An E-Commerce Website for the Future

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Abstract

Despite the advancements of technology in recent years, many companies and retailers are slow to adopt new designs and technologies. This study has set out to research future technologies within the e-commerce industry and established how they can be implemented within a future e-commerce website. Research was conducted into potential e-commerce technologies and future web development techniques. A progressive web app was then developed, incorporating the researched future e-commerce technologies and web development techniques. Analysis was conducted of the developed site and areas of further research within the future technologies were documented. Based on the findings and results, it is concluded that the research undertaken, and the developed site, fulfil the aims set out in the beginning of this paper. Furthermore, the developed PWA is a decent representation of a future e-commerce site and the subject of product visualisation requires further research in order to be successfully implemented within this site.

Dedication and Acknowledgements

Dedicated to Fred.

Author's Declaration

I declare that the work in this dissertation was carried out in accordance with the Regulations of Glyndŵr University. The work is original except where indicated by special reference in the text and no part of the dissertation has been submitted for any other degree.

Any views expressed in the dissertation are those of the author and in no way represent those of Glyndŵr University

The dissertation has not been presented to any other University for examination either in the United Kingdom or overseas.

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Abbreviations

HTML
Hypertext Markup Language.

CSS
Cascading Stylesheets.

JS
JavaScript.

US
United States (of America).

PWA
Progressive Web Application.

AR
Augmented Reality.

SaaS
Software as a Service.

RWD
Responsive Web Design.

HTTPS
Hyper Text Transfer Protocol Secure.

SEO
Search Engine Optimisation.

SERP
Search-Engine Results Page.

URL
Uniform Resource Locator.

XML
Extensible Markup Language.

WCAG
Web Content Accessibility Guidelines.

Mbit/s
Megabit per Second.

KB
Kilobytes.

UK
United Kingdom.

HTTP
Hyper Text Transfer Protocol.

CDN
Content Delivery Network.

TCP
Transmission Control Protocol.

W3C
World Wide Web Consortium.

AI
Artificial Intelligence.

SDK
Software Development Kit.

IBM
International Business Machines.

API
Application Programming Interface.

CMS
Content Management System.

GPS
Global Positioning System.

CPU
Central Processing Unit.

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1. Introduction

Over the last 30 years or so, society has witnessed an unparalleled period of technological advancement, paramount to this period of progression was the internet. The internet has been one of the most rapidly evolving environments for technological development and information exchange since its creation in 1990. There isn't an industry around the globe that wouldn't benefit from the universal reach the internet can offer it, however, these industries cannot fully benefit from the internet without the use of web applications, these are developed with HTML, CSS, and JavaScript in order to create web pages.

HTML was created in 1990, a programming language that provides the building blocks for website development, this was followed by JavaScript and CSS in 1995 and 1996 respectively, which have contributed to the evolution of dynamic and responsive websites. In recent times, web development frameworks, such as Angular and React, have been developed that provide developers with standardised constructs to create and deploy web applications.

E-Commerce is an industry that has emerged as a direct result of the development of the internet, the definition of which, is the buying and selling of goods and services over the internet. This industry has been growing since the early 90's when the internet was still in its infancy, notable major advancements of e-commerce include[1]:

- Amazon and eBay (1995) – 2 of the largest e-commerce sites in the world.
- PayPal (1998) – Facilitated payment processing for e-commerce sites.
- Google AdWords (2000) – Online advertising tool that allowed e-commerce sites to advertise over Google search.
- Amazon Prime (2005) – Subscription service that gave customers free two-day shipping.
- Google Wallet (2011) – Peer-to-peer payment service that allowed users to send and receive money from a mobile device or desktop.
- Facebook Sponsored Stories (2011) – Advertisers could pay to show their stories in users newsfeeds.
- Apple Pay (2014) – Mobile payment method that allowed Apple users to pay for goods and services with their device.

In 2017, sales from global e-commerce totalled 2.3 trillion US dollars[2]. In the US, e-commerce already relates to more than 10% of all retail sales, and in China, more than 20%[3]. How we interact, discover, and acquire goods and services is now a 24/7 process, with customer journeys now an amalgamation of in-store and on-line experiences. It is estimated that global retail sales will reach $27 trillion US dollars by 2020[4], with e-commerce sales accounting for 4 trillion US dollars, making up 14.6% of the total[4].

Some of the larger players in the e-commerce industry are already trying to implement innovative technologies on their sites. For instance, Amazon has started employing the use of artificial

intelligence to provide real-time product recommendations to users browsing their site[5]. Also, as an example of a more practical technological development, Lancôme have rebuilt their e-commerce site as a progressive web application (PWA), which uses modern web capabilities to provide an app-like experience to all customers[6]. PWAs have become an increasingly popular development choice and are now widely adopted for many new mobile projects, with both Apple and Android supporting the PWA format on their respective mobile operating systems. These examples above show a couple of ways in which future technology can help businesses improve their e-commerce sites and solve possible problems they may face, or, simply increase sales and efficiency.

Because of these emerging technologies, the main objectives of this study are; to research the future technologies that have been proposed to be part of a future e-commerce site and establish how future technological advancements can be successfully implemented into an e-commerce website. In order to determine this, an investigation of future technologies that have been preliminarily researched during the dissertation proposal (See Appendix A) will take place. As well as this, an investigation into the areas of web development that will need to be considered will take place, combined with case studies of existing implementations of the future technologies that can provide examples of successful approaches and possible development processes that require undertaking. A website will then be developed, that will showcase future technological advancements applied to an e-commerce website.

2. Literature Review

2.1. Virtual Product Visualisation

The way in which products are advertised online has gone through a multitude of changes over the years. Starting with the first e-commerce sites, that were developed with a solitary product description, the next step was the inclusion of product images, early sites included a singular low-resolution image of the product, and later sites included multiple high-resolution images of the product. Product images are still a vital component in todays e-commerce, the next evolution in product visualisation was the addition of product videos, when web pages started to incorporate more multimedia content, e-commerce sites utilised videos to display short product videos which could give users practical demonstrations of products.

When we look at e-commerce sites presently, many will display product images that, at the very least, include multiple high-resolution product images, and at the most, include 360-degree images of the product from multiple angles, in high resolution, with zoom capabilities so that users can see close-up details of products. These 360-degree product images are the first steps towards the future of virtual product visualisation in e-commerce, Miesnieks[7] estimated in 2017 that there would be 1.5 billion augmented reality ready devices in consumers hands by 2019, during this time, many companies have been developing ways in which they can make use of these technological developments. For example, Gap, in combination with Avametric[8], have produced a virtual dressing room app for modern smartphones that gives users the ability to select their clothing style and body type, and a virtual mannequin will appear in 3D space to show how the selected clothes will fit, shoppers can then rotate the mannequin to see how the clothing looks from all angles, and they also have the ability to proceed straight to the checkout within the app if they like what they see.

