creating policies around funding distributions and standards implementation, and local governments are responsible for making decisions to meet those standards at each individual school. There is considerable autonomy at the local and school level in implementing programs, but some difficult requirements limit school autonomy, such as Common Core standards, preparing students for college, and meeting testing requirements.

[22] US Department of Education. (2020, June). Introduction - Office of Educational Technology. Office of Educational Technology. Retrieved April 10, 2021, from https://tech.ed.gov/netp/introduction/

3. Privatization Trends

The most recent trend of the education system is increased privatization and decentralization.

i. Private and Charter vs. Public

In the past 20 years, there have been increased commitments to charter schools, school vouchers, and school choice, as a result of Obama and Bush era policies. More vouchers and school choice encouraging entrenched educational inequities to be ignored, and allowing for higher levels of personalization. There has been a rise in charter schools, which now enroll 7% of all students nationally since their introduction only 20 years ago. These effects can be seen dramatically in Washington, D.C., where 50% of students attend charter schools.

The privatization of education bodes well for XR in education. Charter schools are privately run and funded by public funds. Administrators have near full reign over their curriculum, but have to meet the same testing standards. XR can be implemented by directly marketing to administrators and teachers.

ii. Platforming of Education and MOOC's

With the mass popularity of MOOC's in 2012, thousands of institutions have produced content on platforms such as Coursera, edX and Udemy. Furthermore, platforms such as Blackboard, Canvas, and Google Classroom have allowed educational institutions to host all their content in one centralized digital platform. All assignments, lectures, readings, and activities can be integrated into these tools.

With these two trends taken in tandem, the avenue for XR to enter the education system has been paved. Now that in many school districts, content can be digitally delivered, the biggest difficulty is reworking the content from MOOC's and other online courses to include XR experiences and tools. In other words, integrating an activity into Canvas that requires an Oculus is no longer a herculean task, as the platforms exist for delivery.

iv. COVID-19[23]

With the COVID-19 pandemic, schools were forced online, and the most under-resourced schools were overcome by the challenge of providing digital resources such as internet hotspots, laptop computers, and environments that were conducive to learning. Both the higher education and K-12 education systems were challenged and forced to adapt, and to varying success, as reported on extensively by the Hechinger Report. Many schools were forced to adopt online tools such as Zoom, Canvas, and Gmail to replicate their traditional forms of communication and instruction.

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[23] Baumhardt, A. (2020, April 9). How students are managing college online in the time of coronavirus. The Hechinger Report. Retrieved April 16, 2021, from https://hechingerreport.org/college-in-the-time-of-coronavirus/

IV. Strategic Approaches to Implementing XR (3 pages)

1. The COVID-19 Pandemic

In response to the COVID-19 Pandemic, XR companies should take advantage of the wave of digital learning acceptance across the world. With most schools transitioning to some form of online learning, teachers and students are now more accustomed to receiving information, conducting assessments, and holding classroom activities entirely through virtual settings. This trend is likely to continue for many schools, especially in school districts where internet access is not a large issue. Now that the nation is captivated by the idea of fully online learning, more and more professionals in the education field are viewing XR as a realistic supplement to learning, as it possesses key advantages over the traditional delivery of digital learning on a 2-dimensional screen.

2. More Quality Content

The XR industry is leaving its infancy. Notably, the gaming industry is taking off (12 companies made over a million last year, and 35 companies this year), and several EdTech startups are beginning to grow into the sector. More and more people are beginning to use the technology, with 90% of people using the Oculus Quest were first time users. Society may be slowly shifting to become more accepting of the technology, especially as it starts to penetrate the households of students, parents, teachers, and policymakers alike.

As the amount of quality content increases, there will be more and more buy-in from interested teachers and students. If XR companies can position themselves as supplements to traditional teaching, they can ease the adoption of the technology by individual educators. For example, the company Lifeliqe went through a process of developing their science curriculum to align with NGSS and Common Core standards, and therefore they can be easily adopted by teachers.

3. High-Touch Approach

In education, the first splashes have already been made. Google Expeditions reached a few hundred thousand users, at very low costs they provided under-resourced schools the chance to visit Mount Everest. These experiences may have a broad impact, as echoed by Dr. Queiroz, since most educators have less misgivings about the technology after they have given it a test-run.

Furthermore, the legitimacy of the technology is only increasing as the technology takes root in other arenas, such as entertainment and gaming. Highly respected institutions such as the UN have even used the technology, producing an award-winning movie project called *Clouds Over Sidra*, which showcases the plight of refugee camps following the Syrian Civil War.

