Go beyond the screen:
the evolution and design pressures of viewership, from Hollywood to Silicon Valley

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Abstract

This paper investigates the possible disappearance of the screen with the evolution and design pressures of viewership in mind. It begins with the complexities of the screen. This includes the aspect ratio wars of cinema's widescreen and the square television standard which changed in favour of the cinematic. This leads onto the constraints and imposed aspects formed from the additional orientation change of smartphones and tablets. The successive changes have led to an attempt at established forms of viewing with wearable screens which provide relief from the health risks of using handheld devices which are unique to the current generation.

Augmented reality, an extension of the real world with additional overlays provides new experiences with practical uses to visualise new and unseen possibilities. One of the earliest forms established for consumers is the overlaying of information onto live sports broadcasting to increase user's enjoyment and understanding. Smartphone cameras augment reality using their cameras for user created visual content, with new possibilities for location based mobile games in real-time user environments. The educational values of this form of viewing are investigated, including the latest and future heads-up displays and head-mounted devices.

Virtual reality is mediated with immersive screens for three-dimensional experiences in 360-degrees. The potential exists for a new medium of 360-degree video and photography for consumer content creation. Real world applications of virtual reality are investigated beyond the established gaming genre of this form of viewing. Head-mounted displays include motion controls for new interactive screen abilities with potentially limitless possibilities. The screen is in fact not disappearing as future technologies appear to suggest. It has evolved into the next dimension, beyond the screen as it is known.

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Introduction

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"Go beyond the screen" is the Microsoft HoloLens slogan

The goal of this paper is to investigate screen viewership, touching on its past with emphasis on the present and future. The range of screen sizes and inconsistencies has never been more complex. The changes in technologies and the circumstances they present for content producers and visual and user experience (UX) designers are questioned. With this, is the possible disappearance of the screen in a move towards the practicality and convenience of current trends in interactive digital media.

Context

Viewing formats are in a constant state of change evolving as fast as technology allows. Hollywood includes the widescreen formats of the epics in Cinemascope film projection which displays no signs of diminishing while the Silicon Valley technology of mobile devices like smartphones and tablets follow non-conformist rules of screen that are caused by adapting to a different platform. Television and the personal computer are intermediaries between Hollywood and Silicon Valley with the rather square 4:3 to 16:9 aspect ratio which are accepted as standard from their inception.

The latest revelatory technologies are the disappearance of the screen. The augmented reality that is free of the confines of the screen as it is known blurs the definitive lines of vision by inserting digital scenes into reality. This is parallel to virtual reality which is an immersive experience in the digital realm, the illusion of viewing with one's own eyes.

Overall outlines of interest are format and viewership, including cinema and television, mobile and handheld devices, plus technology and trends with further interest in user case studies including complete changes in this area and the ability of technology to keep up with new ideas with the likes of the Apple Watch, (Figure 5) and smartphone applications interfaces. The aforementioned augmented reality of Microsoft HoloLens and Google Glass, add digital viewing to reality. Also of importance, the virtual reality of Oculus Rift, HTC Vive, Samsung Gear VR and Google Cardboard, adding realism to the digital world through a non-restrictive format and view providing further research potential. These areas are discussed with interaction design and experience in mind also.

The struggle of screen orientation and the mobile touch screen are questioned with this new experience of viewing. This leads to themes of interaction design in user experience and responsive design, particularly with the mobile. The disappearance of the screen from cinemascope, widescreen, and the vertical smartphone and tablet screen orientations to virtual and augmented reality is a fundamental topic. The advent of technology shows like the annual Computer Electronic Show (CES) in Las Vegas present the latest technology that will without fail disrupt apparent standards from reworking screen size to virtual and augmented reality. Interaction and responsiveness have never been more crucial in the trend towards convenient and practical mobile viewing. Perhaps the screen will become a non-argument, it still remains an issue, the experience of viewing and its implementation is central to the technological age. However, it is now no longer limited to the confines of screen.

Methodology

Introduction: Provides the research question with an overall context behind the research paper that investigates screen viewership including, cinema, television, handheld devices and other mobile devices including smartphones, tablets and wearable devices. The augmented reality of Google Glass and Microsoft HoloLens, and the virtual reality of Oculus Rift and Google Cardboard amongst others.

Complexities of Screen: Delves into the history of cinema and television screens including the 4:3 to 16:9 aspect ratio change for broadcasting and the portrait smartphone and tablet screens which offer different experiences and solutions to aspect ratios. Using second screen viewing on handheld devices to enhance visual experiences which merges the television and handheld devices for multi-screen are investigated. The latest mobile devices including the Apple Watch provides a familiar whilst also different screen viewing experiences for mobile viewing with a host of differing complexities and solutions introduced.

Augmented Reality: Augmented reality is an extension of the real world with additional digital overlays for new experiences with practical uses for entertainment and design to visualise new and unseen possibilities. Google Glass is investigated with a look at why it was discontinued. The forerunner is currently Microsoft's HoloLens. Augmented reality is also used to enhance and understand the viewing of sports. Another feature is the ability to provide a real-time and place mobile gaming experience.

Virtual Reality: Focuses on virtual reality which is a 3D immersive experience that blocks out the outside world completely with wearable devices including the Oculus Rift, HTC Vive, Samsung Gear VR and Google Cardboard. The latter two utilise smartphone screens with applications that support virtual reality. Support is constantly improving with 360-degree videos, educational uses, virtual environments and entertainment.

Conclusions: A summary of investigations of the evolution of the screen and the future that can be expected with regards to practicalities and convenience including responsive design and user experience with user case findings. It is a culmination of findings of the complexities of these products that focus on viewership and the obstacles they find themselves in and beyond.

1 Complexities of Screen

1.1 Introduction

Screen has evolved to more than simply viewing on a television set or going to the cinema. The ever changing face of viewership with regards to screen sizes, orientation, the responsive design of aspect ratios, to user experience in the form of handheld devices present a number of issues. These issues include the composition for these devices including cinematography and safe zones. Also to user cases, theory and practice in technology limitations and health concerns, which are just the beginning. Interactivity has taken the reigns for cross platform multiscreen viewing and compatibility. The likes of smartphone applications are in a continuous state of change to provide a sense of the familiar for user experience to make it enjoyable and thus successful. Consumers are becoming more conscious to what is available and to what they want in keeping up to date with current trends. Conventions are constantly contested in striving towards the latest formats in interaction design.

1.2 Aspect Ratios: Square 4:3 television standard vs cinematic widescreen 16:9

Viewership formats are in a constant state of change from their inception from its beginnings in the 35mm 4:3 format of silent cinema to the widescreen of CinemaScope and Panavision's Super 70 in the 1950s and 1960s. Home consumer products lagged behind with the 4:3 format of standard television through the 20th century. It was not until the 21st century did the home television set become the widescreen 16:9 standard in homes that is familiar today. Arcade machines were an exception to this rule with a vertical screen for game play. Now format standards are increasingly becoming looser with different devices in a variety of formats and standards in screen. These include the smart phones of Google Android and Apple iOS, tablets like the Apple iPad and Samsung Galaxy Tab. One of the newest options are wearable technologies like the Apple Watch, (Figure 5) Pebble Smartwatch and Android Wear Watches. The ability to use these devices side by side or in combination with Smart TVs represent possibilities for future development. These present complexities in interaction design and user experience that do not currently have set guidelines, and are in a continuous state of change as they become recognised and adhered to. The highly competitive market coupled with their rapid evolvement and adoption means that they may not survive.

Widescreen is perceived to be cinematic. However, it is not typically noticed unless it differs from the norm or uses alternative aspect ratios. It is frequently overlooked historically and aesthetically, even misunderstood. Comparisons between television and cinema can be disadvantageous. (Cardwell, 2015, p.84) Despite this, it is crucial to exploring the boundaries of television space, forming and framing it to examine how it changes the viewer's relationship with the fictional spaces on screen. The digital switchover to HDTV was first developed by the Japanese in the 1970s for their national television system. Two decades later the television industry in the United States proposed its own in 1995 which was not compatible with the progressive computer screens at the time. It was not until 1996 that it was settled, taking a decade before HDTV became accepted with the arrival or large, thin screens, a total process of roughly 35 years. (Norman, 2013, p250-251)

Alternative viewing platforms and changes in camera technology are part of the technological and commercial developments that have caused the switch to widescreen. This presents new artistic capabilities. The reason behind screens dimensions being measured diagonally is due to it being a diameter of a circular image emitted by a cathode ray tube (CRT) television that was cropped by the placement of a screen frame over the image from within. It is not ideal for comparing screen sizes of different ratios proportionately. Various screen aspect ratios were tested; including portrait oriented 2:1 and square 1:1. The classic television ratio of 4:3 originated from the Academy Ratio established in 1932 by the US Academy of Motion Picture Arts & Sciences. This was adopted until the 1990s switch backed by a huge marketing push from television set producers and the European Union 16:9 action plan for commercial reasons. The switchover proved troublesome with 4:3 viewers watching letterboxed 16:9 productions. The BBC recommended a protected ratio of 14:9 so that old television set users would not miss too much vital information. It acted as compromise from 4:3 to widescreen cinema for televisions and monitors to display high definition video. (Cardwell, 2015, p.84-86)

The perception for viewers proved problematic with the change in perception most affected by a loss in overall image area, earliest adopters found their broadcasts still in 4:3 resulting in pillarboxing. The black bars of pillarboxing were overcome with scaling the image to fill the screen losing details at the sides, most noticeable with on-screen text or stretching the image to high levels of distortion. Widescreen films broadcast practice followed this horizontal cropping technique, black bars were perceived by viewers to be hiding visuals. Pillarboxing today is considered to look dated and have a lower quality. (Cardwell, 2015, p.86-87) Older series like *The Wire* (2002-2008) are converted from their 35mm film negatives into the widescreen 16:9 aspect ratio for Blu Ray releases and new broadcasts, not simply panned and scanned to fill the screen. Some scenes required cropping with their newly looser framed space. The greater clarity allowed viewing of things that should not be seen in the artifice of film with no intentions of a high definition 4:3 aspect ratio due to the new industry standard broadcasts by HBO. (Simon, 2014)

