AR and VR in Gaming

Matthew Lessman and Conner Hubbell

4949 Words

Abstract:

Since before television and video games, developers and inventors have worked hard to create a mechanism or machine that allows the user to employ Augmented Reality (AR) and Virtual Reality (VR) to experience new realms of reality. Typically this has been done through headsets and other ocular wear. To look into the future of AR and VR in gaming, one must consider the past; the basis of AR and VR and its history, as well as failed concepts and headsets offer a lot of information on current limitations; one must consider how current AR and VR headsets came to be due to past and current setbacks (specifically the Meta Quest 3 and the Apple Vision Pro); furthermore, one must also consider the future implications of AR and VR in gaming and beyond. While past models of AR and VR machines did not offer a whole lot of success, current and future implications of AR and VR have much to do with learning, healthcare, and business. While AR and VR gaming will definitely experience steps toward innovation within the near future, AR and VR machines are more likely to see a usage increase in the aforementioned future applications (learning, healthcare, and business).

Background Literature and Introduction:

There are many definitions on the internet for VR and AR; the general consensus is that VR gives "you the impression that you're somewhere else," whereas AR allows you to see your reality differently; put simply, "virtual reality replaces your vision, augmented reality adds to it" (Greenwald, 2023). The first concept of VR as we know it was surprisingly created in the 1830s, when an English Scientist, Charles Wheatstone invented the stereoscope (Balasubramanian, May 2022). This original stereoscope was based fully upon stereopsis, meaning that "our two eyes

perceive objects from slightly dissimilar perspectives" (Balasubramanian, May 2022). These dissimilar perspectives allow "depth perception and a 3D view of the world" (Balasubramanian, May 2022). Stereoscopes allow a user to put binocular-like lenses up to their eyes to view 2 photos that are skewed slightly, allowing the user to see a 3D image. While it took around 100 years for stereoscopes to become somewhat mainstream, these stereoscopes gave way to create further innovation in the 1960s; first, came the Sensorama by Morton Heilig, a machine that allowed users to watch television through very small TV tubes - an impressive feat for the era (Brockwell, 2016). Due to major commercial failure from Sensorama, the "Sword of Damocles" created by Ivan Sutherland in 1968 became much more well-known; this device was the first AR device, as the device allowed users to interact with a wireframe cube that appeared "as if they were in the same environment as the user" (*The sword of damocles*). This "Sword of Damocles" paved the way for many AR and VR devices to be created; by 1985 NASA had created its own headset, heavily influenced by the "Sword of Damocles", a machine that was focused upon "telerobotics, data management, and human factors research" (*NASA virtual reality*). AR and VR headsets and devices were continually produced in the hopes that a prototype may break through and be the next 'big thing' in technology. As time, passed into the 1990s, more and more groups attempted to make a VR headset for which user-experience would become a widespread success; Nintendo's Virtual Boy was the only device that could be utilized for at-home gaming to this point, however, it was another failure to attract more than a handful of consumers due to high prices and poor graphics (Balasubramanian, May 2022). Companies eventually improved these technologies, and in 2012, the Oculus Rift by Palmer Luckey was released - the first commercially widespread VR device! (Balasubramanian, May 2022).