4. Stakeholders

Humans are most naturally visual and spatial thinkers. Hearing or reading things and writing them down are less effective, but that is what the current education system is. We learn best by using chunks that contain concepts. That is why we like mnemonic devices, analogies, metaphors, and demonstrations. But those occupy a small sliver of educational experiences, even though they are the most effective and *sticky*. Imagine if the ratio was flipped, and we used visual and spatial concepts as the basis for learning, and reading and writing were adjuncts. Not only would more students be engaged, but the quality and longevity of learning would be improved. Teachers could spend less time lecturing and spend more time assessing, engaging, and directly interacting with students.

i. Faculty

A difficult stakeholder are faculty members, who would have to adapt their curriculum in order to meet the already stringent requirements facing most K-12 educators, and they would also need to be retrained in order to learn how to facilitate these sessions. Mr. Sato confirmed this assumption in my interview, and showcased the change in attention at several conferences, such as ISTE. With COVID-19, more and more educators at these teacher conferences were interested in the technology.

When it comes to approaching faculty, it is important to position the technology as a time and cost save, as well as a chance to engage students with naturally enticing content. It is also necessary, as Dr. Queiroz suggests, to implement a high-touch approach when using the technology. Most teachers were highly resistant and doubtful of the technology until they used the technology for themselves. Dr. Queiroz mentioned that implementing the technology can successfully engage the affective and emotional responses of the learner, and once the educator has experienced this fact for themselves, they can better appreciate the potential of the technology in enhancing experiential learning.

Furthermore, as research findings get more conclusive and the effectiveness of content is verified at regulatory standards, there may be increased buy-in from policymakers as well. A national study of teachers showcased the general support for technology:[24]

> *Sixty-nine percent of respondents said differentiation and/or personalized learning is "very valuable" for improving student outcomes. Nearly all respondents (93 percent)*

[24] Dreambox Learning, PBS, & The Education Week Research Center. (2018, December 1). Educators Believe Educational Technology Can Personalize Learning—And Want Additional Support in Training and Professional Development. DreamBox Learning. Retrieved March 28, 2021, from https://www.dreambox.com/resources/research/educators-believe-educational-technology-can-personalize-learning-and-want-additional-support-in-training-and-professional-development

> *agreed that using technology for instructional purposes is an effective way to provide differentiated and/or personalized learning experiences that adapt to student needs.*

If XR content providers can hone in on the existing need by teachers, they may be able to fill a need that the current education system cannot provide.

However, this push for more content and technology should come with an understanding of the pressures teachers currently face, and the training necessary to implement this technology effectively.

> *Still, 42 percent of respondents said teachers in their school community or district do not have the support they need to effectively use educational technology, and 69 percent of respondents indicated they need more training in using technology tools.*

ii. Policymakers (California, Forbes, MIT Technology Review, TechAdvocate)
As stated above, the policymaker approach can come at one of the myriad levels of the education system. In terms of immediate adoption, it may even be more advantageous to directly pitch the technology to teachers and schools. However, XR proponents can follow the precedent set up by the widespread adoption of computers, iPads, and laptops for students in many local school districts. By approaching the district budget coordinators, XR proponents can encourage shifts away from traditional technologies and towards the adoption of XR in classrooms. Especially in the case of the Oculus Quest 2 (at $300 USD), this technology is priced at a similar or cheaper amount compared to other technologies, such as Mac computers, Windows PC's, and iPads.

Policymakers also have a tendency to purchase education technology even when their adoption is not supported by any rigorous metrics on how they will improve student performance. Needless to say, XR proponents can capitalize on this trend and implement XR technology and content that can deliver scientifically verified improvements in learning.

iii. Parents
As for parents, the most important concerns will vary based on the demographic of the parent. While more wealthy parents are more likely to be cognizant and worrisome over the effects of technology on children, this is not the case for middle-and-lower-income parents[25]. Research is not yet available regarding precisely how parents would react to XR in education, but XR companies can expect a similar resistance to a technology that is championed without actually exposing parents to the technology itself and allowing them to experience it. Because of the nature of the education system, parents (particularly affluent ones) can play a significant role in

[25] Christopher, R. (2018, October 31). iPads Are Not The Future Of Education. Forbes. Retrieved March 26, 2021, from https://www.forbes.com/sites/christopherrim/2018/10/31/ipads-are-not-the-future-of-education/?sh=4a8c0ffb1f54

influencing school policies, and therefore XR companies should hold this in mind when approaching individual schools and districts.

iv. Students

The case for XR is strongest because of the high amounts of student interest in XR technology. Especially in an education system where students are often consulted last, XR presents a powerful exception, and one that not only grabs student interest but also aligns with improved learning and outcomes.