There are many examples[9] of these augmented reality (AR) product visualisation applications in their infancy, and it is stated to be giving users the ultimate ‘try before you buy’ experience[10]. Following on from 360-degree product images, AR product visualisation seems to be a likely next step within e-commerce as consumers generally enjoy being able to interact with a product before purchasing it, in order to allow consumers, the opportunity to understand and experience a product before making the decision to purchase it. These user-experience journeys are important to e-commerce companies as they give consumers more access to a product which can improve the possibility of purchase, Krambeer, senior managing director of 3DEXCITE, states that “it can instil a sense of ownership even before interaction with a physical product takes place… This can lead to typically higher conversion rates”[11]. Another benefit of AR product visualisation is the ability for consumers to customise products to their own liking which can also enhance conversion rates as it gives consumers a sense of ownership before purchasing the product.

In order to fully take advantage of AR product visualisation the devices and applications used must marry up well and provide a good user experience, otherwise a poor experience can lead to consumers being put-off by a clunky design or unresponsive interface. Keith, account director of

Column Five, states that “There's nothing worse than trying to engage with interactive product visualization and the tool isn't intuitive… interactive product visualization with a poor user experience can actually do more harm than good, in most cases.”[11].

Looking into the future, further progress within the product visualisation field will likely come as a result of developments in augmented reality, virtual reality, and 3D rendering. Virtual and augmented reality technologies in recent years have been utilised to enable users to visualise products within their own space, such as their homes and cars, this can let users see how a product will suit their individual lives. These types of product visualisation have recently seen increases on mobile devices, as the technology allows the device to be used as a portal into the virtual or augmented world, Krambeer explains that “The immediate future is all about mobile”, as consumers are increasingly researching products on their mobile devices before ending the buyers journey on a desktop computer or brick and mortar store.

An example of AR product visualisation development can be seen at Emersya[12], which is a company that specialises in providing virtual product visualisation for businesses with an e-commerce platform. Emersya state that they can offer award winning 3D technology capable of showcasing and customising products on the retailers’ website and in their brick and mortar establishments. Emersya have worked with well-known brands such as Samsonite, Salomon, and KitchenAid, the technology works as a software as a service (SaaS) platform, with its own interface for uploading 3D models of products, which can then be fine-tuned in the proprietary software, before eventually generating HTML code that can be embedded into the e-commerce website that will display the 3D model, as shown in the figure below.

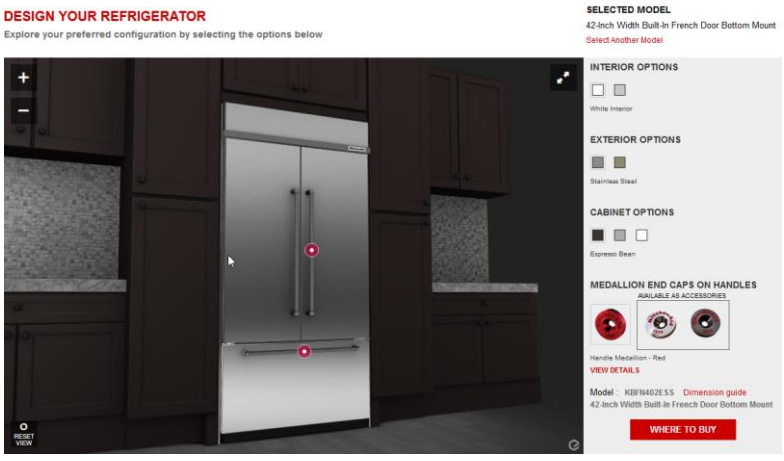


Figure 1 – KitchenAid Emersya Interactive Product Configurator[13]

Another example can be seen at 3D EXCITE[14], which is a service provided by tech-giants Dassault Systèmes (3DS), a company responsible for software such as Catia and Solidworks, both incredibly popular products in their respective industries. The 3D EXCITE service specialises in virtual product visualisation and similarly to Emersya, also offer a SaaS platform that works using 3D models of products. Seemingly specialising in the automotive industry, 3D EXCITE has worked with well-known manufacturers such as Audi, Mercedes-Benz, and Lamborghini to name a few.

Whilst both previous examples can be accessed on mobile, they do not provide support for mobile devices to be used as a portal into the virtual world and display the product within an augmented space. This is an issue that can be solved using Google's ARCore[15] or Apple's ARKit[16], these operating software frameworks allow the respective platforms devices to be used in augmented reality. IKEA are a company that have created a successful AR app, named 'IKEA Place'[17], using both AR frameworks mentioned, within the app customers can take true-to-scale 3D models of IKEA products and place them in their homes to see how they look and if they will fit in certain spaces. The figure below displays the 'IKEA Place' app in action.

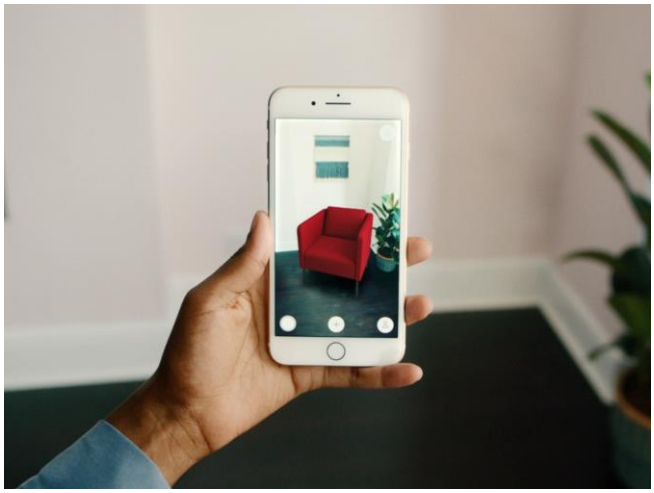


Figure 2 – IKEA Place AR app[18]

2.2. Virtual Support Service

Virtual support services, more commonly known as chatbots, are computer programs designed to imitate an intelligent instant messaging conversation with human users. Chatbots have been designed for many different uses, the very first conversational program to be described as a chatbot was created in 1966, known as ELIZA[19]. These initial chatbots were programmed for basic interaction and 'small-talk' with users, this involved the recognition of words and phrases being sent to the bot and then outputting pre-programmed responses that aim to continue the conversation in a constructive way[20]. Current conversational chatbots, such as Cleverbot[21], have a more sophisticated method of interaction, instead of making use of pre-programmed responses, it learns from the human input[22] that it receives and develops appropriate responses based on previous conversations that the bot has recorded, current chatbots are now at such an advanced stage where they are able to pass the Turing test[23]. In 2015 the developers of Cleverbot started to build a new conversational chatbot that would make use of modern machine learning techniques[24].

When incorporating chatbots into websites, it is important to understand how the technology will be used by visitors to the site and use it as a solution to some of the challenges they may face. For example, many of todays websites rely on menu-based navigation, however if the website is poorly structured or contains a large amount of content then this type of navigation can lead to

poor user experience and disgruntled users, the design of the chatbot in this case should have the ability to suggest specific site pages based on the users input and make it quicker and easier for users to find information. If we were to develop a chatbot for this scenario then it must be able to work with dynamic inputs from users, similarly to Cleverbot, and it can also make use of pre-programmed responses for frequently asked questions, in order to present the information as quick as possible.