Increasingly becoming more common and popular, other companies such as Google, Apple, Playstation, Microsoft, and Meta all began to create VR headsets that offered a range of user experiences that weren't consumer-grade until about 2016 (Balasubramanian, May 2022). Almost every successful VR game that was created in the first few years of consumer-grade VR headsets was central to simplicity in terms of movement and graphics while still maintaining engaging and fun gameplay for the user; less movement and simpler graphics were enabled in these games "to prevent motion sickness" (Balasubramanian, May 2022). These types of games quickly became a popular genre – indie games – and experienced success because they were so simple. As game developers desired more intense graphics and interactions, certain games yielded little success due to trying to do too much in a VR world that couldn't keep up with how humans actually perceive reality. Eventually, in 2018, perhaps the most well known VR game to-date was created: *Beat Saber*. *Beat Saber* allows users to cut through lighted segments within the game's reality with lighted swords that the user is holding in the reality; the user cuts the lights to rhythms and beats of a multitude of songs; this game, being simpler in terms of movements, allowed for less motion sickness and also allowed users to workout while on a screen - a game that was a win, as oftentimes motion sickness plagued users in the early stages of VR (Balasubramanian, May 2022). In 2020, given a couple more years for developers to focus on increasing gaming mechanics and graphics, the game *Half: Life Alyx* was introduced and became the "pinnacle of VR development" with increasingly complex physics and more realistic ways for the user to interact with the game's environment (ducking for cover, reloading and loading a gun, drawing on windows, picking up and throwing bricks, etc) (Balasubramanian, May 2022). While the evolution of VR games has created better user experience in recent years,

there have still been many reasons for concern with AR and VR, hence why AR and VR have not become overwhelmingly involved in gaming yet.

While the VR realm of gaming has seen much more attention due to the ability to fully immerse oneself into another world of reality, the AR realm of gaming, and AR applications in general, have been arguably easier to implement into gaming successfully. One example of AR in gaming is the "AR Games" by Nintendo designed for the 3DS. These AR games utilize plastic cards and create an illusion based upon a card, which a user can select to enter and play the game on their 3DS (*AR Games)*. Another example of how AR is utilized in gaming is through "Pokémon Go". "Pokémon Go" is a mobile game that allows the user to travel around and use AR to view 'where' a Pokémon is, and in turn, catch the Pokémon with a Pokeball that appears on the screen; this Pokeball will react with the users motions on the screen as the user throws the Pokeball toward the Pokémon in an effort to catch it in the augmented reality upon the mobile screen; the AR feature on "Pokémon Go" has allowed users to be able to take pictures of the Pokémon in the augmented reality displayed on the screen; Pokémon will also interact and react to how quickly or carefully the user approaches, so the user essentially has to 'sneak up' on the Pokémon to catch it (Catching pokémon in ar+). Beyond gaming, AR is also seen in many everyday devices, with tablets and smartphones now having cameras with the capabilities to display items onto the reality that aren't actually there!

Given that there have been many different AR and VR devices, most of which have generally had short life spans, it begs to be asked as to whether or not AR and VR gaming can attain a mainstream status, and, furthermore, whether or not a mainstream status is sustainable through gaming for AR and VR. In consideration of these points, one must reflect and review the history of AR and VR gaming, as is done in the aforementioned history; one must also reflect

and research current models of AR and VR devices, their implications for gaming, and current limitations to AR and VR gaming; finally, one must also consider the future implications of AR and VR technology and what it may be utilized for within and without the realm of gaming.

Literature and Discussion for Current AR and VR Headsets:

New models of AR and VR equipment designed by Meta and Apple account for many of the shortcomings of the previous AR and VR devices that have generally demonstrated low success rates in not only gaming, but in real-world applications as well. That being said, there are generally still problems that remain within the AR and VR devices that have been created in the recent past; for example, the Google Glass was supposed to be the next big thing in AR, allowing users to wear glasses that act as a computer (users could take photos, send messages, and surf the internet); however, due to privacy concerns, costs, as well as usability limits (this includes failure to meet customer needs due to being unable to adapt to certain user needs and user feedback) (Price, 2023). Failed versions of AR and VR machines date back to even before the 1990s, but, as aforementioned, the 1990s was a decade central to the "craze" of AR and VR machines and their potential implications' this gave way for many failed models: Sega's VR prototype that never hit the market due to real-time lag, Tiger Games' failed R-Zone (limited sight to one eye, flickering images), the aforementioned Nintendo Virtual Boy (one of the more successful machines from the 1990s, but experienced motion sickness, uncomfortability, and real-time lag), Virtual IO's I-Glasses (market issues due to limited consumers and technology), and even models as recent as the Google Glasses from 2013 and 2019 (both launches of Google Glasses experienced dissatisfied users) and the Metaverse by Meta from 2021 (lacks participation from users) (Ward, 2022). A realm of failed endeavors, AR and VR systems have many general

