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To what extent have technological innovations facilitated growth in the gaming industry?

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Abstract

The gaming industry is one which is incredibly popular amongst the masses. However, there is no doubt that the industry has evolved drastically since the time of its inception. Whilst many factors may have caused the aforementioned evolution, technological innovations have one of the biggest parts to play. This research paper aims to thoroughly analyse the history of the gaming industry including some of its biggest revolutions that have been witnessed over the years. The paper then goes on to evaluate some of the main technologies, namely Augmented Reality (AR), Virtual Reality (VR), Artificial Intelligence (AI) and Cloud-Based Gaming, playing the most significant role in shaping the scope of the current gaming industry as well as its future.

Introduction

Just how big is Gaming?

For a person living in the modern world, 'video games' is a common term, and we have all played at least one game in our lifetime. However, few people know the actual scale of the industry. The gaming industry is worth over $200 billion and will continue to grow (MOMIN, 2022), according to experts. Physicist William Higginbotham, the creator of one of the first video games (Lambert, 2008), would never have imagined the technological and scientific innovations caused by humankind's fascination for video games - after all, it is estimated that video games enamour over a third of the human population (Clement, 2022a). Over the past 60 years, the gaming industry has shown unprecedented growth and quickly risen to the top of the entertainment sector.

In the early days of gaming, the industry was dominated by arcade games like 'Pacman' and 'Space Invaders' which required you to insert coins to play. However, as technology improved, consoles and home systems began to emerge. In the 1990s, 3D games revolutionized the industry, offering players a more realistic experience. Today, the gaming industry is experiencing another major shift with the introduction of new technologies like Virtual Reality (VR) and Cloud gaming. In addition, mobile gaming has exploded in popularity, with people being able to play games whenever and wherever they want.

As the gaming industry continues to evolve, it is clear that technology will play a key role in its future growth. With new technologies like 5G and cloud gaming, we will likely see even more advanced and realistic games in the coming years. Additionally, the rise of e-sports and online gaming communities is creating new opportunities for players to connect and compete with each other, which could change the way we think about gaming as a social activity. In line with the aforementioned, this paper aims to answer the research question "**To what extent have technological innovations facilitated growth in the gaming industry?"**

The first half of the paper will focus on analysing the scale of the current gaming industry - including how gaming gained popularity and the innovations which created new methods of gaming. The latter half of the paper, on the other hand, will explain and evaluate new technologies which are gaining popularity and shaping the future of gaming.

Literature Review - Innovation

Innovation is a complex yet vital component that facilitates competitiveness, economic growth and progress in society. Many scholars and researchers have closely studied various aspects of innovation to understand its nature, determinants, and outcomes. For instance, the 'National Innovation System' framework developed by Freeman (1987) is one of the most commonly cited works on innovation. The framework emphasises the importance of the interaction between various entities in the economic world, including firms, universities, governments, and other organizations, in driving innovation. Another popular approach to studying innovation is the 'Innovation Value Chain' (IVC) framework developed by Gereffi and Korzeniewicz (1994) which details the various stages of the innovation process - ranging from research and development to commercialization - and the importance of linkages between the said stages. Schumpeter (1934) is another influential scholar whose work has shaped the study of innovation. He defined innovation as the introduction of a new product, process, or organizational form that disrupts existing markets and creates new ones. Schumpeter's work also explained the importance entrepreneurs have in driving innovation and economic growth. Whilst most of the literature quoted has covered perspectives from earlier years, more recently, the concept of 'open innovation' has gained prominence. Chesbrough (2003) defined open innovation as the use of external knowledge and resources to accelerate innovation. The open innovation approach challenges traditional notions of innovation as an internal, closed process and emphasizes the importance of

collaboration and co-creation with external partners. The aforementioned makes it clear that innovation is a complex and multifaceted phenomenon that has been studied from various perspectives. While there is no single definition or approach to studying innovation, the frameworks and concepts discussed above provide a helpful starting point for understanding the nature, determinants, and outcomes of innovation.

Innovation has several advantages for the business world. Firstly, innovation can lead to the creation of new markets and industries with products being introduced to meet either unmet or changing consumer needs. This benefits the economy as it facilitates job creation and economic growth. The emergence of the internet and mobile technologies, for instance, has led to the creation of industries like e-commerce, social media and the sharing economy, all of which have transformed how we communicate, work, and consume goods and services (Brynjolfsson and McAfee, 2014). In fact, technology does not only lead to innovation, but innovation can also lead to the development of new technologies that have far-reaching impacts on industries and society. For example, advances in biotechnology and nanotechnology hold promise for breakthroughs in medicine, agriculture, and manufacturing (Cheng et al., 2016). Additionally, a positive correlation between innovation and firm performance has been found. For example, a study by the European Commission found that firms that invest in innovation are more likely to achieve higher sales growth, higher levels of productivity and increased profitability (Hernández et al., 2014).