Simon (2014) describes a scene in *The Wire* (2002-2008) season one: episode one, where two characters meet beneath a burger and chicken sign. The new aspect ratio captured more of the world and detracted from the scene and shot's intention and composition. It was cropped to retain the original composition in a compromise. (Figure 1, 2, 3) The old 4:3 aspect ratio is perceived as inferior due to the ever expanding size of widescreen televisions, the pillarboxing of old footage and the technological limitations of the time. The argument that widescreen is closer to cinema is conflicted with the fact that it has lost this connotation with a further letterboxing of the widescreen image to renew this reference for cinematic effect. (Cardwell, 2015, p.88) The historically changing aspect ratios for older television programmes pose challenges to viewership on screens today; one possible solution is to be displayed in their original context on smaller screens in the correct aspect ratio. The next standard is the move to three-dimensions (3D) and ultra-high definition (UHD) up to eight times high definition, or 1080p. Despite the ever changing standards, they are necessary to simplify lives making it possible for differing brands of technology to work together in harmony. (Norman, 2013, p.252)

Figure 1: *The Wire* Season 1: Episode #1 The Target - SD Clip (HBO) – 4:3 (HBO, 2002)

Figure 2: *The Wire* Season 1: Episode #1 The Target - HD 1.0 Clip (HBO) –16:9 (HBO, 2014)

Figure 3: *The Wire* Season 1: Episode #1 The Target - HD 2.0 Clip (HBO) – Newly cropped 16:9 to regain composition (HBO, 2014)

1.2 Portrait vs horizontal orientation on handheld devices

Cardwell states that freedom has been lost on the vertical axis whilst gaining breadth in the switch from the 4:3 to 16:9 aspect ratios. The current smart phone and tablet screen trends challenge this conclusion, albeit in differing media forms. (Cardwell, 2015, p.96) The mobile form factor is transient, with multi-touch interactions. This effects the navigation, layout, and also the behavioural strategies and patterns. While Android, Windows tablets and mini-tablets are biased towards landscape usage in their design with a 16:9 format, Apple's iPad at 4:3 functions in both orientations frequently. Handhelds like smartphones, despite their wide 16:9 aspect ratio are used in portrait orientation most frequently. (Cooper et al., 2014, p.509)

Modern mobile phones detect the screen orientation, rearranging the layout to suit the current orientation. The majority of applications are fixed in portrait even if rotated for list and grid based content with the assumption that users operate smartphones with one hand in portrait orientation. Camera applications allow rotation to landscape orientation to support the medium itself which can be presented this way with iconic controls that make sense and are easily figured out by users. (Cooper et al., 2014, p.512) For example, smartphones are the most common video creation devices with a tendency to record in portrait orientation. Smartphones or tablet users spend twenty-nine percent of their day using their devices in portrait mode, five years prior it was only five percent stemming from most content like webpages, applications and videos providing viewing in a widescreen format. (Schmutzler, 2016, p.40) Tablet users have the same habit with increased space for keyboard typing acting as an additional benefit. Snapchat is a photograph and video sharing application that encourages use of portrait orientation exclusive to smart phones. vertical video advertisements have a nine percent higher completion rate than a horizontal equivalent, users do not want to turn their phones horizontally and wait for the accelerometer to catch up with their orientation. (Schmutzler, 2016, p.40) Tablet applications must also be reoriented rather than simply rotated. Relocation of tabs, navigation and tool bars to the top or sides of the screen is necessary. More complex and dedicated applications like video streaming applications in landscape, suit a fixed orientation. (Cooper et al., 2014, p.515) Thus, the debate of horizontal versus vertical has come down to a matter of convenience dependant on the type of content.

1.3 Constraints and imposed aspects

YouTube updated it's Android and iOS applications in July 2015 to enable vertical videos to be played vertically without pillarboxes on either side with Facebook following suit. (Wise and Stern, 2015) Instagram overcame the issue by adhering to a square format cropping image and video content allowing suitable viewing on both handheld devices and desktops. In August 2015, Instagram added a format icon (Figure 4) to adjust orientation to portrait or landscape stating that visual story should come first whilst also considering the annoyance of cropping. Emphasis is placed on what is described as the cinematic quality that widescreen produces relatable to the television switch from the 4:3 to 16:9 aspect ratios in what they call "thinking outside the square." (Instagram, 2015) A camera application for Android and iOS smartphones called Horizon shoots all videos in landscape regardless of how the phone is held by the user. While it appears to be a solution in theory, it requires a digital cropping of the image which creates a degradation in quality, it also zooms in and out to retain the orientation on the vertical axis. (Horizon, 2014) Users who are aware of the issue that install it need only change the orientation in any default camera application to solve this issue rendering this application pointless as a third party application not default on handheld devices.

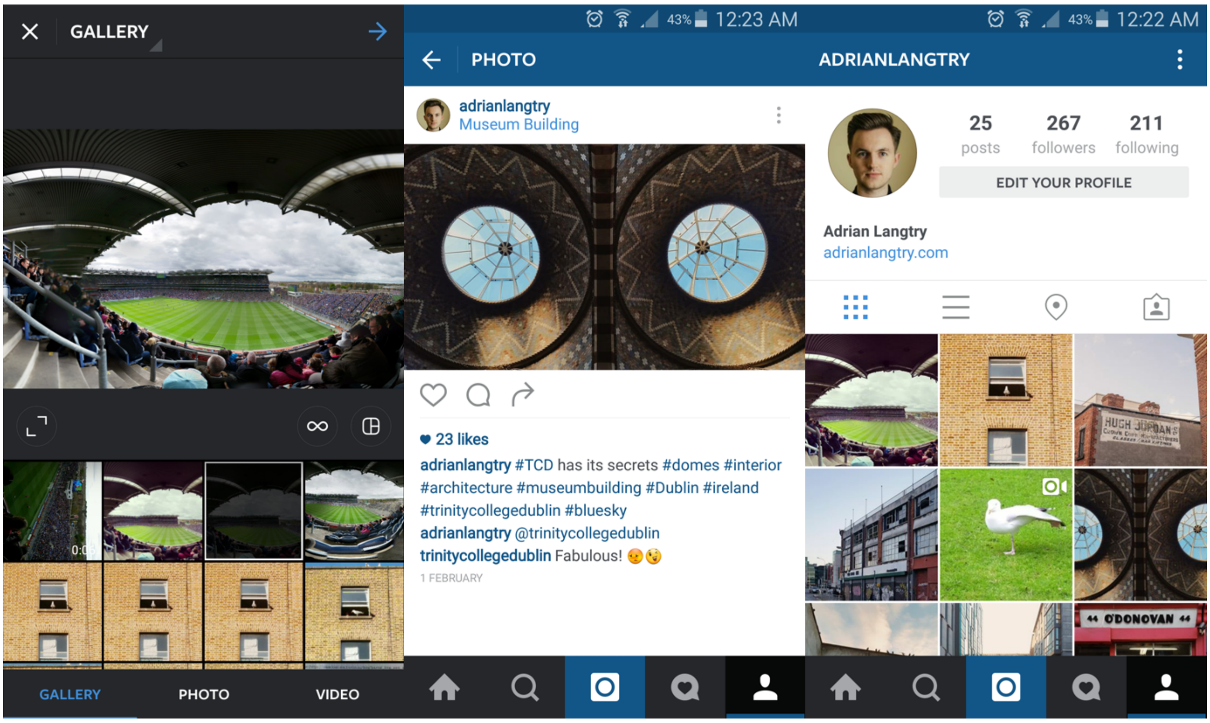

Figure 4: Left: Instagram import with format icon, Centre: uncropped image, Right: profile view retains the cropped image grid

Seven-inch tablets which sit between a smartphone and much larger sized tablets suffer with the 16:9 Ratio. The Amazon Kindle Fire HD and Google Nexus 7 have a form factor with dimensions that do not lend themselves to either list or grid views with more than two rows or columns which are either uncomfortably wide or too cramped. Designers must not treat these types of tablets layouts like oversized smartphones. (Cooper et al., 2014, p.228)

1.4 Second Screen Viewing

Multiscreen or second screen viewing combines smart handheld devices and television broadcasts. An Irish design studio made a concept design for this area called it MetaMirror. The idea combined the use of metadata from the internet streamed to devices providing real-time information overlaid on a secondary device mirroring the television broadcast with an intuitive user interface. Differing statistics and updates are viewable depending on whether it was sports with statistics, Twitter updates and betting, lifestyle programming with ingredients and shopping baskets, or music broadcasts with track information, buying and ticket selling. (Smith, 2010) This proposition did not take off when proposed in 2010, Twitter and Facebook have taken over in this department without the need for a purpose built product rich in screen information.

Second screen viewing is not only affecting television, but social media itself. The interactive medium of social networks, especially Twitter provide a new social aspect to television. Television is the primary device, the secondary screen, usually a handheld device, fulfils the social aspect with global conversations during the live airing of shows taking precedence. This facilitates the personalisation of content and advertising in the designing of mobile applications**.** (Mukherjee and Jansen, 2014) Media multi-tasking has become common with viewers using smartphones, tablets and computer desktops and laptops in a new multi-screen generation. Currys PC World analysed data from January 1st to December 31st 2015 of the sixteen most popular shows totalling forty-five million tweets. The most popular show Game of Thrones (2011-) garnered the highest number of tweets on Sundays and Mondays, which are the air days in the US and the rest of the world suggesting that it is very much a live television event. (Brown, 2016)

Streaming services like Netflix provide movies and television series content that utilises the multi-screen experience. It has the ability to view programmes on an array of devices including smart TVs, streaming players, gaming consoles, smartphones and tablets. It has the ability to pause on one device and pick up on another at any time. A seamless interaction user experience between their computer and mobile devices is achieved. Users want two different interfaces, not two completely different systems. (Moyer, 2011)

1.5 Wearable Screens

Another form of viewing is in wearable computing, providing a satellite device with contextual information provided from a paired device. Wearable computing lies in wrist worn watches with the first wearable computers attempted by researchers in 1961 by Thorpe and Shannon with the purpose of beating statistics and increase winning chances in roulette and card games. (Reiss and Amft, 2015, p.584) The 1970s introduced LED and LCD watches. Up until recently, the watch was neglected to tell the time with a return to the pocket watch in smartphone form. Technological improvements with multiple functionalities question this trend. (Rawassizadeh, Price and Petre, 2014, p.45)