problems that have been experienced among many AR and VR devices, especially VR headsets; these challenges include short battery life, small displays, uncomfortable head gear, limited accessibility due to technology insufficiency as well as consumer cost, and, perhaps the pinnacle of AR and VR device issues – motion sickness (Balasubramanian, October 2022). As previously noted, the new models of AR and VR equipment designed by Meta and Apple took heed to the long list of problems within such devices and took on the challenge of making devices that work soundly for users and immerse the user in a helpful augmented or virtual environment rather than one that experiences technical issues, is uncomfortable, has limited sight, suffers on the market due to overpricing issues (although they are still expensive), and much more; to combat these things, Meta and Apple have worked diligently to improve the interface that the user is interacting with, to make it more like the desired 'wearable computer.' Further problems with power, vision, and feedback are solved by improved storage, improved display, more powerful processors, increased connectivity, and more access to applications and games (with some expected limitations).

In recent years, the VR industry has witnessed significant growth and advancement, with Meta emerging as the frontrunner in consumer VR applications. This dominance has enabled Meta to secure a substantial majority in market share across the world. This growth mainly stems from their enormous investment into VR technology, spending over $36 billion dollars on research and development of the technology and only seeing a fraction of that back in revenue so far (Dean G., 2022). But all of their research has led to consumers being able to get a very powerful headset with numerous innovations built in for a very reasonable price. The Meta Quest 3 is the newest offering in their lineup and has some exciting new features that allow it to shift the VR landscape in a new direction (Meta Inc., 2023).

The Meta Quest 3, released in October 2023, built upon the base that was the old Quest 2 which held the title of the world's most popular VR headset and improved in almost every way (Meta Inc., 2023). The Quest 3 now has Dual 2064 x 2208 LCD (Liquid Crystal Display) displays achieving a combined resolution exceeding 4K. These displays now also run at a 120 Hz refresh rate which is incredibly important for a smooth and responsive gaming experience. Internally, the headset also now has a faster and more efficient Snapdragon XR2 Gen 2 chip inside to run the games at a higher frame rate and quicker load times for games. The RAM has also been upgraded to 8GB from the previous 6GB in the Quest 2. In terms of storage, the Quest 3 now comes in 128GB and 512GB variants to allow more onboard storage of games and apps. Improved connectivity comes via Wi-Fi 6E for lower latency and faster speeds which are crucial when playing any type of online multiplayer game with the headset (Meta Inc., 2023).

All of these changes point to Meta continuing to try and make the Quest 3 a standalone device that won't need the power of an external PC to run the games and apps and instead have everything be done by the headset itself. Though they are not disallowing users from tethering wired or wirelessly to a PC to play more resource intensive games, as there is still support for SteamVR connectivity to the PC. The Quest 3 is also backwards compatible with all of the older games and apps that were on the Quest 2 which helps a ton for people switching over or upgrading from an older headset and allowed it to launch with an already massive library of games and other apps ready to go. The familiar interface of the Quest 3 also made it an easy switch from other headsets. Overall, the Quest 3 seems to be the best option in its price range for consumer VR applications, and with Meta also adding some AR capabilities to the headset, could hint at a more mixed reality (a combination of AR and VR) future for Meta's headset lineup as they continue to research and develop both technologies (Meta Inc., 2023).

The Meta Quest 3 also has the advantage that comes with this large market share of years of development for its apps and operating system already done. Since all of the apps and games from the older Quest models are backwards compatible with the new headset, it shipped with an enormous library of apps already available to download and use. This market share allows developers to feel safer dedicating time and resources developing an app for the platform whereas smaller companies may not have that same stability and user base to ensure that. The addition of AR to the Quest 3 may also invite new developers who were working on AR applications on other platforms to try making Quest 3 AR experiences due to the large user base and opportunity that comes with it.