5. Tactics

1. *Use XR as a supplement. An engagement tool.*

Cutting-edge researchers, including Dr. Bailenson and Dr. Queiroz at the Stanford VHIL, have emphasized the role the XR can play in supplementing learning by providing "field trips" and creating social emotional learning experiences. Neither of them have suggested that XR could one day replace the current educational system and its brick-and-mortar components.

2. *XR must be well-integrated into the curriculum, with clear outcomes for students and support by teachers.*

The many difficulties that teachers face in meeting bureaucratic requirements means that any new technologies or platforms must recognize these realities, or risk becoming adjuncts to the delivery of content. The oversaturation of requirements in schools means that educators do not have the time

3. *XR is a cost-and-time-save for vocational training, and the education system can capitalize and center traditional learning around character development, SEL, service learning, and creativity.*

As seen in the workforce development industry, corporate trainings that use XR are highly cost-effective and time-saving. The education system as a whole must understand this reality and position XR as a chance to effectively teach individual, highly technical skills and save teachers time where it is sorely needed. By working with curriculum developers at the state and national level, XR providers can strategize in which parts of Common Core they can position XR to save teacher's time and improve effectiveness.

4. *XR unlocks potential for social change, such as overcoming bias and student-ownership of education.*

Lastly, XR has been proven in isolated cases to improve empathy across difference and increase self-efficacy and self-confidence. These outcomes map well onto the current societal shifts, such as calls for racial equity and increasing civic engagement and participation in democracy for young people. By centering these two outcomes and their tangible societal benefits, XR companies can highlight their popularity amongst both young people and policymakers, increasing the likelihood of governmental adoption of the technology.

6. Promising Cases

i. Vocational Training (JFF Labs, and Interplay Learning)

The easiest case to discuss which is the most ripe for disruption is vocational training. Companies like Walmart and industries such as HVAC, solar installation, food safety, and even surgery have clear standards and skills they need workers to accomplish for certification, opening the door to clearly delivered virtual trainings that utilize XR. By implementing XR, they can save resources, manpower, and actual brick-and-mortar costs. It is highly feasible and affordable to $300 dollars on a headset that employees can borrow for 2 weeks, then reuse for the next batch of hires.

ii. STEM

The cost of educational lab equipment is high, the facilities are construction nightmares requiring special pipelines and vats, the chemicals themselves can be very expensive, and the potential dangers posed to students are all factors that make the laboratory components of STEM educations ripe for disruption by XR. With XR, students can practice pouring, pipetting, and seeing reactions take place all through the use of a single headset, and the headsets themselves are reusable, whereas reacted chemicals in vials are not.

Two notable entities have tackled the creation of a XR lab for stem usage, the first being Labster, a Danish company that recently raised $21 M in funding, and the Indian government, which has made the creation of XR labs a priority in its efforts to supplement the XR education in under resourced schools in rural India [26, 27].

iii. Social Emotional Learning and Soft Skills Training (PWC and Deloitte)

The social emotional learning capabilities of XR are the most exciting for many researchers and educators, as echoed by Queiroz. Two studies by major corporations, PwC and Deloitte, have

[26] O'Hear, S. (2019, April 25). Labster scores $21M Series B to bring VR to STEM education. TechCrunch. Retrieved April 18, 2021, from https://techcrunch.com/2019/04/25/labster-series-b/

[27] Warsi, S. (2018, December 28). How AR And VR Transformed The Indian Education Industry In 2018. Opportunity India. Retrieved April 6, 2021, from https://www.opportunityindia.com/article/how-ar-and-vr-transformed-the-indian-education-industry-in-2018-12351

championed the cost-effectiveness and overall improvements offered by XR training[28, 29]. A few of the headliner findings include a four-fold increase in cost-effectiveness, 275% increased confidence in skill applicability, four-fold increase in focus compared to e-learning, and 3.75 times more emotional connection with the learning experience and content.

V. Regulatory Concerns

1. Student Health

One of the primary concerns with XR in education is ensuring student wellness. Cybersickness, emotionally jarring content, and potential seizures for at-risk students are each well-documented and will have to be included in a policy framework if institutional, governmental adoption is to begin.