All that being considered, it is important to note that the literature also highlights some of the drawbacks of innovation. For instance, since innovation requires significant investments in research and development and can be risky, it can pose challenges for firms and industries. Moreover, in reality, the benefits of innovation do not tend to be evenly distributed across firms and industries and this leads to increased inequality and market concentration. That being said, it remains inarguable that innovation is a critical driver of industry growth, competitiveness, and societal progress. While it poses challenges and risks, its benefits are far-reaching and can lead to the creation of new industries, increased productivity and efficiency, and improved customer satisfaction. This paper, therefore, focuses on the innovation that has taken place in the gaming industry.

Overview of the gaming industry

The video game industry encompasses the development, marketing, and monetization of video games. It is a massive industry worth over $300 billion providing entertainment to over 3 billion people (Clement, 2022b), increasing in the past few years due to COVID-19. Video games have come a long way since their advent in the 1970s. With technology constantly improving, what is considered cutting-edge today may become obsolete in the next few years.

For many people, games are a part of daily life. However, many people don't realise that games influence our lives and the world we live in. Unlike watching a movie or reading a book which only gives us a story, games offer us

control, and a chance to create our own story - they give us an immersive feeling as we interact with the game world. In this way, games mimic the real world. At the same time, most games don't have consequences for the player's actions - players can do whatever they want without having to worry about morals or values. Many social groups argue that this will influence the behaviour of the players, however, the results from studies differ. Games also help players to connect to other people from every region in the world through the help of the internet. It brings individuals together as they get an emotional connection with the game - like-minded players form groups where they come together for the same objective. Video games show that people have more in common even though they have been brought up in different cultures. It breaks barriers in society (Our Culture Mag & Partners, 2020).

In order to understand where the industry is headed, we must understand how it has come this far. The history of video games begins in the early 1950s when scientists were experimenting with electronic machines to create relatively new game systems such as *Bertie the Brain* or *Tennis for Two*. With the advent of many useful technologies such as high-level programming languages and time-sharing in the 1970s, video games were exposed to a large base of users. The modern video game industry grew out of the concurrent development of the first arcade video game and the first home video game console in the early 1970s in the United States.

In 1966 Ralph Baer came up with an idea for an entertainment device that could be connected to a television monitor. This led to the development of Magnavox Odyssey, the first commercial home console, in 1972 (Smith, 2019). Concurrently, Nolan Bushnell and Ted Dabney had the idea of making a coin-operated system to run *Spacewar!* By 1971, the two had developed *Computer Space* with Nutting Associates, the first arcade video game. Bushnell and Dabney struck out on their own and formed Atari, a pioneer in the gaming industry which helped define the electronic entertainment industry from the 1970s to the mid-1980s. Just as dedicated consoles were waning in popularity in the West, they briefly surged in popularity in Japan. Notably, Nintendo entered the video game market during this period alongside its current traditional and electronic toy product lines, producing the series of Colour TV-Game consoles in partnership with Mitsubishi.

Space Invaders led off what is considered to be the golden age of arcade games which lasted from 1978 to 1982. Several influential and best-selling arcade games were released during this period by companies like Atari, Namco, and Nintendo, including *Asteroids* (1979), *Galaxian* (1979), *Tempest* (1981), and *Galaga* (1981). *Pac-Man*, released in 1980, became a popular cultural icon, and a new wave of games appeared that focused on identifiable characters and alternate mechanics such as navigating a maze or traversing a series of platforms (June, 2013). According to the trade publication Vending Times, revenues generated by coin-operated video games on location in the United States jumped from $308 million in 1978 to $2.8 billion in 1980 (Despotakis, 2020).

Following the success of the *Apple II* and *Commodore PET* in the late 1970s, a series of cheaper and incompatible home computers emerged in the early 1980s. These new systems helped catalyse both the home computer and game

markets, by raising awareness of computing and gaming through their competing advertising campaigns. During this time, many small-scale coders emerged and began selling their software for these platforms. Games from this period include the first *Ultima* by Richard Garriott and the first *Wizardry* from Sir-Tech. Games dominated home computers' software libraries. By 1984 the computer game market took over from the console market following the crash of that year (Beren, 2022). Consumers preferred personal systems as computers offered equal ability and, since their simple design allowed games to take complete command of the hardware after power-on, they were nearly as simple to start playing with as consoles. Since then, many notable discoveries were made in the gaming industry, the most notable being the creation of 3D graphics. Video games have also entered handheld devices such as mobile phones and are now headed for more immersive devices like Virtual Reality.