The Quest 3 shows Meta's shift towards mixed reality with its new AR features that were not present on the older models. With new dual RGB cameras for pass through of the outside world Meta is able to create experiences in the users real environment using 3D mapping (Meta Inc., 2023). One fascinating demo I saw of the new AR technology was using the new PianoVision app to show which notes to play on a piano in VR on the user's real, physical piano (Meta Inc., 2023). Allowing the pianist to be able to learn a new piano song without necessarily needing to be able to read music at all. While this AR technology is still relatively new and not fully fleshed out, it has exciting connotations as to what the future of mixed reality may look like as the industry and technology grow in the coming years.

Though Meta has a large market share in the VR space, there are many other large tech companies investing heavily in the industry. Most recently, Apple released their first-generation Apple Vision Pro at a starting price of $3,499. While not competing with the Meta Quest 3 in terms of price, the Vision Pro has some exciting technology and innovations that come along with the high price tag. Apple designed their new headset to fit many different sizes and types of

faces. When ordering on their website, they have the customer do a 3D face scan using an iPhone camera to measure and decide which size light seal and headband is right for that customer (Apple Inc., 2024). It also ships with 2 different adjustable headbands so the user can decide which one feels better and has a nicer fit for them personally. The headset weighs in at just over 600 g which is heavier than the Quest 3 by 50 g, but the feeling of this weight is mostly alleviated by the headband design (Apple Inc., 2024). All of these subtle changes add the comfort and ease of use of the Vision Pro as Apple tries to make AR/VR more than just a medium for entertainment.

The design is not the only unique touch Apple has added to their Vision Pro headset. It also boasts some impressive technological specifications that greatly enhance the “Spatial Computing” experience presented by Apple. The displays of the Vision Pro are 2 OLED (Organic Light Emitting Diode) panels with over 4k resolution each. Using OLED display technology instead of the more common LCD panels allows the Vision Pro to have even lower display latency and allows for darker blacks in the display since the individual OLED pixels are able to shut themselves off completely, unlike LCD which has a backlight behind it. This high resolution eliminates the “Screen Door Effect” that plagued older VR headsets which is when the viewer is able to perceive the gaps in between pixels since the display is so close to the user's face. The Vision Pro also has a 100 Hz refresh rate which is plenty to drive games with low latency and negligible screen tearing when objects on screen are moving quickly. The Vision Pro also has media playback at the forefront with both 24 and 30 FPS video playback supported. So whether it is a Hollywood film shot at 24 FPS or a YouTube video filmed at 30 FPS, the Vision Pro will play it back at its intended frame rate, giving the viewer a more immersive experience. To increase immersion even more, Apple included 3D audio with special head tracking so that

the sounds actually sound like they are coming from the direction that they are in VR/AR space. This, paired with the latest audio and video formats that are supported, including Dolby Atmos and HEVC (High Efficiency Video Coding) lead to a totally immersive audio and visual experience when consuming content on the Vision Pro (Apple Inc., 2024). Apple also added integration into their ecosystem with existing AirPods Pros owners being able to pair them with the Vision Pro with very little latency.

Since the apps and uses of a device can make or break the success of a product, Apple reimagined some of their apps to take advantage of the new technology of the Vision Pro. The one that uses these features the most is the new FaceTime app on the Vision Pro. It takes advantage of the iris and face scanning built into the Vision Pro to digitally create a 3D avatar that Apple calls a “Persona”. Then when facetiming other Vision Pro users, these Personas accurately track the users facial expressions and movements and can even track who the user is looking at in the 3D FaceTime call and use the 3D audio accordingly (Brownlee, 2024). This showcased how all of the different innovations, from the sensors to the software come together to create a completely unique experience that you cannot get on any other VR headset currently on the market.