Smartwatches smaller screens are designed to be used in a unique context to smartphones with optimisation for “brief, intermittent activity.” (Saran, 2015, p21) They are a new generation of devices that support an on the go context by providing succinct information with a minimal amount of options. Known as satellite posture devices due to their emphasis on retrieving and viewing data on screens, limited screen real estate delivers information that is paired from a standalone convergence device like a smartphone or desktop computer with Bluetooth or other wireless connection. Their function is transient in nature with touchscreen or heads-up displays and voice commands to provide just enough information including notifications and other relevant information like the time. (Cooper et al., 2014, p.225-227)

Samsung and Sony smartwatches function as a complimentary interface for their smartphones and tablets. The Android Wear watch can operate independently once the applications are installed from a smartphone. The Microsoft Band and Apple Watch (Figure 5) work independently also, with further functions in conjunction with a smartphone. (Rawassizadeh, Price and Petre, 2014, p.46)

Figure 5: Apple iPhone 6 Plus Watch App and Apple Watch are mirrored via Bluetooth connectivity for selective notifications and alerts (Apple, 2015)

Despite its small portrait screen with an aspect ratio of 4:5, (Sonelra, 2015) the Apple Watch (figure 5) can make and receive calls functioning like a smartphone. However, the small size limits complicate interactions. Native and third-party applications have a difficult time displaying their more useful value than looking at the applications on full-fledged smartphones. It also costs ten times more than a watch that is quicker and better at telling the time. (Murphy, 2016) Android Wear Watches, Sony and Samsung smartwatches are not without their problems with telling the time as the main use, with a lack of interface. (Segan, 2016, p.48) The small screen size is poor for multimedia displays of video and imagery, a possible solution is the curved screen around the wrist like the Samsung Gear S smartwatch. (Rawassizadeh, Price and Petre, 2014, p.46) The Samsung Gear S has a resolution of 360 by 480, one of the highest available. This new screen size and type requires new user interface design thinking to compliment smartphone usage according to Dineen, (2015) assisting the user visually and also ergonomically to make them fundamentally useful for users.

The main issue with the likes of the Apple Watch is their slow speed and processing power as an extension of a smartphone which is increasingly more powerful than the rate at which developers can keep up. Smart Watches are questioned as computers, nonetheless their convenience to provide notifications and health tracking is positive. It is necessary that Apple reconsider aspects fundamental to conceptual design with new capabilities. (Patel, 2016)

1.6 Health Risks Using Handheld Screen Devices

The method of using smartphones and tablets at a low angle puts unnecessary pressure on the neck, particularly for younger generations with prolonged usage. A study in Korea stated that 97.4% of people in their twenties spend an average of 4.1 hours per day on their smart phone, going up to 5.4 hours for heavy users. The downward flexing of the neck for extended period of time can cause musculoskeletal disorders and the head forward posture can create a posterior curve known as the turtle neck posture. The weight of the head increases exponentially from the normal ten to twelve pounds up to sixty pounds at sixty degrees causing an overstretching of the muscles. Good posture involves keeping the ears in line with the shoulders with retracted shoulder blades. (Lee et al., 2015, p.12-13) Adjusting the viewing angle provides relief to the neck, head and shoulders. Tablets suffer from the same problem of being held too low which can strain vertebrae and muscles which can cause injury to nerves, tendons, ligaments and spinal discs also. (Harvard Health Publications, 2012, p4)

Another issue is the indication that smartphone use has negative effects on human psychology due to social isolation from the real world leading to feelings of isolation and loneliness which are symptoms of depression. Smartphone use is also associated with anxiety and insomnia leading to psychological distress and thus an unhealthy lifestyle. (Lee et al., 2015, p.16)

A solution is to prop the tablet or smartphone at a steep angle in a case on a table to reduce neck strain and pain, changing position every fifteen minutes according to Dr. Dennerlein. This applies to laptops and desktops. The top of the screen should be just below eye level sitting up straight with a level head not bending forward with relaxed shoulders and elbows close to the body on a chair with good support with wrists, forearms and thighs parallel to the floor. Laptops should be used like desktops with an external keyboard where possible due to the low monitor and high keyboard. (Harvard Health Publications, 2012, p4) The correct posture is not common practice for smartphone usage unlike the established television or cinema seated positions. It suggests the industry will lean towards more established forms of ergonomically friendly wearable electronics.

1.7 Chapter Conclusions

Design is a discipline that brings together technology, culture, business, commerce and most importantly people. Design pressures and challenges must remember that these products are made for use by people regardless of the complexities and constraints. It is about developing products "that assist and enrich the lives of people, that bring benefits and enjoyment." (Norman, 2013, p.250-251)

The changing aspect ratios and high definition video in cinema and television is led down a path of constant evolvement in ever increasing size and width in the new industry standard of 16:9. This presents issue for older formats that must update to the new standard of familiarity for users. The loss of the vertical in video in the broadcast industry is met by the portrait oriented smartphone which is here to stay and continues to get larger, assisted by larger tablet devices which users prefer in portrait orientation also. Solutions exist to combat users preferred use of mobile handheld devices portrait orientation for cross compatibility on horizontal screen devices. However, the content for these devices indicates that vertical video is established and accepted by users who do not wish to turn their phone, and for designers, their icons and interface.

Multiscreen usage is becoming increasingly common between televisions to smartphones and tablets, not least computers also with fundamental social capabilities. Wearable devices like smart watches are questionable in their true function due to their similarity to the standard wrist watch. Their small screens have restricted user interfaces and are unsuitable for video and imagery display. Nevertheless, they provide an alternative user experience for users with quick access to notifications and time without the need to search their pockets for their smartphones. Health risks do not favour the newer smartphone's increased usage but favour the more established wearable smart watches for their practical and convenient user friendly accessibility and usage.

2 Augmented Reality

2.1 Introduction

Augmented reality is an extension of the real world with additional digital overlays for new experiences with practical uses for entertainment and design to visualise new and unseen possibilities. It was developed for aircraft cable assembly guidance and surgical training in 1992. It was also used for laser printer maintenance demonstrations in 1993, but was limited in popularity due to the restrictions of head-mounted displays and backpack computers. (Tasi and Cheng, 2014, p303) Google Glass (Figure 15) was the first widely popular realisation of this technology for consumers but was discontinued in 2015 unexpectedly despite its capable future which is investigated in this chapter. The forerunner for consumers is currently Microsoft's HoloLens which has promising capabilities as it establishes itself on the market. (Figure 16) Augmented reality has further capabilities in the live sports broadcasting industry for television broadcasts. It functions to enhance and understand the viewing of American sports with video assisted overlays for aesthetic entertainment purposes. The smartphone camera has augmented reality features including the ability to provide real-time and place mobile gaming experiences utilising the camera and global positioning system (GPS) of a handheld device, for instance the soon to be released Pokémon Go. The very popular photo and video sharing application Snapchat is a prime example of augmented reality providing drawing, emoticon and text overlays. Snapchat's lenses feature is its most popular feature entailing animated overlays with face detection and tracking. Last but not least are heads up displays (HUDs) that are used mainly in the motoring industry for vehicle displays with future potential for motorcycle helmets. Disney has been working on implementing an augmented reality colouring book that presents a three-dimensional image of a two-dimensional drawing utilising a tablet or smartphone screen in real-time. It has not yet been released to the public, however it presents an outlook on future uses of this technology.

2.2 Augmented reality in Live Sports Broadcasting

American sports broadcasters like ESPN and Fox use augmented reality to display more visual information on screen and to help make the viewing experience more understandable and thus enjoyable. Real-time sports use includes the National Football League's (NFL) yellow first down line, which draws a yellow line over the field for the offside line. (Squadron, 2014) The National Hockey League (NHL) had Foxtrax Glow Puck that highlighted the puck and its direction. Major League Baseball (MLB) has the K-Zone that covers the players providing function over aesthetic. (O'Connell, 2015) Most recently, the National Basketball Association (NBA) has begun lighting up the three-point line whenever a player is deemed to score from beyond the arc of this line. (D'Orazio, 2016)

The Fox Network debuted its FoxTrax glow puck system at the 46th NHL All-Star Game that tracked the movement of the puck by superimposing a blue glow over it for viewers in real-time on television. (Figure 6) It was developed by Stan Honey, the VP of Technology at Newscorp. It merged computer graphics with live sports presenting the first augmented reality system used in sports. It received a mixed response, favoured by those learning about hockey rather than devoted fans. The concept was formed with the intention of making the puck glow because it was difficult to follow the key element of the sport all of the time making it a low rated sport in the USA.

It utilised infrared emitters fitted inside the puck with sensors fitted in the rafters and near the television cameras. The television cameras were set on special tripods that detected the pan, tilt and zoom to ensure that the tracking system and game footage lined up. Data was then rendered by computers as a superimposed blue glow that highlighted the puck if it was obscured by players, when passed it would display a blue streak tail. When hit hard above seventy miles per hour it displayed a red comet tail. (Figure 6) It needed a ten frame delay for live television. Despite its assisting vision abilities, fans disliked the bright graphics according to Honey, chief engineer of FoxTrax. (Barry, 2016) Fans found it be unnecessary due to the fact that the puck is black set against the white background of the ice. (Victor, 2011) The video game aesthetic was disliked by purists and hockey fans. Wyshynski, editor for Yahoo Sports described it as "NBA Jam for Idiots." The attacks were misplaced during a time prior to the advent high definition broadcasts. (Gordon, 2014) Broadcasters have become sensitive to how technology is used to tell a story that adds, rather than subtracts from the sport.