Led by colossal companies such as Microsoft and Sony, the gaming industry is pushing the limits of technology, and it will continue to do so. Not only do we have access to games in the form of the best technology in the market, but we also have the opportunity to watch some of the best gamers compete in e-sports and play some of our favourite games through platforms like YouTube and Twitch. Through streaming, many people have been able to gain employment. As compared to the beginning of the 21st Century, people now are more inclined to adopt new technologies. This may be an effect of gaming; however, it has also been beneficial to gaming.

Extended reality - use of VR and AR technology in the gaming industry

Augmented reality (AR) is the integration of virtual game elements with the physical environment of the player. Augmented reality games scan the real world through a camera and then overlay game visuals using sensors and the global positioning system (GPS). Virtual Reality (VR), on the other hand, uses headsets to simulate a virtual world, where the user is cut off from the real world (Wright, 2023). The main difference between VR games and AR games is that in virtual reality, the user is visually cut off from the real world, whereas in AR, the user can still see and navigate real-world locations. This means that VR requires a dedicated headset as well as a clear playing space. It may also lead to accidents if players are not careful. AR games can be played from a smartphone or a dedicated headset. A headset can provide a fully immersive experience by displaying game visuals in three dimensions from the player's point of view. These high-tech headsets, such as the Meta Quest series (known as Oculus before Meta acquired them), are expensive and in short supply. Because it does not require expensive dedicated hardware, smartphone-based AR gaming is much more popular. However, these games are much less immersive and not many games exist that creatively utilise AR technology. Some of the most popular AR games require a VR headset to play, and many VR games also rely on AR technology. One of the most popular games of all time, Pokémon Go, is also an AR game. Some popular VR games include BeatSaber, Superhot, and even games by popular franchises such as The Walking Dead.

Virtual Reality has been a game changer in the gaming sector. VR is considered one of the hottest topics in current

gaming trends, grabbing the attention of the industry with several big releases by many famous franchises like The Walking Dead and Star Wars. There are several benefits that VR-driven applications in gaming are providing. Since VR devices used in the gaming industry are enabled with interactive software and hardware and the games can be experienced or controlled by the movement of the body, the player can move around and interact with the artificial world freely. The aforementioned delivers an immersive and enjoyable gaming experience. However, whilst new technology is exciting for gamers, many people are not able to enjoy these wonders. High prices for VR headsets prevent the average consumer from purchasing VR games and limit participation to only serious gamers for now. The cost of these devices will likely decline as the technology develops and becomes more mainstream. As a result, AR games that can be played on almost all smartphones that people already have are gaining popularity. Furthermore, according to the ESA report, when choosing a game, price is only a secondary factor in purchase decisions. Sixty-seven percent of gamers consider the quality of the graphics first. This suggests that if AR and VR games can deliver a high-quality visual experience, gamers will be eager to buy and play (Jabil, 2023).

Additionally, AR and VR technology are being used in many aspects other than gaming. At the University of Maryland's Augmentarium - virtual and augmented reality laboratory - the school is using AR in healthcare to improve how ultrasound is done. Using a Microsoft HoloLens and special software, physicians wearing an AR device can look at both a patient and ultrasound imaging directly in front of them instead of having to look at a bulky screen off to the side, says Barbara Brawn-Cinani, Associate Director for the University of Maryland's Center for Health-Related Informatics and Bioimaging (CHIB) (Brown, 2023).

Use of artificial intelligence in the gaming industry

Artificial Intelligence (AI) is defined as the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages. AI is code that can perform certain tasks that are usually performed by humans for the sake of convenience and efficiency. These tasks may be performed faster with a computer as compared to manual work.

Due to the negative portrayal of AI and lack of information, a large number of people have difficulty trusting AI. Although the idea of AI 'taking over the world' is not completely unfounded, we are safe for the time being. Some believe that AI will not be able to coexist with humanity, however, they lack information on how AI operates in the first place. The scariest aspect of AI is that, unlike humans, a computer does not follow morals or ethics. Its only goal is to perform the task at hand using the most efficient method possible. For example, if an AI model is given a vague task such as 'solving poverty', it will decide that the most effective way to complete the task is to distribute

wealth and resources equally. This decision would be seen as 'unjust' by humans. Thus, it is evident that AI may prove to be dangerous, however control over the usage of AI can effectively prevent such dilemmas, and AI is still just a useful tool.