All of these new features are being driven by the combination of Apple’s M2 chip and new R1 chip. The M2 chip is the same silicon used in Apple’s Mac lineup brings the power of an entire PC to the Vision Pro, with the efficiency needed to cool and disperse the heat from the small form factor of the device. The R1 chip facilitates all of the input and data from the sensors, cameras, microphones, and displays to create a cohesive experience with very little latency between all of them (Apple Inc., 2024). This combination of new Apple silicon allows for a

much more powerful standalone VR experience than any of its competitors, which will enable game developers to create bigger, more demanding games than they previously could.

One gripe some Vision Pro users had at launch was the absence of some key apps that were expected to be on the device. Since most iPad apps were already compatible and ported to the Vision Pro, popular content apps were expected to also be available on the device. But some companies, mainly YouTube, Spotify, and Netflix have opted out of their app being available on the Vision Pro which could deter some customers. It is speculated that they do not think that the Vision Pro will ship enough units for it to be worthwhile to develop an app for the new OS but only the companies know for sure. On the other hand, some companies like Disney have taken a different approach and decided to make a Vision Pro version of their streaming service. The Disney+ app on Vision Pro even offers a few panoramic videos made specifically for VR which is a stark difference from these other companies. Developers have already begun making workarounds for these apps to make at least the ported iPad version usable on the Vision Pro but only time will tell if these are allowed to continue being downloaded (Brownlee, 2024).

Discussion of Future Implications and Conclusions:

In some ways, the future of AR and VR technology is in the present; with the Apple Vision Pro's recent commercial release, consumers, investors, entrepreneurs, inventors, and many others hold their breath as they wait for reviews and feedback to flood in about the new craze of AR and VR technology. While the Vision Pro may not be all that central to AR and VR gaming, it does offer a variety of helpful venues, from mixed reality learning, to virtual workspaces, the goal of the Vision Pro is to strap a workable computer to the head of the user; a computer that can augment realities as well as immerse the user into a reality of their own.

Pertaining to the problems that have created issues with Google Glass and other AR and VR devices that maintained a similar goal – a wearable computer – the detailed increase in visual prowess and increases in storage and power will aid in the creation of a more friendly user experience with the latest and greatest mixed reality headset on the market; the extent to which the improved technology will satisfy users, though, remains to be seen. In regards to the implications for AR and VR gaming with the Apple Vision Pro, being that it is apparent that this is the closest model to a 'wearable computer' thus far, it will pave the way for game developers to produce more complex games; the new M2 chip, designed to replicate the cooling systems of a Mac computer and R1 chips that are implemented to process information and facilitate data faster, as would be necessary for keeping frame rates up and game lag low. While Apple has created and released some games for the Vision Pro, such as an interactive *Fruit Ninja* game, as well as others, there haven't been many complex games released to test the true capabilities of the Vision Pro and how it handles heftier games; this is also in part to Apple's dedication to spatial computing, and making a mixed reality experience possible through a headset (rather than utilize the Vision Pro as a gaming device) (Hayden, 2024).

Circling back to the Meta Quest 3, a device that is much more central to immersing the user through gaming experiences, the Meta Quest 3, similarly to the Apple Vision Pro, improved upon previous models, including their own models, to create a device that has 4k vision, increased storage, and increased capability to run games – although one of its limitations is that it may need to be connected to a PC to run certain games well. Regardless, Meta, as a company, simply fine tuned the user experience issues that were being experienced in their previous models, specifically the Meta Quest 2; with these issues, in today's age of technology and resources, Meta had the ability to create a gaming machine that may prove to be the blueprint for

future gaming headsets involving AR, VR, and mixed realities. While there are many competitors attempting to create an equal, or better device, Meta has a firm grasp upon the AR and VR gaming community at this point in time. With other companies, like Apple, Samsung, Google, and others more focused upon creating AR and VR machines that will allow for spatial computing and other applications, Meta has all but taken control of the AR and VR gaming market (Heater, 2023).