FoxTrax glowing puck was too new for its time, the blue glowing puck was an indicator to show tracking by developers, who would have preferred a subtler look. It was never replaced by Fox's art department and disappeared after the 1997-1998 season when Fox lost broadcasting rights. Stan Honey set up Sportsvision in 1998 which created the yellow first down line for the NFL and baseball pitch tracking which are still used presently and loved by viewers. Modern sports technology uses passive technology that does not require tracking devices for camera tracking. The intent has changed to subtle on screen cues to help understand the game when it comes to the yellow first down line. The primary purpose is improving the viewing experience for those who watch the sport, unlike the glowing puck FoxTrax which attempted to attract viewers. An engineer from the original project, Cavallaro, states that if the glowing puck was reintroduced, it must be subtler and not add a foreign colour "to the viewer's palette, perhaps a black blur behind the puck on the white ice." (Gordon, 2014)

Figure 6: NHL All-Star game, 1996. FoxTrax glow puck, glows in blue and in red with a comet tail when travelling over 70mph (Fox, 1996)

The yellow first down line for the NFL aimed to enhance fans television experience, whilst also helping young or casual fans learn the game. It is a virtual line that appears on the field beneath player's feet, virtually painted on the grass to transform football viewing. (Figure 7) It had to be thick enough to be a viewer's guide and fade out when the referee placed the ball on the ground and not display in replays to avoid inaccuracy controversy for the referee in real-time. It also utilised sensors and the movement of the cameras with precise measurements of each field and colour sampling grass colour to appear like paint over it whilst avoiding players. It debuted on September 27th, 1998 exclusively on ESPN and received phenomenal reviews earning an Emmy award for technology. It is now used for every NFL and college telecast with accuracy, abolishing the need for a line fade out when the referee spots the ball. Honey and Gepner commented that it made the game more understandable for male fans wives and girlfriends, children look for the line when attending games and that some are of the opinion that it is done with disappearing paint or lasers. (Squadron, 2014)

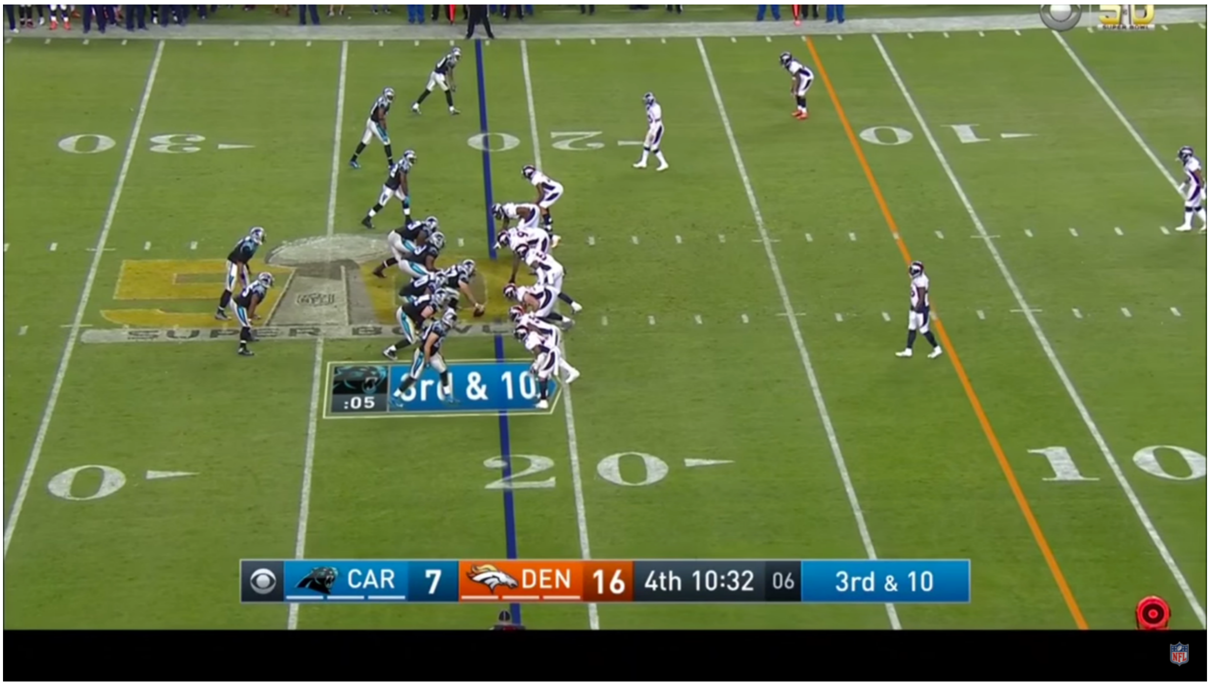

Figure 7: Super Bowl 50, 2015. Yellow first down line on right of screen, blue scrimmage line has since been added (CBS, 2015)

ESPN uses an overlaid strike zone in its MLB live broadcasts with every pitch using a system that perceives the ball and strikes using an array of markers on the x and y axis. (Figure 8) It is called K-Zone, characterised as a device that is stated to be essential, changing the way baseball is watched according to Phil Orlins, its spokesperson. The lengthy nature of the game has led to quick, precise cuts with a centrefold camera providing a better view on screen than at the stadium itself. However, the camera is off centre and provides an illusion that K-Zone provides clarity for. It is disliked for its video game aesthetic and deciding on the quality of every swing on algorithms rather than visuals. It is less forgivable, “perfect information over beauty, precision to custom” according to O’Connell. (2015) It provides an insight into the viewing American public with increased replays and angles, an eradication of grey areas. K-Zone denies balls and strikes being an imprecise science and is considered distracting, nevertheless ESPN overlays it on all of its MLB broadcasts. (O'Connell, 2015)

Figure 8: NYY@BOS, 2016. K-Zone rectangle and bat hit location (ESPN, 2016)

ESPN has since introduced “Virtual 3” technology to the NBA three-point arc which lights up in red if a shot is in the attempted range. (Figure 9) Much like the NFL’s yellow first down line, it is not an official system, it differs in the sense that the line does not move. This augmented system is for broadcasts with the goal of making it clearer when a shot is in the three-point range. It is not necessary; however, it is not unsightly like the MLB’s K-Zone. (D’Orazio, 2016) (Figure 8) The existence of the three-point line in reality requires the virtual line to mask it exactly through video analysis of tracked cameras to assist producers in telling the story of three-point shooting for viewers. (Perry, 2016)

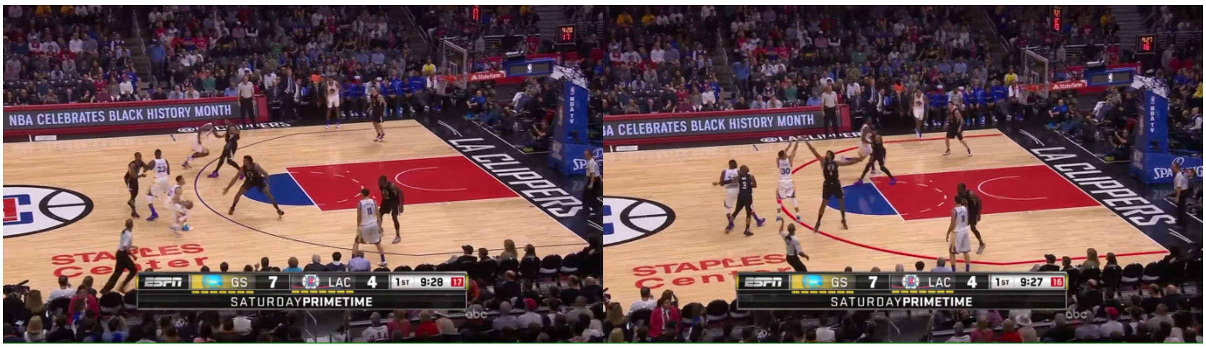

Figure 9: GS@LAC, 2016. Virtual 3 lights up the three-point arc in red on shot attempts in range (ESPN, 2016)

Data visualisation technology makes sports accessible and easier for viewers to understand what is happening with graphical representation. They change the way sport is watched, Stan Honey, engineer and sailor, has led to the development of all of them. The most innovative of these is for the America's Cup sailing race allowing it to be understandable, accessible and more enjoyable like other augmented reality technology for live sports broadcast before it. It calculates the orientation of the camera and the distance of the helicopter from the boats within two centimetres and the camera to the nearest one-hundredth of a degree. Graphics are superimposed over the image along with marks and sail boats in real-time with on-board computers and trackers for the boats. (Figure 10) A LiveLine on-air producer directs the camera and pilot to compose the shot to put in visual elements avoiding too much material to confuse viewers using precise time and measurements. Nevertheless, it is still intended for sailor viewers rather than the unknowing viewer albeit making it more accessible to sports fans who are not yet sailor fans with boundaries, one-hundred metre lines and finish lines to figure it out very quickly. (Figure 10) Honey states that the objective is the same as the other augmented reality systems, it takes things that are important to the sport, and makes them easy to see for the viewer. (Taylor, 2013)

Figure 10: America's Cup sailing race with LiveLine. Superimposes distance, marks, speed, boundary and boat country (LiveLine, 2013)

2.3 Smartphone Cameras Augmented Reality

Snapchat is a photo sharing application for Android and iOS that is used by a young demographic with tracking, face detection and augmented reality features. It is currently valued between ten to twenty billion dollars, with ever increasing rates of users, activity and fundraising used by one-hundred million users per day. It is used by celebrities and curated content from National Geographic to ESPN. Videos are viewed six billion times per day in total, approaching Facebook's eight billion. Snapchat CEO Evan Spiegel states that seventy percent of its engineers are working on new products that continue to change digital communication conventions.

One such experiment is an augmented reality feature called lenses, which is now a core feature on the platform. It relies on touch screen signifiers (Figure 11) which are arrows and icons providing signals about permissible operations including swiping left, right, up or down and selecting tools and areas of the screen like the face to bring up the lenses feature for augmented reality. (Norman, 2013, p.21) It does not implicitly display this feature otherwise.