Current e-commerce sites can contain a vast range of products which can lead to potential consumers trying to navigate a large and complex database, typical navigation in these scenarios consist of navigating product menus or typing in keyword searches, which can be time consuming and frustrating, leading to a poor user experience. A chatbot endeavours to subvert these bad user experiences by presenting a more intuitive and familiar way of accessing products within the site, by offering suggestions and asking simple questions that can narrow down a specific query. Some chatbots even have the capability of searching for items via there product code, which is helpful for consumers that know exactly what they are looking for.

Nike are one example among many, that make use of a Facebook Messenger chatbot for their e-commerce platform. Facebook Messenger is a popular format for these chatbots as it has over 1.3 billion users[25] and can be accessed from mobile and desktop devices. The Nike e-commerce chatbot[26] allowed customers to develop their own shoe designs or browse user uploaded versions for inspiration, as well as this, the bot can show customers images of the shoes being worn with a full outfit and send users to a checkout screen if they want to complete a purchase. During the 'AirMax Day' campaign that Nike were running alongside the e-commerce chatbot, their average click-through rate was 12.5 times higher than previous campaigns and conversions were 4 times higher[27]. It is estimated that over 300,000 Facebook Messenger based chatbots have been created so far, with businesses and customers exchanging more than 8 billion messages per day on Facebook Messenger[28]. Another large business that had made use of a Facebook Messenger chatbot is eBay, they released their 'ShopBot' in 2016, it could help users browse products and filter them to a certain price range. It could also provide personalised recommendations based on previous purchases and allow buyers to leave their item feedback to sellers over the chatbot interface[29]. However, after 2 years, eBay shutdown their Messenger based chatbot in 2018, it is proposed that the dedicated eBay mobile app was performing much of the same role and was much easier to use[30], eBay also integrated their site into an app design incredibly well, evidenced by the fact that their app has been downloaded over 476 million times[31].

Another chatbot example can be seen at Amtrak[32], a national railroad service in North America, although not strictly an e-commerce company the Amtrak website chatbot, named Julie, can perform a multitude of tasks including route-finding and booking tickets for customers which has generated a 30% increase of revenue[33]. On top of this statistic, the Amtrak chatbot has also saved $1 million on customer service expenses in a single year and answers over 5 million customer questions per year[34].

2.3. Responsive Design & Progressive Web Apps

Responsive web design (RWD) became an influential trend at the start of the 10s, the term was devised in 2010 by Marcotte[35], with 2013 coined as 'Year of Responsive Web Design' by Cashmore[36], nowadays, responsive web design is a major part of the web design process.

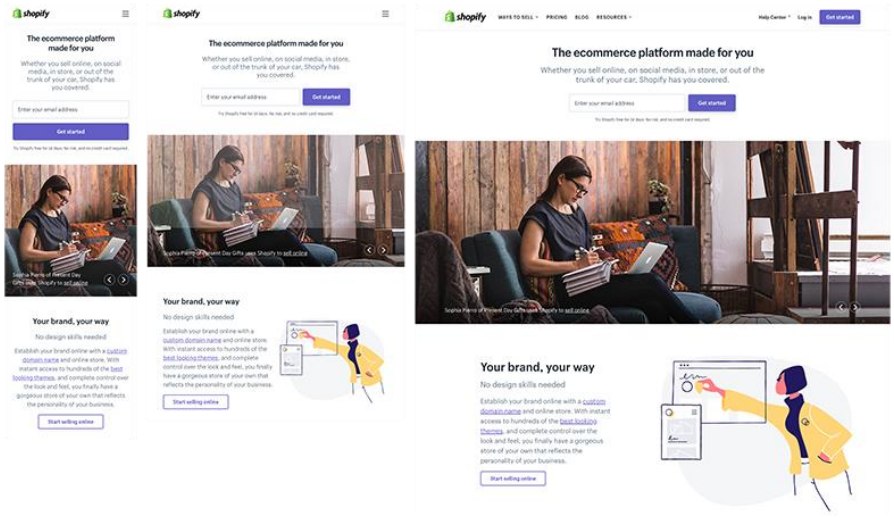


Figure 3 – Example of Responsive Web Design in use by Shopify[37]

With the increasing development of technology in past years, a large range of devices are now used to access the web, this is the area in which RWD operates. Before these technological developments, websites were traditionally developed with a fixed-width design, centred in the middle of the page, that allowed multiple resolutions to display the page correctly. However, this did not translate well to any resolutions outside of the range, such as that of smartphones and tablets. With RWD, it is possible to build a website that will adapt to multiple devices of differing screen resolutions and display the content of the site on each device in such a way that makes the most of the available screen real-estate.

RWD can be best summed up as a series of best practices that can be followed when designing and developing a website in order to make it responsive, the main points consist of the following:

- Mobile-first design – A mobile-first approach means designing the mobile website first and working through the screen sizes towards the desktop version, generally consisting of mobile > tablet > desktop. This design process used to be hotly debated, before the dramatic increase in web users using their mobile phones to access the internet, and the statistics continue to rise, Clement[38] states that as of February 2019, mobile devices account for 48% of web page views globally. Previously, a desktop-first approach was a common design process when the expected devices being used to access a website were limited to desktops and laptops. However, the mobile-first approach has become part of the zeitgeist for many reasons, primarily because it is far easier to scale-up from the mobile version of a site than it is to scale-down from a desktop version. Also, there are many more usability concerns on mobile, largely due to the lack of screen real-estate, therefore it is more practical and effective to focus firstly on the mobile design.

- Varying resolutions – There are a wide range of resolutions used by web users to access and view web pages, as can be seen in the figure below:

Top 10 Screen Resolutions		
1	640x360	16.81%
2	1024x768	10.11%
3	1366x768	9.02%
4	1920x1080	7.99%
5	667x375	6.11%
6	800x600	3.46%
7	720x360	3.17%
8	760x360	2.63%
9	1440x900	2.44%
10	736x414	2.26%

Figure 4 – Top 10 Screen Resolutions used on the Web[39]

This top ten only accounts for 64% of users, which shows why it is important to consider different resolutions when designing and developing a website. As well as being aware of the multiple resolutions used on the web, also being aware of the target audience of your website and the devices they use to access your site can dictate which resolutions are worth designing and developing for. It is also worth knowing which screen resolutions are gaining popularity or on the rise via a new device release, as this can help futureproof a website. For example, between June 2016 and June 2017, the 640x360 resolution, commonly used by Samsung phones, rose by 17.95%[40].

- Media queries – A CSS technique, introduced in CSS3[41], media queries allow a developer to design and customise different layouts for different devices and viewport sizes. This is executed by stating the media type in the code, then when the media type matches the device or format that a page is being displayed on, it computes the code as 'true' and attempts to run the code that matches the media type. The following list defines the media types that can be used for media queries:
    - 'all' – corresponds to all devices.
    - 'print' – corresponds to printers and 'print preview' pages.
    - 'speech' – corresponds to devices that dictate a page such as screen readers.
    - 'screen' – corresponds to all devices not matched by 'print' or 'speech'.