Considering the implications that the Meta Quest 3 and the Apple Vision Pro have offered in regard to ability to create more complex games in their respective virtual, augmented, and mixed reality environments, the history of AR and VR devices must throw caution toward potential overexcitement and potentially unrealistic expectations; historically, as has been covered thoroughly throughout this paper, many different companies thought they had figured an AR or VR device out, only to learn of its shortcomings through testing, user experience, or lack of market success due to price and popularity; in relation to the current models of AR and VR machines, there is still some limited accessibility due to price, and there are everlasting customer complaints and critiques that Meta and Apple will have to sort out. That being said, the historical review points to a trend of quick turnover in the realm of AR and VR devices; this points mostly to customer dissatisfaction in one aspect or another. Will these current models offer a halt in the trend of unsuccessful devices?? That remains to be seen, however, it is not unlikely that these devices, even with all the hype around them, become a fad that is forgotten for the ‘next big thing’ in AR and VR gaming and technologies, especially at the rate that technology itself is improving and expanding. Having discussed historical and current implications of AR and VR gaming, one must also consider the future implications of AR and VR technology outside of gaming and what it may be utilized for within and without the realm of gaming.

With respect to gaming with AR and VR, a popular topic that has not yet come to fruition in all aspects is that of the aforementioned Metaverse. While Meta's Metaverse from 2021 was not a commercial success, it simply may have been too early for such technology to become successful on the market due to many factors, including limited access. The goal of the Metaverse is to immerse users into a virtual reality that is a "shared digital world" in which people can game, hang out, do work, learn – the possibilities are meant to be near endless (Ward, 2022). A virtual reality such as the Metaverse would allow users to 'travel' miles in seconds, being able to interact with family members that are far away, and simply enjoying a nice, virtual cup of coffee with them (Ward, 2022). While this includes real-life application, the Metaverse would also allow people to immerse into a game that is joinable at any time, perhaps one that you can save with your friends that's similar to a Minecraft world – the possibilities for gaming are literally endless if the Metaverse achieves its ultimate goal in allowing users to fully immerse into a virtual environment as described. While the gaming applications are massive, the real-world applications of AR and VR devices in the future could be even moreso. The learning implications behind AR and VR are so immense it is hard to comprehend; in relation to the aforementioned piano demo, in which keys came toward the user so the user could learn how to play the song on piano, similar implications are true for healthcare workers (surgeons, dentists, nurses, physical therapists and more). Furthermore, today NASA further utilizes AR and VR systems in flight simulations, which can be related to gaming, and is far less dangerous than actual flight runs; this simulated aviation research also allows other similar simulations to base their ideas off of the work that NASA has achieved (Dinius, 2023). Finally, business applications of AR and VR outside of the realm of gaming are very lucrative and offer a lot of options for how consumers and businesses may shop differently, how museums may be able to offer you

virtual reality displays, how real estate may be able to offer in-home house tours, and how managers may be able to look over blueprints and product designs more efficiently (Farshid, 2018). Future implications as to what AR and VR could look like in gaming still remains to be seen; current devices are increasing in capabilities in attempts to stem the flow of a history of disappointment in the creation of AR and VR devices, and while this paper is a review on AR and VR in gaming, it cannot go without being said that there are major future implications for these devices in many, if not all aspects of life as we know it.