The success of this feature lies in its playful use of the technology that overlays animations onto the face of the user which is mapped by pressing on the face on screen. (Figure 11) It is real-time video imagery that alters the face with reactions based on face movement including opening the mouth, raising eyebrows or blinking eyes. Premium lenses and sponsored lens by brands designed by Snapchat for purchase for ninety-nine cent each, successfully commercialising consumer augmented reality. It proves that augmented reality can be successful on devices that are currently in use by users, like smartphones. It should be noted that augmented reality has been in use before the new face recognition lenses feature. It has always had the option to select from a colour palette in order to draw and annotate visual messages. Last but not least are the filters. These include geo-filters that display banners in certain regions, colour filters, contextually aware temperature, speed, and time filters. Certain filters are used on special occasions for charity organisations to raise money each time they are used by donations from foundations like the Bill and Melinda Gates Foundation for World AIDS Day. This means it is not just Snapchat profiting from the use of augmented reality, but redirects to charity. (Racette, 2015)

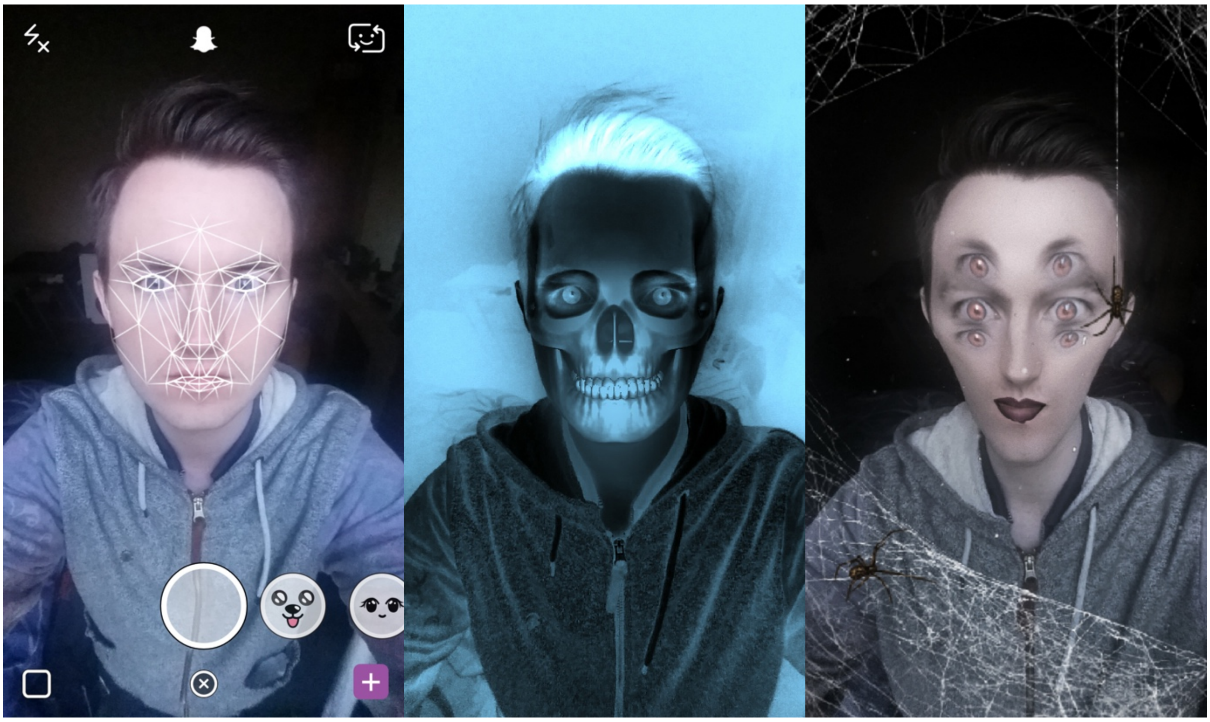

Figure 11: Left: Snapchat's facial recognition when the face is selected, with icon display. Middle and Right: Filter effects mapped onto face in real-time

2.4 Location based Augmented Reality Mobile Games

This enables new forms of storytelling beyond traditional media with mobile gaming in particular containing virtual content connected to locations in meaningful ways. Content is superimposed into three-dimensional space onto the real world in real-time with a focus on entertainment and educational purposes for consumers. Stories are enjoyable and memorable; thus they can be used as a method of education. Genres of location based experiences include alternate reality games, puzzle hunts, pervasive games, cross and trans-media and also performance art. These location-based games take place outside of the home. (Azuma, 2015, p259-260) This section focuses on the upcoming Pokémon Go smartphone game to discuss these possibilities.

Figure 12: Left side: Augmented reality of virtual Pokémon in a real location using smartphone camera
Right Side: Real location map using player's GPS co-ordinates, different geographical features attract suitable Pokémon (The Pokémon Company, 2016)

Pokémon GO is a soon to be released an augmented-reality game for Android and iOS combining the smartphone screen with the real world. It is developed by The Pokémon Company and Niantic with contribution from Nintendo. (Figure 12) It is a mobile application that is downloaded directly onto a smartphone to play in the real world through it. The game encourages connections with other players nearby with the aim of locating, catching, battling and trading Pokémon, virtual animal creatures. They roam the real world with the ability for players to capture them in parks, shopping areas, pedestrian streets and the countryside all over the world. Eventually, a player must join one of three teams with real players, locate a virtual gym and challenge them using one of the Pokémon in an augmented reality that truly goes beyond the screen. (Pokemon.com, 2016) It utilises location data from the player's smartphone GPS that dictates the type of Pokémon that that can be caught in certain areas geographically. (Figure 12) For instance, near a body of water will present water-type Pokémon. It blends the real and digital world into one. It also suggests a move into mobile gaming on smartphones replacing hand-held gaming devices. It serves to tap into a growing audience for video games. Nintendo's first official smartphone application, Miitomo, more of a social network, garnered one million users in five days in Japan. (Tsukayama, 2016)

The game has a companion device called the Pokémon Go Plus, (Figure 13) which is a companion device that is worn like a watch that is intended to enhance the enjoyments of playing this augmented reality game. This device allows the game to be played without looking at the smartphone screen with indicators in the form of haptic feedback vibrations and flashing coloured LEDS. This has the purpose of encouraging players to not just look at their screens, but to experience their real world surroundings. Like the previously mentioned Apple Watch, it is connected via Bluetooth to a smartphone with notifications on events, in this case they are within the game world augmentation. For example, a nearby Pokémon that can be captured. It has a button to perform simple game actions like throwing a Pokéball to a catch Pokémon. (Brewis, 2016)

Figure 13: Pokémon Go Plus worn on wrist with Pokéball button and coloured LEDs (The Pokémon Company, 2016)

The user experience of this game has yet to be seen, in theory it sounds promising, its practicality could have a different outcome. Potentials for location based augmented reality include navigation, history and education. The opportunities for further interaction out of the home could provide more social interaction rather than arguable isolation. Risks exist for privacy and distraction in a real world environment that must be solved. Design goals of touch screen and gesture input to support interaction should provide the illusion of augmented reality through a perceived spatial relationship between the player, real world and virtual world. The location of the interaction should appear to be in the perceived augmented reality and not on the screen. It would be beneficial for the interaction techniques not to remind the player of the smartphone in their hands, otherwise risking the interruption of the player's belief in an immersive experience. It must be enjoyable for the player from a design perspective and so avoid frustration, fatigue and discomfort. Player's comfort is of utmost importance for a mobile gaming experience in augmented reality. (Handreck, 2015)

2.5 Educational Values of Augmented Reality

The main goal of adding augmented reality to books in visual, audio or transitional interfaces is to create engaging user experiences that enriches the reading of drawing made possible by this technology. There is the added interactivity of manipulating the tangible book to experience virtual content from different positions and flipping pages. The implementation of an augmented reality book avoids separate development of different setups or input devices. The integration and distribution of additional tangible interface abilities is more feasible. One example is the engagement of users in creating augmented reality colouring book drawings in real-time providing enhanced educational abilities. (Clark, Dunser and Grasset, 2012, p.7) Disney researchers have developed an augmented reality colouring book for children that converts two-dimensional drawings into three-dimensional characters by texturing them onto corresponding regions of the extra dimension. (Figure 14) Its purpose is to provide a bridge between real world activities and digital enhancements using an application on a handheld mobile device. It is detected and tracked, the device video streams the animated three-dimensional version with custom texturing in accordance with the child's coloured drawing, all with real-time tracking. Disney's aim was to target the growing market of digital devices that are causing traditional activities like colouring books to be less engaging for children due to their unexciting nature in comparison. This has led to more passive consumption with digital devices, thus leading to less engagement with real world activities to challenge creativity. Augmented reality can bridge this shortcoming to direct the popularity of smartphones and tablet devices to renew emphasis on these more practical traditional activities.

The colouring application is not without its problem. It generates a colour textured character for occluded areas of the drawing that do not appear on a two-dimensional image using a look-up technique, and also accounts for the uneven surface of a bound book with surface tracking for the generated texture. (Magnenat et al., 2015, p.1201) Studies found that sixty percent of participants felt that the application increased their motivation to draw in colouring books, thus having a positive effect, with twenty percent stating that it affected drawing skills positively.

The most successful engagement of eighty percent felt an increase in feeling for the character being coloured. Total findings concluded that seventy-five percent of applicants would use the application if it was provided for free. Therefore, the augmented reality colouring book application is proven to improve a sense of connection with the drawn character, with this it motivates users to draw more. Real-time texturing that copies existing pixels with surface tracking on a selected template using a look-up technique is required for mobile devices. It offers potential for further development in visual computing. (Magnenat et al., 2015, p.1209-1210) It should be noted that this technology was debuted on September 29th, 2015 at the IEEE International Symposium on Mixed and Augmented Reality and is still in its infancy, it could be a while before colouring books with this capability are on the market for consumers. (Cox, 2015)

Augmented reality for education indicates an enhancement in motivation to learn in a classroom environment for book research. However, the tangibility of traditional paper books trumps electronic books for their physical tangibility. The additional computer generated imagery of augmented reality information serves to enrich a users' learning experience beyond electronic books. The familiar physical use of books for a more natural and intuitive usage of paper is aided by augmented reality. The seamless qualities, even for those with limited computer experience create new educational benefits and learning possibilities, particularly in aiding children's understanding of the content of books. Improvements for students include cognitive attainment in spatial ability, conceptual change and language skills, however in-depth studies are limited and not fully understood in the process of learning. (Tasi and Cheng, 2014, p.303)

Figure 14: Disney Research colouring book application augmenting an elephant drawing in real-time (Disney, 2015)

2.6 Augmented Reality Heads-up Displays (HUDs)

This section focuses on the wearable computing of the discontinued Google Glass (Figure 15) and the current Microsoft HoloLens (figure 16) which is currently the frontrunner in satellite posture devices in the eyeglass format. (Cooper et al., 2014, p.227) Heads-up displays like the aforementioned are used in a distracted manner and so must be optimised for beginners, otherwise they will be abandoned with a design principle that imagines “users as very intelligent but very busy.” (Cooper et al., 2014, p.244)