Together with media types, media features can also be used to match a characteristic and then run certain lines of code. The difference between the two however, is that "a media feature is a more fine-grained test"[42], that can test a particular feature of the display device, such as; the width of the viewport, the aspect ratio, or the orientation, among many other features.

- Fluid grids – A grid layout for web pages that automatically adjusts to the viewport size of the device that is being used to view the website. Conversely, an adaptive grid layout requires manual adjustment of the height and width of the grid in order to display properly across different devices, this is because the dimensions are defined in pixels. Whereas, in a fluid grid, the dimensions are defined in percentages, this allows the grid to adjust from ultra-wide devices to mobile devices automatically, without the need to adjust the dimension values.
- Flexible images – Images that can scale to fit the viewport size, this is achieved a couple of different ways. Firstly, by setting the max image width to 100% of the container in CSS, this will then scale the image proportionally to the container size. Secondly, the image size can be linked to the text size using em units, which will be discussed in the point below.
- Flexible typography – Similarly to flexible images, flexible typography will adjust font-size relative to the viewport size. This is successfully executed by using em[43] units to specify the font-size, em units are a responsive unit that are relative to the defined font point size, generally defined within the parent element in the code. The figure below shows an example of em units in use.

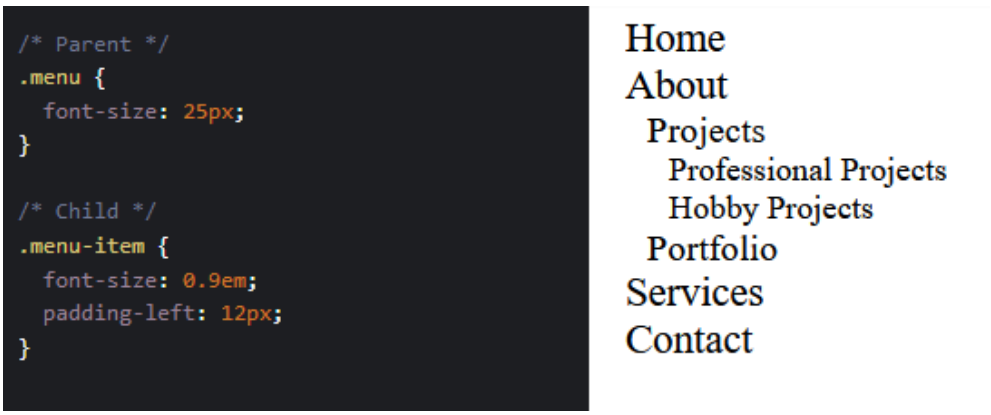


Figure 5 – Em Units Adjusting Font-Size in CSS[44]

The reasoning behind the inclusion of RWD and PWAs in the same section is that many professionals, such as those at Smashing Magazine[45] and Creative Bloq[46] believe PWAs to be a natural progression from RWD that includes many of the same design principles. Some of these standards have already been considered within this section, and there are also some that will be discussed in later sections of the literature review. New developments that are aimed at uniting online experiences across multiple device platforms will now be explained in this section.

However, multiple device accessibility isn't the only benefit of a PWA, Russell and Berriman[47], the duo that coined the term 'Progressive Web App', noted the following attributes and characteristics that should be associated with PWAs in order for a web application to meet the specification[48]:

- Progressive – a PWA should operate across all devices and progressively improve, allowing users to make the most of the available features on their device or browser.
- Discoverable – a PWA should be able to be searchable and make use of SEO, unlike native mobile apps.
- Linkable – a PWA should use unique URLs to indicate each different web page, this allows the PWA to be reloaded at a specific page location.
- Responsive – a PWA user interface must fit to the device viewport that the web page is being viewed on.
- App-like – a PWA should have the look and feel of a native mobile app and minimise page refreshes.
- Connectivity-independent – a PWA should be operable in locations with little to no connectivity.
- Re-engageable – a PWA should make use of mobile app re-engagement methods, such as push notifications and rich media advertisement.
- Installable – a PWA should be able to be installed on any device's home screen, such as an app icon or desktop shortcut.
- Fresh – once published, new content should be available to users on the web app as soon as they are connected to the internet.
- Safe – a PWA makes use of service workers[1], so it is imperative that the web app is hosted over HTTPS which can counteract man-in-the-middle network attacks.

According to Google[49], there are many benefits involved with developing a website as a PWA. For example, Konga[50], a Nigerian based e-commerce website, had the challenge of making their site available to a country with nearly two-thirds of users on a 2G network. By developing a PWA, Konga employed the use of service workers that sent 63% less data for initial page loading and 84% less data in order to complete a transaction, this allows users to quickly browse for products with limited connection and they can also continue their searches while offline. In another example, eXtra Electronics[51], a Saudi Arabian electronics retailer, wanted to improve re-engagement with their consumers who shopped via their mobile devices. By developing a PWA, eXtra could send push notifications to users that visited their new mobile web app, even when the web browser was not running on the device. Over a six-week period, customers that had opted-in

[1] A script ran in the background of a web browser that can enable additional features such as push notifications and background syncing.

to the push notifications were returning 4x as often and staying on the site for 2x longer, which lead to a 100% rise in sales from consumers opening the site by means of web push notifications.

2.4. Search Engine Optimisation

"SEO is about the on-page and off-page design strategies you can use to improve your search engine ranking"[52]. Many companies make their online presence a critical factor to their business process and according to Hollingsworth[53] and Gudivada[54], search-engine rankings are an essential marketing strategy that greatly helps boost a websites visibility. Each results page of a search engines findings contains a list of clickable links that will also include a paragraph or so of preview text that establishes how the page is relevant to the users search query. The order in which the relevant web pages are listed is not arbitrary and in the case of Google, the most popular search-engine over desktop, tablet, and mobile[55], is based on a series of algorithms that considers many different factors[56]. In terms of e-commerce, a high results ranking is vital, in 2016 Wolfgang Digital[57] reported that 43% of online customers began their shopping on a search-engine, and 75% would only click through to links on the first page of search results[58].

Developers have a multitude of methods available to them in order to achieve a high search result ranking, or SERP (search-engine results page) ranking, these are collectively referred to as SEO. However, there are many unethical practices, known as black hat SEO or spamdexing, that should be avoided, which trick search-engine algorithms and try to artificially boost a webpages' SERP ranking, some of these techniques are listed below[59]:

- Keyword Stuffing – keywords or numbers that often appear in a list or group, or out of context. Such as, multiple blocks of text listing countries that a website is attempting to rank for.
- Cloaking – presenting specific content to users and differing content to search-engines.
- Sneaky Redirects – redirecting users to a significantly different URL to the one displayed in the search results.
- Automatically Generated Content – content that has been produced programmatically that aims to influence search rankings. For example, text with no coherence that the reader cannot make sense of but contains search keywords.
- Paid Links – the buying or selling of links that direct to your website.
- Abusing Structured Data – providing inaccurate information within structured data formats on search-engines. For example, a website awarding themselves 5 stars from a fake review and adding the review to the structured data, in order to fool users into thinking their site is reputable.
- Link Farms – a website developed with the specific intention of link building, in which the website links to the sites they want to rank higher on search-engines.