References

Apple Inc. (2024, February 2). *Apple Vision Pro - Technical Specifications*. https://support.apple.com/kb/SP911?viewlocale=en_US&locale=en_US

AR Games: Augmented Reality. Nintendo of Europe AG. (n.d.). https://www.nintendo.co.uk/Hardware/Nintendo-3DS-Family/Instant-Software/AR-Games-Augmented-Reality/AR-Games-Augmented-Reality-115169.html

Balasubramanian, K. (2022, May 23). *The evolution of VR Gaming*. Gameopedia. https://www.gameopedia.com/evolution-of-vr-gaming/#:~:text=In%201966%2C%20Thomas%20Furness%20developed,rather%20than%20using%20TV%20screens

Balasubramanian, K. (2022, October 19). *The future of VR gaming (sleeker headsets and mo-cap wearables)*. Gameopedia. https://www.gameopedia.com/future-of-vr-gaming/

Brockwell, H. (2016, April 3). *Forgotten genius: The man who made a working VR machine in 1957*. TechRadar. https://www.techradar.com/news/wearables/forgotten-genius-the-man-who-made-a-working-vr-machine-in-1957-1318253/2

Brownlee, M. (2024, January 30). *Using Apple Vision Pro: What It's Actually Like!* YouTube. https://www.youtube.com/watch?v=dtp6b76pMak

Catching pokémon in ar+ mode - pokémon go help center. (n.d.). https://niantic.helpshift.com/hc/en/6-pokemon-go/faq/28-catching-pokemon-in-ar-mode/#

:~:text=AR%2B%20mode%20is%20an%20enhanced,or%20the%20perfect%20photo%20opportunity.

Dean, G. (2022, October 29). *Meta has pumped $36 billion into its metaverse and VR businesses since 2019*. Business Insider. https://www.businessinsider.com/charts-meta-metaverse-spending-losses-reality-labs-vr-mark-zuckerberg-2022-10

Dinius, D. (2023, July 26). *Virtual and augmented reality technologies*. NASA. https://www.nasa.gov/centers-and-facilities/armstrong/virtual-and-augmented-reality-techs/

Farshid, M. (2018, July 26). *Go boldly!: Explore augmented reality (AR), Virtual Reality (VR), and mixed reality (MR) for business*. Business Horizons. https://www.sciencedirect.com/science/article/pii/S000768131830079X

Greenwald, W. (2023). *Augmented reality (AR) vs. Virtual Reality (VR): What's the difference?* PCMAG. https://www.pcmag.com/news/augmented-reality-ar-vs-virtual-reality-vr-whats-the-difference

Hayden, S. (2024, February 2). *Existing VR games would look great on Vision Pro, but without controllers most are stuck*. Road to VR. https://www.roadtovr.com/vision-pro-vr-games-are-stuck/#:~:text=To%20Apple%2C%20it's%20all%20spatial,immersive%20games%20to%20Vision%20Pro.

Heater, B. (2023, October 9). *Meta quest 3 takes a step closer to mainstream AR/VR*. TechCrunch. https://techcrunch.com/2023/10/09/meta-quest-3-takes-a-step-closer-to-mainstream-ar-vr/

Meta Inc. (2023) *Quest 3 Tech Specs* https://www.meta.com/quest/quest-3/#specs

NASA virtual reality headset. Ultimate History of Video games. (n.d.-a). https://ultimatehistoryvideogames.jimdofree.com/nasa-virtual-reality-headset/

Price, L. (2023, September 24). *Why did google glass fail in healthcare and overall with consumers?*. Nelson Advisors Blog. https://www.healthcare.digital/single-post/why-did-google-glass-fail-in-healthcare-and-overall-with-consumers#:~:text=User%20Acceptance%20and%20Privacy%20Concerns,by%20others%20wearing%20the%20device.

Rokhsaritalemi, S., Sadeghi-Niaraki, A., & Choi, S.-M. (2020). A review on Mixed reality: Current trends, challenges and prospects. *Applied Sciences*, *10*(2), 636. https://doi.org/10.3390/app10020636

The sword of damocles. Ultimate History of Video games. (n.d.). https://ultimatehistoryvideogames.jimdofree.com/head-mounted-display-sword-of-damocles/

Ward, C. (2022, September 17). *The biggest VR and AR flops of all time*. SlashGear. https://www.slashgear.com/1012807/the-biggest-vr-and-ar-flops-of-all-time/