2. Privacy

A second concern regards the privacy of students. XR HMD's are capable of storing information about student log-ins, as well as their performance and behavior in a XR simulation. There are even software which track student eye movements and collect patterns on thought processes and responses to stimuli. Each of these privacy concerns are well-documented and precedent is in place for creating special education servers for technology or software companies that wish to enter schools. For example, Microsoft Windows, Apple, and Google are all familiar with privately hosted school domains with limited logins, restricted access to the internet, and private storage of student information. These privacy controls are already in place and can be easily translated to regulate XR and other software.

3. Multi-User Behavior

With the arrival of multiple-user software that allows for interaction between students who are immersed in virtual environments, policymakers and educators must address the behavioral problems that may arise in these virtual settings. Currently, most policies that limit cyber-bullying were developed through the application of existing codes of student conduct that limit bullying and inappropriate behavior that may harm other students physically or emotionally. Both physical misconduct and cyber misconduct are addressed by most school policies, it is easily foreseeable that these codes of conduct can apply to VR misconduct, which is a mix of the two.

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[28] PWC. (2020). How virtual reality is redefining soft skills training. PwC. Retrieved March 22, 2021, from https://www.pwc.com/us/en/services/consulting/technology/emerging-technology/vr-study-2020.html

[29] Cook, A. V., Griffiths, M., Anderson, S., Kusumuto, L., & Harr, C. (2020, May 8). The benefits of AR and VR for soft skill training. Deloitte. Retrieved March 26, 2021, from https://www2.deloitte.com/us/en/insights/topics/emerging-technologies/immersive-technologies-soft-skill-training.html

4. Content Effectiveness

In the same way that there are "good books and bad books, this is the same case for VR content," remarked Dr. Queiroz. Her research found that studies with less rigorous methodologies are likely to report greater improvements to learning outcomes. Coupled with an understanding that many companies seek to maximize profit as their primary concern, these findings should provide a fair amount of concern. Unlike ineffective books, VR content has great implications for student emotional development, their self-concept, and the way they can understand educational content. Therefore, there probably have been and will be more situations in which ineffective VR content produced by profit-maximizing companies will be heavily pushed for in schools despite research outcomes that are shoddy at best. A more rigorous standard for content introduction into schools is needed, especially given the potential impact on the basic cognitive functions of students.

VI. Conclusion

1. XR's Future in Education

XR can start by disrupting higher education, as seen with Virtual College in the UK. By partnering with a for-profit university and developing a hybrid curriculum in XR, similar to ENGAGE, they can systematically lower the pushback to XR and make the technology appear more visible and understandable through a high touch approach[30].

- They can utilize a high touch strategy and host demonstrations with key teachers' organizations, influential parent groups, and Common Core and other standard/ curriculum developers.
- Privacy concerns can be mitigated through development of limited connection Oculus sets, which have precedent with iPad's and school computes.
- They can look to replace STEM labs and field trips by providing high quality, experiential learning at a fraction of the cost.
- They need to incorporate teachers into the process every step of the way. Teachers will push back if they are not included, but if they can dictate the process and reduce their workload it will be mutually beneficial.

2. XR as a Tool and Amplifier

When discussing technology in education, it is important to understand that the history of the education system is a complicated network of policies and histories that manifest in more ways than simple testing scores and college matriculation rates. With that being said, XR presents a unique and tangible way to save costs in various aspects of the education system, and its new affordability makes it a viable new technology at the systemic level.

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[30] Toohey, B. C., Dailida, M., & Bartholomew, L. C. (2003). Intersection of 21st century technology with 20th century laws: a case study in proactive issues management. In Journal of Public Affairs (Vol. 3, Issue 3, pp. 232–244). Wiley. https://doi.org/10.1002/pa.151

XR content developers can partner closely with curriculum designers and developers to create new course syllabi that leverage the specific advantages offered by XR experiences in relation to traditional classroom instructional tools. Companies such as Lifeliqe have been able to adopt this approach to facilitate adoption of these tools.

On a broader scale, the inequities and inefficiencies of the current education systems pertain primarily to nebulous national, state, and local policies. EdTech companies have shown considerable prowess in the past to encourage adoption of their specific technologies or platforms, and XR is not likely to be any different. A broad, systemic approach is needed in order for these technologies to get to the root of the problems plaguing the educational system.