Conversely, white hat SEO is the commonly agreed ethical technique to help boost a webpages' SERP ranking organically. White hat SEO has two distinct sectors of techniques, the first is on-page optimisation, this involves the content and structure of the website, which can range from specific word choice, to the inclusion of a page that describes the site's privacy policy[54]. Some on-page optimisation techniques are listed below[54]:

- Word Choice – the content of the web page should organically use keywords and phrases that stay authentic to the subject matter of the page.
- Anchor Text – succinctly and meaningfully describe the topic of the webpage that the link points to.
- Semantic Indexing – Latent Semantic Indexing is an indexing method that can identify patterns and terms within a webpage and detect the relevance of a webpage to the search terms.
- Non-HTML Content – content such as images, audio, and videos should contain *'alt'* attributes that describe or transcribe the content so that it can be indexed by search-engines.
- Title and Meta Description Tags – using the appropriate title tags and semantic elements that reflect the webpages' hierarchy will allow a search-engine access to appropriate snippets relevant to the topic of the webpage.
- Privacy Policy – some search-engines will measure a websites trustworthiness based on the inclusion of a privacy policy page that states what personal information the site collects and distributes.
- Custom 404 Page – if the requested webpage cannot be found a 404 page will be returned in its place. Developers can customize a websites 404 page with links back to the websites homepage or links to similarly related content, this helps keep users on the site even if the search result link is broken.
- Restricted Page Indexing – there may be times when a developer does not want a webpage to be indexed by search-engines, it may contain too many links or may only be intended for registered users. In these cases, webcrawlers can be denied access to a page by using the robots.txt file to indicate which pages are accessible or not.

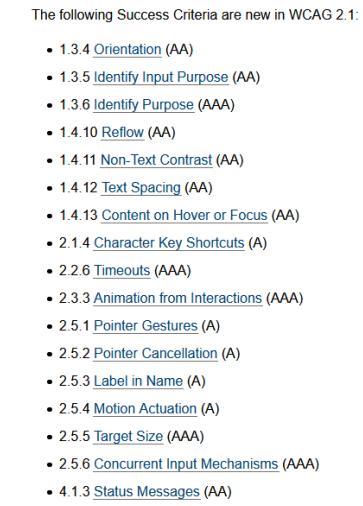
The second white-hat SEO sector is off-page optimisation, this involves techniques outside the content of the website, such as backlinks and sitemaps. Some off-page optimisation techniques are listed below[54]:

- Breadcrumbs – used to show the navigational trail of a user, if this information is available in HTML format within the body of a webpage, then some search-engines can use it in SERPs.

- Sitemaps – used to represent the website structure to assist navigation. In XML format, sitemaps can be used by search-engines to determine indexing order and promote the most important pages on a site.
- Backlinks – links pointing to a specific site will increase the SERP ranking of that site, but the quality of the link is significant. Artificial and black hat methods of linking to a site will risk removal of that site from search-engines. Similarly, a page with external links to other sites can risk search-engine penalties if the links point to untrusted sites.
- Robots Meta Tag – this tag can be used to specify if a page can be indexed or not, or whether the links on a page can be navigated to by a webcrawler. Developers can employ a multitude of robot tag attributes to control how their web pages are indexed.

2.5. Accessibility

Accessibility in web design can be defined as making sure all users are able to access and navigate your web page from whichever device they choose or require. Web accessibility guidelines involve development strategies to try and overcome most disabilities that limit internet access. The World Wide Web Consortium (W3C)[60] established the Web Accessibility Initiative[61] in 1997, in order to combat web accessibility issues, and have continually published and updated guidelines for making webpages accessible to those with impairments and/or alternative devices. The most recent guidelines published by the W3C are the Web Content Accessibility Guidelines (WCAG) 2.1, which were published in June 2018[62]. The previously published guidelines, WCAG 2.0[63], focused on four principles; perceivable, operable, understandable, and robust, guidelines would then fit under one of the four principles. "WCAG 2.1 builds on and is backwards compatible with WCAG 2.0"[62], the newly published guidelines are considered as incremental advances to all web content accessibility areas and do not alter any of the previous guidelines in 2.0, instead, this additive approach allows backwards compatibility between the guidelines, as any website that conforms to WCAG 2.1 will also conform to 2.0. The new features added to WCAG 2.1 can be seen in the figure below:


The following Success Criteria are new in WCAG 2.1:

- 1.3.4 Orientation (AA)
- 1.3.5 Identify Input Purpose (AA)
- 1.3.6 Identify Purpose (AAA)
- 1.4.10 Reflow (AA)
- 1.4.11 Non-Text Contrast (AA)
- 1.4.12 Text Spacing (AA)
- 1.4.13 Content on Hover or Focus (AA)
- 2.1.4 Character Key Shortcuts (A)
- 2.2.6 Timeouts (AAA)
- 2.3.3 Animation from Interactions (AAA)
- 2.5.1 Pointer Gestures (A)
- 2.5.2 Pointer Cancellation (A)
- 2.5.3 Label in Name (A)
- 2.5.4 Motion Actuation (A)
- 2.5.5 Target Size (AAA)
- 2.5.6 Concurrent Input Mechanisms (AAA)
- 4.1.3 Status Messages (AA)

Figure 6 – New WCAG 2.1 Success Criteria[64]

The layers of guidance used in the WCAG can be broken down and defined as such[65]:

- Principles – The top four foundation principles.
    - Guidelines – There are 13 guidelines that define the basic goals within each principle.
        - Success Criteria – Within each guideline is testable success criteria, there are three levels of conformance, defined as; A (lowest), AA, and AAA (highest).
            - Sufficient and Advisory Techniques – Within each guideline and success criteria there are a wide variety of documented techniques; *sufficient* techniques that meet the success criteria, or, *advisory* techniques that go beyond what is required by the success criteria in order to better address accessibility barriers.

As can be seen in figure 4, the updates to the WCAG from 2.0 to 2.1 consist of 17 new success criteria, along with definitions and techniques to support them.

In 2011 the World Health Organization published a report stating that there was an estimated 15% of the global population with some form of disability[66], many of which will require websites to follow the guidelines set out by the WCAG so that they can access and navigate web pages. Even people without a defined disability can benefit from web pages that follow WCAG recommendations[67]. From a pure business perspective, developing an e-commerce website that is not accessible to 15% of the population is missing out on a significant amount of potential revenue in the market. It is clear to see why following web accessibility guidelines is an important part of web development, with such a high percentage of people requiring some part of their use, in order to successfully access and navigate a site.

However, there are many popular websites that do not comply with WCAG fully or even at all. Many times, web accessibility is left as an afterthought to development projects with no time or money spent on it; sometimes due to a lack of awareness, other times a shortage of experience in the field which leads to insufficient knowledge to incorporate guidelines, or simply a lack of motivation to include accessibility guidelines. Some of the more commonly found accessibility issues within e-commerce sites can be found listed below[68]:

- Form Field Usability – online forms that are not considered for keyboard and screen reader users. As can be seen in the figure below, the form fields have no descriptive labels telling users what each field represents, instead they use prompt or placeholder text inside each field which disappears when the field is highlighted.