Heads-up displays for jet fighters have been augmenting vision with information for decades, with versions for car windscreens also in the last decade. (Moggridge, 2007, p.519) For jet fighters, superimposed readings of critical instruments are on the forward view of the cockpit windscreen, without the need to use peripheral vision to take readings while navigating flight. (Cooper et al., 2014, p.256) Windscreen displays eliminate the need for eye movement to monitor critical instrument panel readings and navigation information by placing them in the forward view of the driver also, although a slight shift is required. The key is to support the relevant activities with sensitivity to human capabilities. Similarly, technology called LiveMap is being developed for use in motorcycle helmets. (Siler, 2016)

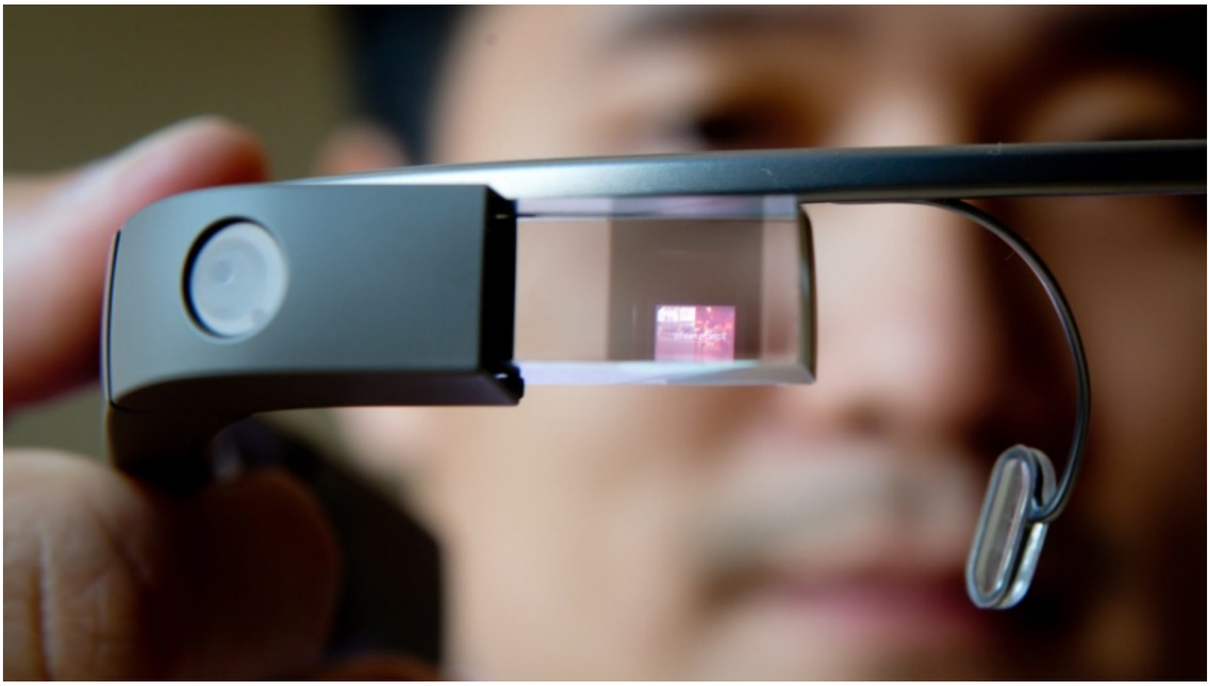

Figure 15: Google Glass projected imagery onto lens (Gadgetadda, 2014)

Google Glass (Figure 15) was found to not be very useful and tended to disturb people surrounding a user that they were wearing it. The problem began by Google releasing it as a beta product with limited functionality that was perpetually in view with a hope that software developers would provide attractive applications with early explorers to spread the word. Its looks were not its shortcoming but rather the lack of utility, why a user would want to wear such a device on their face. Especially in obstructing typical social interaction. It can take video, give directions, make phone calls and search the web, but none of them very well. In order to succeed it must have amazing capabilities or be unobtrusive otherwise. However, smart glasses ability to view digital information at a glance is powerful with no interruptions. Activities like cooking, cycling or real-time language translation and navigation without a smartphone would benefit.

The potential as a memory aid and productivity enhancer are useful. Researchers aim to design smart glasses that are unnoticeable, operated with inconspicuous gestures, eye movements and voice commands. It would not disturb people around the user if this were the case. Google Glasses magnified lens display is not discreet. It sits above the eye on the frame with a display that is reflected on the eye when it is on, which is noticeable for others. When turned off, it is still apparent and noticeable. (Metz, 2015, p.79) Possible solutions include removing the lens magnifier for the display (Figure 15) and bringing it closer to the eye to make it practically invisible. An efficient battery that lasts a day would be needed to reduce the large battery size. Users require good function, like a real pair of glasses. (Metz, 2015, p.81-82)

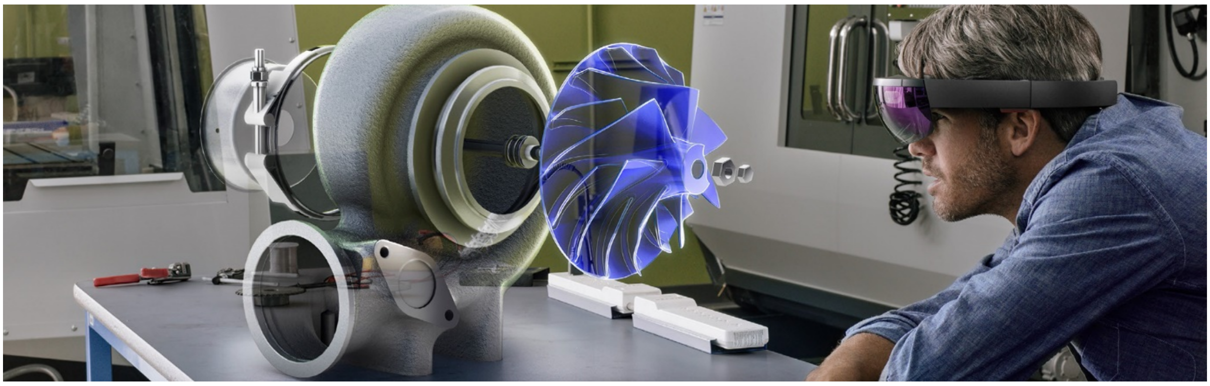

Figure 16: Microsoft HoloLens brings “products and information to life” (Microsoft, 2016)

Microsoft HoloLens allows users to interact with their digital content in a real world environment in what Microsoft refers to as “mixed reality” to give holograms “real-world context and scale” to interact with digital content in the user’s surroundings. (Microsoft, 2016) (Figure 16) It is a heads-up display holographic computer. It was first shipped to developers on the 30th of March, 2016. (Statt, 2016)

NASA use the device on Earth to interact with images from the Curiosity Mars Rover in order to send commands to it and also for remote maintenance assistance on the International Space Station. It is a combination of digital to interact with the analogue world with primary interaction features of gaze, gesture and voice states Heckman. (Merrett, 2015) However, it must be marketable for consumers. Unlike Google Glass, which was not aimed at the industry or business sectors, Microsoft HoloLens is a business tool for commercial applications. (Figure 16) It has a context that means it is not designed to look discrete, it is obvious if it is on or not. Google Glass was the opposite and may have secretly been recording the unsuspecting public.

It has applications for planning, drawing the likes of buildings for construction sites and the simulation of body parts in three-dimensions to educate students on their functions. (Figure 16) Remote house tours for estate agents, technical assistance from maintenance workers and customised personal experiences provided by customer service. It is intentionally coming from a commercial end in order to make more sense to users, businesses in particular. It is managed like a smartphone or tablet with passworded access.

The main distinctive feature of HoloLens is the ability for users to have the ability to interact with digital objects like their real world counterparts, walking around them in three-dimensional form. (Figure 16) Google Glass was augmented reality, (Figure 15) but it did not have this interactivity of movement, it was always in the same place in two-dimensional form despite it being contextually relevant to the real world. HoloLens is designed and engineered to follow the laws of physic when it comes to digital objects. A holographic bottle will roll off a real world table for instance. It integrates the real and virtual world by not covering the users entire field of view. The user is fully capable of interacting with the real world, to see their computer screen with simultaneous abilities to interact with an object next to the user. Thus, computing enters the physical real world, a Skype video call can be hung on a wall with the user at the end of the call see what is in the room. (Merrett, 2015)

Microsoft HoloLens uses projected video cards that appear in the air and can be walked around, grabbed and placed in varying positions. (Figure 16) Like Google Glass, a fitting is required to measure the distance between the pupils. A headband collar for wearing, and a separate one for adjusting the optics angle are possible. It has gaze, gesture and voice control. While it is an untethered and mobile device, it would not be worn all day and is liable to vertigo issues. (Muchmore, 2015, p.20-22)

Nevertheless, with HoloLens, (Figure 16) the virtual has made a shift towards a sense of "the real and tangible," rather than "transcendental and intangible" as an augmented reality device, despite Microsoft's labelling of a "holographic device." It's ability to merge the real and virtual is questioned by its small field of view that tends to inhibit the illusion of merging. (Gottmer, 2015, p.25-26) HoloLens inventor, Alex Kipman spoke at TED2016 in February, likening the field of view problem to asking how big a television screen is. He states it is the wrong question. The angular resolution of things that are seen is what is important in the scene with spatial mapping at five frames per second. It is not as limiting as the screen, by extending vision beyond them to interact, work and play. It merges a real and virtual world with future possibilities of touch and feel for digital content. (Kipman, 2016)

2.7 Chapter Conclusions

The merging of digital technologies be it, superimposed overlays in the world of sports broadcasting, the use of mobile device cameras for augmented imagery and new forms of video games are here to stay. They provide helpful and enjoyable experiences for users. Whether they understand the technology or not is arguably irrelevant, for its practicality is at the point of necessity for viewers and users. New forms of vision with Google Glass assist reality, but unlike the aforementioned products, it did not have a clear purpose of use and was no better than the existing smartphone screen other than the convenience of multi-tasking. Its discrete and obtrusiveness for others was unsettling and thus was ultimately discontinued. On the other hand, Microsoft HoloLens has a clear commercial approach for businesses with an intentional use that is clear. Google Glass merely extends to an extra digital dimension in real world vision. HoloLens "goes beyond the screen" by turning a two-dimensional image into a three-dimensional one with real world usage cases with clear intention. It is nevertheless in its infancy and like Glass, may be discontinued for a new technology that will possibly proceed it.