The use of AI in gaming is not always evident. Video games often have many characters that you can interact with, however, they are not being controlled by another person. They are referred to as Non-Player Characters or NPCs (Cambridge Dictionary, 2023). The NPCs' behaviour is an application of AI in gaming. These characters have a predetermined path they take every day, which may alter depending on specific occasions. They have a limited number of dialogues and reactions, and only some of the NPCs have any actual purpose, such as vendors and characters related to the game's story. Even the enemies we face are NPCs which follow a specific pattern in their actions. The use of NPCs is widespread in single-player games, however lately multiplayer games have also begun to use AI to enrich user experience. In games such as Fortnite where many players are required to start a match, it is not always possible to have as many users. As a result, the players have to wait for a long period of time to begin playing. To counter this problem, games use NPCs to fill up the 'game lobby'. These characters have varying difficulty levels depending on the average skill of players in the game. Another example of this is Chess. Many chess platforms such as chess.com allow you to play against AI of varying difficulties in order to allow you to practice whenever you want.

Many companies have begun to integrate AI into their games for a multitude of reasons. One such reason is 'Data Mining'. Data Mining refers to collecting data from players and turning it into useful information (D'Souza, 2022). Through this method, companies know which games are doing well, what the players like about the game, and even predict future growth. The use of AI also saves time and money for the company.

Artificial Intelligence will continue to be a part of gaming for years to come. It will continue to make even more realistic experiences and the NPCs will only get smarter as time progresses. The game content generated by AI will continue to improve (Darbinyan, 2022), and its unpredictability will draw in even more players. As the role of AI in the gaming industry is expected to grow even further, it can enable many more innovations in the future. All of these current and potential future applications of AI in gaming seem fascinating, but it's hard to say how far AI can go and impact the future of the gaming industry.

Cloud-based gaming

Until now, we've analysed different types of game systems and technologies that run different kinds of games. However, not everyone has every console or system in the market, so the range of games they can play is limited. This is why Cloud Gaming is appealing to many gamers. Cloud gaming is a method of playing video games using remote servers in data centres (Roach and Parrish, 2019). There's no need to download and install games on a PC

or console. The required system specifications are already present in the host server, which the user can control from their personal system. It is similar to watching a live stream that you can control. In order to play these games, you need a monthly subscription from the respective provider. Due to high demand and short supply, users have to wait in line for long periods to play a game for short duration. This problem may be resolved in the future when cloud gaming gains more popularity.

Cloud Gaming has taken inspiration from popular platforms such as Twitch and Netflix where the user doesn't need to download a movie or show to watch it and can access it through the company's servers. Netflix's interactive games are also an example of cloud gaming. In fact, many website games have been developed on a small scale where the user only needs the internet and a browser to play the game. Some examples include RuneScape, Browser Quest, Geo Guesser, and NeoPets.

Cloud Gaming has gained popularity as it allows people to play games that are otherwise inaccessible to them. The user doesn't have to wait to download or update the game and can get instant access as long as they have an internet connection (Adede, 2022). It also allows the user to save space on their device. This is also cheaper than buying a new system or the game, especially if you want to try playing the game before you buy it. However, it is not a viable long-term option for continuing to play as of yet. Since the games are running on an external server and not on the device, there is a delay in actions after the button is pressed. Moreover, it can be difficult to find a game to play, and gameplay is directly affected by your internet quality. Thus, for many people that play games regularly, investing in a system may be a better option. As Cloud Gaming continues to progress, these disadvantages will inevitably be fixed, but that may still be a long time away.

Conclusion

As is evident in this paper, technological innovation has accelerated the growth of the gaming industry and in some cases, the gaming industry has inspired technological innovations. The giant industry, worth over $200 billion with 30% of the global population as the market already, still shows signs of potential growth.

The main technological innovations that are playing an active role in shaping the future of the gaming industry are AR, VR, AI and Cloud-based gaming. May it be VR allowing gamers to essentially become a part of the gaming world or Cloud-based gaming allowing anyone with an internet connection to enjoy gaming - each of these technologies is allowing the offerings of the gaming industry to become more accessible, immersive, interactive and enjoyable than ever before. Moreover, these technologies have also allowed economic growth from a more holistic point of view as the facilitation of platforms on which streamers can make a living has become possible.

On the whole, even though technology is ever-changing and further and potentially more impressive innovations

will likely occur in the gaming industry, given the trajectory that the industry has followed since its inception, it can be said that technological innovations have facilitated growth to a great extent.

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