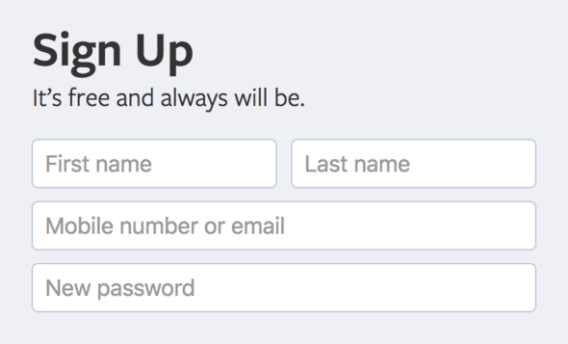


Figure 7 – Placeholder Text[69]

This form design places a cognitive load on users to remember what the field they are typing in requires, because the placeholder text will disappear upon selection. Users with conditions such as short-term memory loss, traumatic brain injury, or attention deficit hyperactivity disorder can all be affected by this ability having to recall information.

- Quality of Information – Keyboard users will often not receive the same quality of information as mouse users. A common issue is displayed on product listing pages, where much of the content provided to mouse users is not accessible to screen reader users, as the following figure shows, the information that is faded out is that which a non-sighted user will not hear from their screen reader.

Figure 8 – Information Missed by Screen Readers[68]

- Screen Reader Testing – a commonly overlooked accessibility process is how the text on your website is read by screen reading software. Within e-commerce, product prices are often read incorrectly for a number of reasons, for example, missing the decimal place in a price can change '£50^{99}' to be read out as 'five thousand and ninety-nine'. Another example is the use of strikethrough text to show a previous price such as '~~£100~~', strikethrough text is not read by screen readers, so developers must use a different method to communicate price changes.
- Image Description – a lack of 'alt' tags to describe images of products can lead to a very frustrating experience for screen reader users. Without any description of the image,

screen reader users must either, rely on the product description which in many cases will refer back to the product images or, require the assistance of a sighted user to describe the product images to them.

- Checkout Navigation Complication – Websites that have completely neglected accessibility guidelines will find incredibly low conversion rates from keyboard and screen reader users[70]. In many cases, users are completely unable to reach checkout due to bad navigation and keyboard controls.

Accessibility is a very forward-thinking field, Andersson[71] states that "the accessibility problems of today are the mainstream breakthroughs of tomorrow". For example, autocomplete and voice control began as technologies designed to help disabled users operate computers with independence but nowadays these technologies have evolved into functions used by nearly all computer users.

Google and Microsoft are both working on computer vision-based accessibility projects which intent to "convey visual information to blind users through computer vision and natural language processing"[71], as these tech-giants continue to develop these advanced AIs they may become sophisticated enough for computer vision to replace human sight completely. These advancements in the accessibility field will have a deeper impact on other technology fields such as robotics and medicine.

2.6. Front-End Optimisation

Front-End optimisation is the process of refining a website in order to make it more efficient and quicker for users to load. The technological advancements within computing over the last decade has resulted in a sizeable increase in internet connection speed and web page size, these two statistics have a generally positive correlation. For example, between 2008 and 2018 the average UK fixed-line residential broadband speed increased from 3.6Mbit/s[72] in 2008, to 46.2Mbit[73] in 2018, which is a 1183% increase over 10 years. Whereas the average web page size increased from 312KB in July 2008[74] to 1896KB in May 2019[75], an increase of 507% in over 10 years.

The larger in size that a web page is will result in a longer load time for users. According to Steve Souders and his 'Performance Golden Rule'[76], 80 to 90 percent of the end-user response time during the loading of a web page is spent on the front-end, as opposed to the back-end of the page. This time loading the front-end consists of processes such as executing JavaScript, downloading any referenced resources, and rendering the page; the main goal of front-end optimisation is to reduce the time it takes to complete these processes as much as possible. There are many different methods that can be used to lower these loading times, some of these methods are listed below[77]:

- Reducing HTTP Requests – each element on a website requires a HTTP request in order to be downloaded, there is a limit to the number of concurrent requests that can be made. Therefore, by consolidating multiple elements into a single element, such as images into a single sprite image, you can reduce the amount of HTTP requests.

- Content Delivery Network (CDN) – in a similar vein to HTTP requests, CDNs do not reduce the number of requests, but by pre-pooling the connections, they can stay open during the website session and eliminate the delay associated with closing and reopening TCP connections.
- File Compression – the larger the code files used to create your website the longer it will take to load. File compression can shrink the code files which speeds up site load times. Gzip is a popular file compression process that can shrink code files by as much as 80%.
- Cache Optimisation – by storing static files outside of the web server, load speeds can vastly improve. Cache optimisation can also usually be combined with a CDN which can set site wide and individual caching rules.
- Code Minification – a process that trims developers easy-to-read code, down to just the essential characters by removing spaces, line breaks, comments etc. that make no difference to how a machine will read the code. This can reduce code file sizes by 50%.
- Image Optimisation – there are multiple methods that can be employed to optimise images on a website. Images can be compressed which reduces file size and image quality by removing some of the header information. Vector images can replace raster images where applicable as they have a much smaller file size in comparison. Image caching can store image files on the user's browser cache which reduces the number of requests and the size of the web page needed to be downloaded. Proxy caching stores images on point of presence servers which have quicker rendering times for images.

When talking about speeding up the loading time of the front-end it may only amount to milliseconds of reduction, however, according to studies conducted by Google these miniscule differences in page load time can have a noticeable impact on user retention and, in the case of e-commerce, sales figures. For example, in one study involving Mobify, they found that "every 100ms decrease in homepage load speed worked out to a 1.11% increase in session-based conversion"[78] which amounted to an average annual revenue rise of almost $380,000. Another example, in a study performed by DoubleClick, found that websites which loaded within 5 seconds made up to two times as much advertisement revenue than those which loaded within 19 seconds[78]. Also, in a similar vein, "when AutoAnything reduced page load time by half, they saw a boost of 12-13% in sales"[78]. It is clear from these studies that optimising your website speed is crucial for e-commerce sites as it directly effects sales figures, Google have released an 'Impact Calculator' tool[79], shown in figure 4, that can help reveal to developers how their site performance can theoretically affect revenue.