It is noteworthy that the screen oriented forms of augmented reality are successful due to the fact that they are an extension of the familiar, that allow it be more accessible in terms of television broadcasts. It allows social interaction to lead back to the days of analogue with Snapchat's lenses feature and the incoming Pokémon Go. So too does the colouring book three-dimensional character developed by Disney with the intention of renewing interest in traditional forms of entertainment in the digital world filled with screens. The wearable heads up display of Google Glass and Microsoft HoloLens are two cases with differing results in user experience. HoloLens holograms are a mixed reality in a physical world with digital augmentation in three dimensions. Glass was not, merely displaying a two-dimensional screen in the peripheral vision of the user that did less than existing mobile devices, in an always on fashion that was not compelling, with little practical real world viewing that is expected by the implementation of augmented reality. True heads-up displays do not require an alteration of focal point in vision, neither should augmented reality have to. The education, training and learning possibilities for augmented reality in three-dimensions are promising for future applications. Google Cardboard is in part successful for its budget costs to manufacture, produce and use. This is unlike the more expensive business targeted HoloLens. Nevertheless, users accept the design and cost of devices if their function is satisfactory in relation to content.

3 Virtual Reality

3.1 Introduction

Virtual reality is a current trend aimed at consumers for an all new immersive three-dimensional experience in full 360-degrees. It has emerged from the 1990s taking similar optics and external aspects utilising superior performance in resolution, sensors and content. All new latency and optical compensation is used to combat motion sickness that previously hindered its success in consumer immersion. (Kress, 2016) Current products range from the very cheap Google Cardboard to the more expensive Samsung Gear VR that both utilise a smartphone screen. The 599-dollar Oculus Rift and 799-dollar HTC Vive (Figure 17) are the latest and most expensive providing the most immersive user experience, also requiring powerful gaming computers. The Vive includes additional handheld controllers for motion control and interactivity. These head-mounted displays are visually immersive, thus making the user blind, they require systems to assist the user in the real world space. Another competitor is the Sony PlayStation VR which has not yet been released. Virtual reality has entertainment value; it remains to be seen if it has useful educational value. This is investigated in this chapter. It is noteworthy from a viewership perspective that the current virtual reality devices utilise screens to display their content, it is however in a different design format. Three-dimensional interaction on a two-dimensional screen lacks parallax, the ability to perceive depth. Another issue is occlusion, near objects obscuring far objects. These issues, along with navigation and inputs, are designers most problematic issues. (Cooper et al., 2014, p.509) 360-degree videos, virtual environments, education and entertainment with the likes of gaming are virtual realities potential strong points.

3.2 Immersive screens

Immersion is a state that requires mental effort. (Frasca and Ryan, 2002, p.78) Spatial immersion in virtual reality aims to achieve both "a sense of place and a model of space." The space of virtual reality is potentially limitless whereas place is limited by physical boundaries. Space allows movement and freedom. Place offers containment and security. These are the unique concepts that virtual reality allows. (Frasca and Ryan, 2002, p.86) These devices provide a mental focus state that is intense to the point that awareness of the real world is lost, resulting in feelings of satisfaction and joy. The intention is to provide perceptual and cognitive challenges that are a balance, not too under-taxing and thus apathetic, but not too difficult to become frustrating. For designers, perceptual simulation is easier than cognitive engagement due to the large capacity of humans for cognitive actions. However, perceptual immersion is more difficult to sustain over prolonged periods of time. With this, optimal immersion experiences involve both powerful sensory experiences and cognitive engagement. (Lidwell et al., 2010, p.134) A promising example is Google's free Tilt Brush. It demonstrates new possibilities in three-dimensional painting with various substances and selection tools. The added custom fidelity of HTC Vive's motion and gesture controls utilise the capabilities of this new software for artists. (Peckham, 2016, p25)

Figure 17: HTC Vive on left vs. Oculus Rift on right (Miller, 2016)

The consumer affordable HTC Vive and Oculus Rift (Figure 17) use a 2160 by 1200 LED and OLED panel with a 90Hz refresh rate with two lenses that split the display into 1080 by 1200 images for each eye requiring powerful gaming computers. (Greenwald, 2016, p.98, p.102) The cheaper Google Cardboard and Samsung Gear VR both use smartphone screens that are fitted into the screen with the latter optimised for the full high definition current generation Samsung Galaxy Note or S6 range onwards. (Leswing, 2015) Specialised smartphone applications can be installed for virtual reality for free. The soon to be released PlayStation VR uses a 5.7 inch OLED full high definition display at 1920 by 1080 with a 90 to 120Hz refresh rate designed exclusively for the PlayStation 4 console. (Greenwald, 2016, p.108)

The key distinction from the traditional screen is to enable the user experience of an immersive virtual reality. Whilst a traditional cinema for example provides an immersive experience of another world with an expansive screen and surround sound in a darkened room, the user is merely looking at it. They are not within, or interacting with it like in an immersive virtual reality. Immersion is possible through the use of lenses between the screen and the displays in head-mounted displays with adjustable optics in all but the Google Cardboard. It is a budget device, which like the name suggests, is made from cardboard. (Figure 18) The virtual reality headsets completely block out vision of the real world by covering the field of view. The more the better, for a sense of immersion and situational awareness in virtual reality. These high resolutions and refresh rates not only enhance the viewing experience for users, it helps prevent nausea. Tracking and motion synchronisation plays a part in this also. (Moltenbrey, 2016, p.18) Glasses and facial shapes are accommodated by foam inserts for increased comfort for varying users. (Volpe, 2016) The Rift fit is less extreme and gentler on glasses with better ventilation, is lighter and slimmer with a built in headset compared to its competitor, the HTC Vive. (Hollister, 2016)

This immersive virtual reality experience is not without its problems. Users are completely oblivious to their real world physical surroundings. HTC recommends a space greater than six by five feet with base station devices positioned in opposite corners of the designated play area placed at eye level or higher with up to sixteen feet of range apart from each other. The space is then defined by boundaries of the designated space for what is called the SteamVR Chaperone feature. (Greenwald, 2016, p.101) The HTC Vive uses laser positioning and over seventy sensors assisted by a gyroscope and accelerometer with a front-facing camera integrated with the Chaperone system, titled the Room Scale Experience. (Moltenbrey, 2016, p.21) It projects virtual walls in virtual reality that match the boundaries of the physical room play area with indications if the player is about to step out of bounds and thus into a physical wall. These walls only appear when necessary, utilising the HTC Vive's head tracking. However incorrect setup or poor line of sight can lead to perceptual anomalies for the floor and ceiling leading to disorientation. (Greenwald, 2016, p.101)

The HTC Vive's direct competitor, the Oculus Rift does not support the physical room virtual reality, it can be used sitting or standing, however the external sensor is for head-tracking only. This means that it does not track the users place in their real-world physical space. (Greenwald, 2016, p.101) It allows the HTC Vive to be more user friendly than the Oculus and Sony offerings according to Graham Breen, HTC's project manager. (Volpe, 2016) Not only does it enable the room to be interactive, it means that virtual reality can be exited without taking the head-mounted display off. The Samsung Gear VR deals with physical space with what it calls a passthrough mode. It uses the Android smartphones front-facing camera to display video of the user's environment without needing to take the head-mounted display off, thus is a single button switch between real and virtual worlds. (Leswing, 2015)

Combining Valve's room scale tracking and a front-facing camera with a visual correction called murra correction sharpens the level of detail. Murra correction removes the appearance of seeing a scene on a screen with the illusion of being inside of objects rather than looking at them. (Volpe, 2016) This sensation is described as presence; the feeling that the user is in the mediated virtual environment. The level or immersion and navigation method ultimately influence this. (Lorenz et al., 2015, p.223)

While the Oculus Rift and HTC Vive both offer the same displays and audio headsets, the Vive comes with hands in the form of two motion controllers, try to interact with the virtual environment with a Rift using hands and the presence collapses. Oculus Touch controllers have not yet been released to compare. (Hollister, 2016)

Head-mounted displays are designed to be directly in front of the eyes, thus gaps between pixels may be visible at close proximity. When focusing on objects and textures, a mesh like pixelated effect is noticeable called the "screen door" effect, from the magnified proximity of the eye to the non-retina screens. (Peckham, 2016, p.30) The repercussion of this virtual reality head-mounted device issue has improved the quality of smartphone screens from Samsung. It is most noticeable on Google Cardboard and Samsung's Gear VR powered by Samsung smartphones which look pixelated. The lenses magnify the smartphone screen pixels when creating the immersive experience. Higher resolution smartphones are a necessity for a better sense of presence. This must be balanced with battery life and greater processing power. (Stenovec, 2016) The more expensive Oculus Rift does not suffer from this effect unlike its older predecessors that had a resolution that was too low. (Lang, 2016)

3.3 360-Degree Video and Photography for the Masses

The provision of an immersive view for head-mounted displays leads to a new method and increased interest in panoramic content. Google Street view for instance offers 360-degree imagery of street scenes similar to that of a virtual tour. Smartphones have led to easy panorama creation with applications specifically created for this type of content to capture the user's environment. (Billinghurst, Reichherzer and Nassani, 2015, p.667) Smartphone applications in this area include Google Camera which has a Photosphere feature that stitches together a 360-degree image of a scene that can be user submitted to Google Maps Street View. Google Cardboard's dedicated Cardboard application houses an interface to Street View for photo spheres, Cardboard camera and Virtual Tour for 360-degree panoramas, (Figure 18) YouTube's 360 Video Channel and Cardboard Design Lab with computer generated three-dimensional scenes. Any other third party Cardboard camera applications that have been downloaded appear in the "my library" menu also.