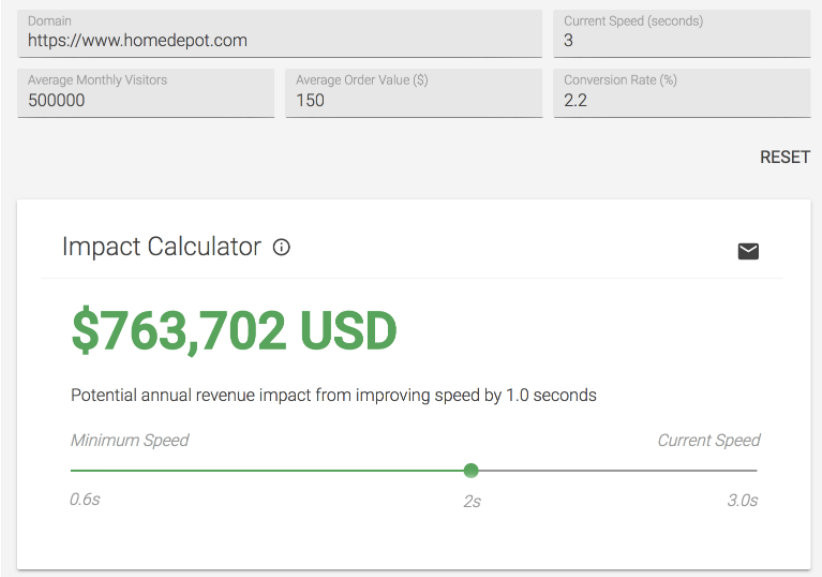


Figure 9 – Google's Impact Calculator[79]

2.7. Conclusion

As we can see from the multiple sections of the literature review, there are many areas that need to be considered before beginning a web development project, and when we incorporate future technological developments it only further increases the planning and designing stages of the site development. Throughout the research into potential future e-commerce technologies, we have seen a general trend of many optimistic theoretical articles with fewer grounded real-world examples. However, this is to be expected, as with any new technological developments, the initial thought-pieces are released, which will usually shine a bright[80] or dim[81] light on the technology, and then as the technology matures the more critical and realistic articles are published[82].

From the research conducted into virtual product visualisation, there were many websites and companies showing proof-of-concept technologies, as well as a strong interest in mobile phone usage as a means to view a product in augmented reality, through the device viewport. The desktop-based sites that were researched had no means of displaying a product in augmented reality, without possible external help from a virtual headset, which is in no way close to a frequently expected user journey. Instead, desktop-based product virtualisation consisted of products as 3D models within a virtual 3D space, this technology did not seem as intuitive or interactive as the augmented reality versions that were possible on a mobile device, however, there were still many well-polished examples that proved to increase conversions and customer satisfaction for e-commerce sites. As the future e-commerce site plans to be accessible across multiple devices, a solution that can be available across all devices should be paramount.

As opposed to the research into virtual product visualisation, the research conducted into virtual support services found many good examples of chatbots. This can be largely attributed to the much earlier invention of the technology, as the first chatbot was developed in the 1960s. Furthermore, there is a much wider area of application for chatbots, whereas product visualisation is mainly

confined to e-commerce and industries that make use of computer aided design. From the examples found within e-commerce, chatbots can be great solutions for customer service, product recommendations, and frequently asked questions, there was also a good amount of crossover between different industries, such as online banking and public transport, that could also make use of similar features. This is another reason why the research into chatbots garnered many more examples than product visualisation. The popularity of Facebook Messenger chatbots should not be dismissed, especially with the mobile accessibility of PWAs, a solution that can make use of the large userbase of this platform will be researched during the planning stages of the site development.

From the research conducted on PWAs it is clear there are some major advantages associated with developing a site under this philosophy. As can be seen from the researched examples, increasing site reliability by having a readily available offline version greatly increases user experience and leads to high levels of consumer re-engagement. Another great benefit is the capability of discovery on the mobile platform, which is the fastest growing commerce platform[83], and also where many users start their shopping or browsing research[84], as the PWA can make use of existing SEO techniques. As well as this, the ability to unify a company's story and style across all devices gives consumers a well-developed understanding of the brand and leaves users with a long-lasting and professional impression.

Throughout the research of Responsive Web Design and Progressive Web Apps, there has been a fairly evergreen collection of techniques that have made up a good portion of web development ever since fixed-width web design was popular, these are SEO, accessibility, and optimisation. Alongside these essential techniques are a handful of smaller decisions and practices that need to be addressed before beginning a web development project. For example, as the site is to be developed as a PWA, the process will follow a mobile-first design philosophy, this is also a general rule that most sites will follow that incorporate RWD guidelines, but it is especially important given the importance of mobile accessibility in PWAs. There will be many other RWD techniques used throughout design and development of the e-commerce site that will be explained in section 5 of this paper. One of the big advantages of following the guidelines associated with the RWD and PWA techniques, is the reduced costs associated with having to only maintain a single platform across a multitude of devices, as Nielsen[85] stated in 2013, back when RWD was gaining popularity, "Companies don't need to deal with two separate sites for desktop and mobile; instead, they can build a single site and make sure it looks right on the small screen.". Furthermore, the 'progressive' nature of these methods hopes to achieve accessibility on upcoming devices in addition to future devices that have yet to be predicted, akin to the rise of the Phablet, which saw a surprisingly dramatic upsurge in popularity throughout 2012 and 2013[86]. These future-proofing and perennial techniques inspire confidence when planning and developing a website for the future, following these techniques allows the author to create a site with an increased amount of certainty towards the accuracy it will portray of future sites.

3. Research Methodology

The main aims of this investigation are to research the proposed future technologies and develop a website in order to establish how the future technologies can be successfully implemented for the future of e-commerce. From the preliminary literature review conducted in the dissertation proposal (See Appendix A), potential future technologies were selected for further research. From the author's review of available open source literature, a strong bias towards positivistic articles was discovered, this is perhaps not too surprising, due to the relative infancy of this body of literature, however, it is still paramount to conduct empirical research of the available literature. Because of these findings, the study will also implement interpretive case studies, in order to develop a broader and more complete understanding of the selected future technologies.

From the literature review conducted, many design processes were mentioned that will need to be addressed before undertaking a web development project, coupled with the injection of future technologies, leads to a longer development process as further consideration is needed for the areas that are not normally integral to the planning and design process.

Following the literature review and case studies, the next step is to begin the planning and design process, complete with the areas of consideration discussed in both sections. For the areas of indecision, ambiguity, or debate, it has been determined that the option most suited to the target audience of the project, and that which is recommended by numerous web development professionals, will be the correct route to take. These areas will be highlighted in the design and implementation chapter of this paper, and the decision process will be described with citations to the stated web development professionals.

Once the planning and design process has been completed, development of the e-commerce website will be undertaken. The total number of pages to be developed will be decided during the planning and design process, however, an index page along with pages involving the use of the selected future technologies will be compulsory. The website will then be evaluated, making use of the common website auditing tool Lighthouse[87], which can run tests to check a sites speed performance, accessibility, best practice use, and SEO. Quantitative analysis can then be taken from the gathered results and an evaluation of the website as a whole can be carried out in section 7 of this paper. However, this analysis will not be able to quantify the value of the future technologies incorporated in the site, instead, an inductive approach will be taken towards the future technological aspects of the project.

As there is no initial theory in which to test a hypothesis against, an inductive approach is taken in order to try and generate an appropriate theory towards a future e-commerce website. The interpretive case study method has the capability to produce innovative and empirically valid ideas and processes, and the results can contribute as a useful overview for future projects and developments. In the final section of this paper, the outcome of the study will be analysed, regarding how the final product can benefit future e-commerce website developments and possible areas of further study that have been discovered during the production of the paper.