Figure 18: Google Cardboard VR2 with input button and smartphone. Display is split stereoscopically for Google Cardboard lenses (Lang, 2016)

Cardboard Camera is the location of user created panoramas (Figure 18) made by rotating an Android smartphone camera in vertical orientation around a fixed axis-point, moving in a complete circle. It has been available since March, 2015. It also captures audio that plays in the background when viewed with Google Cardboard using a smartphone. The user becomes a virtual reality photographer in creating personalised 360-degree virtual reality photographs. It is an immersive image still, enhanced with sound. The top and bottom of the scene captured are blank and there is no share feature within the application other than sharing the Google Cardboard device and smartphone in person. Whilst Google Cardboard is a limited cheap device with the limitations of a smartphone screen, the compromise allows access to virtual reality for more users. (Alba, 2016) User created video for virtual reality is a very expensive endeavour in comparison. GoPro are releasing a six camera rig for 360-degree video creation for filmmakers that will cost five-thousand dollars in late 2016 called Omni. (O'Kane, 2016)

In an attempt to combat the sharing issue, Google created a new VR View tool a year after initial Cardboard Camera release in March, 2016. Embedding of 360-degree video and photography by adding code to websites and applications is now available. A head-mounted display or Cardboard application is not a necessity to view it, however using such a device is the intention in the move towards virtual reality. (Vincent, 2016)

YouTube fulfils the video experience of Cardboard Camera with virtual reality videos which are stereoscopic. It has been supported specifically as virtual reality for Cardboard since May, 2015. Google is creating a virtual cinema for traditional 16:9 YouTube videos with the option of viewing on Cardboard Camera in what perceptually appears to be a large screen in a darkened room. (Robertson, 2015) The more expensive Samsung Gear VR uses a smartphone screen like Google Cardboard with additional sensors. Hardware includes an additional accelerometer to the smartphone's, a gyroscope and proximity monitor. It is not just for gaming, but 360-degree video for smoother head tracking when viewing. The current generation Oculus video application transports the viewer to a virtual cinema with a flat screen. So too does Netflix in an apartment of choice. (Leswing, 2015)

3.4 Real World Applications of a Virtual One

The potential in terms of entertainment for arcades and theme parks is not to be understated. When users of consumer virtual reality devices wish to seek more immersion than what is available in their home, much more is required in terms of multi-sensory experiences. Virtual reality arcades are a merging of the physical and virtual, for unimaginable experiences. The Void is an arcade located in Utah, USA currently in testing, invented by Ken Bretschneider. Users wear a haptic body suit with a high-end virtual reality head-mounted display powered by a powerful computer backpack for no tethered restrictions. Users experience interaction they can see and feel with additional heaters, fans and moving podiums. (Popper, 2016) It is played in a large room with physical obstacles that are textured with virtual reality content. The immersion is developed specifically for the room in question.

The arcade is called a Virtual Entertainment Center (VEC.) It aims to provide an active gaming experience for children and adults outside of the living room with a new interactive multiplayer gaming experience with added physicality. (Krassenstein, 2016) Ticket prices will range in the ten to twenty-dollar range for a fifteen-minute experience to interact with film universe characters and environments for instance. It will debut in Times Square, New York with "Ghostbusters: Dimension" in July prior to the film's premiere. (Popper. 2016)

Education was identified as the industry "most likely to benefit from the widespread adoption of virtual or augmented reality" in a survey at the Consumer Electonics Show in Las Vegas in January, 2016. (Molnar, 2016, p.7) A survey of one-thousand teachers in the USA found a quarter want more game-based learning, with a doubled interest in virtual reality to one in ten. (Brueck, 2016 p.1) A promising use of virtual reality is for education in the classroom in the form of Google Expeditions using the inexpensive Google Cardboard including up to one-hundred-and-fifty destinations. Over half a million students have experienced it so far and is likely to be commonplace in fifteen or twenty years. (Molnar, 2016, p7)

Expeditions transports students to environments like the Great Wall of China or coral reefs off the coast of California. It is creative for teachers and engaging for students according to Google's project manager for Expeditions, Ben Schrom. It aims to be more accessible in classrooms as the technology becomes cheaper, and more advanced for more opportunities. The possibilities for education in virtual reality are endless in terms of learning experiences for children. (Nield, 2015) There is room for improvement from teacher and student feedback. More movement would provide a more enjoyable user experience. Nausea is an issue, it is not an actual field trip experience either. More interactivity for the senses like video, sound and higher resolutions are needed. However, positives include visiting new places to give life experiences in the safety of a classroom setting that are more realistic than photographs. It is an enhanced learning experience in a three-dimensional sense beyond the two-dimensions of a presentation slide. It is interactive visually which is engaging for students, prompting more participation. It is possible to direct attention from a teacher's perspective for their students. It does not replace a lesson, but enhances it, with potential to change education. (techlearning.com, 2016, p.22)

3.5 Chapter Conclusions

In order for virtual reality to succeed as an established from of viewership, it must display optimal immersion experiences that involve both powerful sensory experiences and cognitive engagement. It is distinctive from the traditional screen in the sense that it enables the user experience of an immersive virtual reality. Obstacles in this regard include inadequate field of view to cover the user's vision and nausea caused from a motion sickness. However, increasing resolutions combined with improving tracking and motion technologies are combating these problems. The merging of the real and virtual worlds is complimented by innovative systems It could be said that the room is interactive with these devices, merging the real and virtual, for the Vive in particular.

Nevertheless, the distinction between the real and virtual is blurring. The fundamental aspect of immersion is being achieved. Known as presence, the user wearing the head-mounted display is under the illusion of being inside the mediated environment. The Oculus Rift fails to account for user interaction with the mediated environment due to the lack of interactive controls unlike the Vive's motion controllers. Thus, there is a probability that the sense of immersion could collapse for Rift users, until it releases interactive motion controllers.

High definition for all virtual reality head-mounted displays are a necessity due to the close proximity of screen displays that are magnified by lenses. Otherwise the screen door effect is visible, with gaps between visible pixels, high definition at the very least is a necessity to avoid breaking the illusion of presence. This has led to improved smartphone screens from Samsung for their Samsung Gear VR device and also Google Cardboard. User content creation pioneered by Cardboard Camera and Tilt Brush attempt to make virtual reality accessible to a wider audience. Users become virtual reality photographers and artists. Video is still in its infancy, Oculus and Netflix video applications place the viewer in a virtual room with a flat screen. GoPro’s 360-degree Omni video camera hardware presents user video created content for the future supported by YouTube 360.

The merging of the physical and virtual have real world applications for active gaming outside of the living room that provide exercise and a potential return of the games arcade with specialised locations dedicated to interactive multiplayer virtual reality. The most beneficial real world application is the education industry according to statistics. Google Expeditions is the current frontrunner for educational virtual reality in the classroom. It enhances learning with endless learning experiences in different locations in the safety of the classroom. Future possibilities for gaming have been established. The future is promising for artists and designers for easy three-dimensional content creation and viewing. Further examples for the future include use in the industries of construction and real estate for problem solving and virtual tours amongst others. It is clear that future trends will lead to industry use, conserve budgets, visualise content and provide all new engaging immersive experiences in a virtual world.

Conclusions

In the goal of investigating screen viewership, it has been established that content type and creation and the resulting constraints have led to development into a new dimension. Old technologies are continuously being upgraded to the current standards of screen and also augmented and virtual reality visual and user experience designers and content creators. Largely motivated by the entertainment industries of sport and gaming, they also have profound uses for industry and education when it comes to augmented and virtual reality. The screen is here to stay, however the formats and content delivery is persistently changing to lead to more powerful technologies for clearer and immersive experiences that are blurring the lines of the real and virtual. They also serve to complement each other to provide a more convenient and practical perceptive lifestyle with augmented reality. Whilst the screen lives on, perhaps the most innovative of these technologies is the future of augmented reality that takes the best of both worlds. Virtual reality has entered the users mind through the sensation of presence to transport users to new environments and experiences.

These new forms of viewership have applications in entertainment and the industry. The constraints of the two-dimensional screen are lifted by the availability of the third dimension. The screen is still central to this with increased resolutions and retina displays that keep the sense of immersion of augmented and virtual reality devices intact. Mobility for handheld devices like tablets and smartphones, heads-up and head-mounted displays point towards on the go user experiences that are not confined to the living room. The technical constraints or batteries, screen technologies, ergonomics are user experiences vices that being solved with time. From a design perspective it must be enjoyable for the user avoiding frustration, fatigue and discomfort. It is a fair assumption from a user experience perspective to state that comfort is of utmost importance for the increasingly mobile experiences of the screen from smartphones to head-mounted displays.

The newest generation of devices have introduced health issues in the progression towards new forms of viewing. Health issues suggest that the industry is leading towards more established forms of ergonomically friendly forms of wearable devices.

Augmented reality presently appears to be a third screen in addition to the smartphone interface. Its intentional uses have not been clearly established. Perhaps in the future it could negate the handheld device to become the second screen as a wearable viewing device with more practical and enhanced viewing experiences for the user. Virtual reality is in its own dimension, both literally and practically. Whilst the familiarity of viewing traditional flat screens exists, the aim is the removal of the screen completely, if only in the form of an optical illusion. Screens are still paramount, whether they be a 16:9 television or smartphone, or the evolutionary virtual reality displays that themselves utilise smartphone screen technology. Augmented reality too, like virtual reality acts like an extra screen of reality itself with multifunctional user potential to visualise the likes of a building or design in a real-time location that only exists digitally.

Screen aspect ratios have become increasingly wider over time, then compensated by vertical handheld devices based on content and usability. They are however changing standards beyond traditional formats. Augmented reality serves to expand the format by utilising it in real-time in real locations that expand its capabilities with the likes of sports broadcasts assistance for viewers, Microsoft HoloLens for industry designs and viewing to the location based potential of the upcoming social inducing Pokémon Go for smartphones. Virtual reality utilises presence, the visual perception of the screen is removed to transport users to new worlds for gaming, artistic and industry to showcase virtual content in three-dimensions. The education potential of virtual reality with the cheap Google Cardboard is driving the technology into the hands of more users, further establishing its foothold in future formats of viewing. Without doubt, augmented reality is a fully interactive experience that was not possible with conventional methods afforded by its interactivity with the surrounding environment to enhance traditional media. Virtual reality on the other hand is completely immersive, however its presence allows new forms of viewership in a third-dimension with interactivity in this new environment with potentially limitless possibilities.

This investigation into viewership and its design pressures has established that the screen is in fact not disappearing as future technologies appear to suggest. It has in fact evolved into the next dimension, beyond the screen as it is known.

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