4. Investigation and Analysis

Following on from the initial research into future e-commerce technologies, the next stage involves taking a closer and more in-depth look at some examples of frameworks and technologies that are being used to develop virtual product visualisation and virtual support service experiences. The examples that have been selected have all been considered for the future e-commerce site to be developed in this paper and are capable of providing a deeper working knowledge of the technologies.

4.1. Case Study 1 : Virtual Product Visualisation

The list below denotes all the product visualisation technologies that have been researched in this section, each of these platforms have been researched in order to find an appropriate solution for the future e-commerce site:

- Emersya[12]
- ViewAR[88]
- Shopify AR[89]
- AR.js[90]

Emersya is a company that can provide virtual product visualisation for retailers and industry, the platform was briefly mentioned during the review of relevant literature as they boast many successful implementations and are one of the first search results when researching product visualisation. The platform that they have developed is based on 3D-model versions of products, which are then exported to a virtual space that can be freely moved around in, within a browser. The benefit of this development path is accessibility on multiple platforms, as the 3D viewer can be embedded on desktop and mobile sites. Further research reveals JavaScript documentation of the 3D viewing platform which allows users to customise the interface to their own brands specifications and identity, however, a major drawback is the lack of open source or individual availability to the platform, it is aimed more towards enterprise customers with little knowledge of the development and programming side of the technology. For this reason, it is of little use to research any further, as it will not be available for the future e-commerce project. There were similar examples of enterprise-facing solutions for product visualisation during further research within the field, one example was ViewAR, described as a platform-independent system that is accessible across mobile and web applications, which provided a full software development kit to develop a product visualisation solution, however in order to publish any creations a license was required. These examples are brought up in the research not just for documentation of the process, but also to provide evidence of development within this future e-commerce technology, as scope for expensive software and licenses will be prohibited for the developed site.

The next solution was provided by a similarly enterprise-minded business, however, after the research of Emersya was cut short by the lack of availability, open access to the platform was first

on the agenda for the next platforms that were researched. Shopify does provide infrastructure for individual developers through a free 14-day trial, as well as offering a small business package for $9 US Dollars per month, which is much more accessible than the Emersya proposal. Shopify is an e-commerce platform that can be used as a content management system for your business, they have developed an augmented reality platform that Shopify-based apps can use to view 3D models of products through their mobiles and tablets. Through a business's Shopify-based app, customers on Apple devices can view the products in augmented reality using the built-in Safari browser. A large e-commerce platform developing features for augmented reality is a good sign for future e-commerce systems, however, the limited use of Shopify's current augmented reality platform stops it from being a potential solution for this papers project at present, as it can only be accessed through an app and viewable on the Safari browser, two limitations that thwart development of a PWA, designed to be accessible across devices and browsers.

The next researched solution is called AR.js, which is an open source augmented reality platform developed for the web. It runs over JavaScript and is completely web-based so requires no installation of software, furthermore, it has capability to run on a multitude of device browsers. Perhaps the biggest downside to this technology is the marker-based augmented reality that it has been developed for. Marker-based AR requires a unique symbol that can be distinguished by the device being used to display the augmented images, this unique symbol, namely a 'marker', allows the virtual world to be anchored by the real world and the AR based media can be displayed and tracked by the marker. The pros and cons between marked-based and marker-less AR is a subject that deserves its own paper altogether and such examples can be found by Cheng et al[91], Park & Park[92], and Amin et al[93]. The immediate negative, specifically when viewing augmented furniture, is the additional marker set-up and tracking restriction it imposes, as consumers will not be able to place the augmented furniture out of sight of wherever the marker has been placed, this is not an ideal user journey and can easily lead to frustration or unwillingness to use the technology.

From the research into possible candidates for product visualisation in this papers e-commerce site, there were no suitable solutions that could be implemented without financial means or a longer development period. Furthermore, many solutions that boasted multi-device compatibility could not offer the same level of product visualisation across devices, this type of solution is certainly not what the future of product visualisation will look like, but perhaps it is the current state-of-the-art. Regardless of this obstacle, there will be opportunity for another look at potential solutions, albeit brief, during the site planning and development process, if an appropriate solution cannot be found then the direction taken will be described at the development process.

4.2. Case Study 2 : Virtual Support Service

The list below denotes all the support service technologies that have been researched in this section, each of these platforms have been researched in order to find an appropriate solution for the future e-commerce site:

- Facebook Messenger[25]
- Chatfuel[94]
- IBM Watson Assistant[95]
- Google Dialogflow[96]
- Kommunicate[97]
- Botkit[98]

Facebook Messenger is a messaging service developed by Facebook, once connected to your Facebook profile you can send messages to friends and businesses using this service. As previously mentioned, with over 1 billion users, it is an enticing platform for many companies. In order to develop a chatbot on Facebook Messenger, your business must first have a Facebook Page, this gives the Messenger service a place to store its data. In order to embed the chatbot on a site, an integration platform is required, such as Chatfuel, which provides chatbot features to Facebook Messenger apps. Once created, conversational 'blocks' can be added to the Messenger service that give the chatbot programmed messages in response to certain questions, these blocks can be expanded on until the bot is fairly complex and can handle many different questions and conversational paths.

Similar chatbot offerings can be found at IBM and Google, with their Watson Assistant and Dialogflow services, respectively. In both services, you are able to create a bot and develop intents, which detail questions that customers may ask, you can also add entities that the bot can understand, which detail keywords that will commonly appear in messages that the chatbot can then recognise in order to understand the conversation with the user. These intents and entities can be built up to develop a very comprehensive and company specific chatbot, it can then be integrated directly to many different platforms listed in each console interface. It is possible to deploy chatbots from both services by using the built-in integration options or, in the case of Dialogflow, you can use the Dialogflow API to directly code a bot within your site. There is also the option to use an integration platform, similarly to how Chatfuel can be used for a Facebook Messenger chatbot, Kommunicate is one of these such services, which can take care of the API integration, and then provide JavaScript code that can be added to the rest of your site code.

The last chatbot service researched is Botkit, it is an open source developer tool that can be used to build chatbots. Chatbots can de developed using the software development kit and directly coded, or they can be developed using Botkit CMS which is a graphical console interface. The key benefit of Botkit is the direct integration to a website, without the need for a third-party chatbot service,

such as Facebook Messenger. Similarly to Facebook Messenger, IBM Assistant, and Dialogflow, Botkit provides full documentation of its programming library and development process.

From the conducted research of chatbot solutions, unlike product visualisation, there were many suitable candidates, with varying levels of difficulty and customisation. In order to decide which route to take a combination of ease-of-use and device accessibility has been considered. For the Facebook Messenger bot, although it is home to over 1 billion users, it still requires a Facebook account sign-in in order to chat with the bot, due to this limiting factor, it was ruled out of consideration, as people visiting the site without a Facebook account would not be able to make use of the chatbot. The two solutions provided by IBM and Google had such similar development processes that both will be considered during chatbot development, and the final decision will be explained within this section of site development. Conversely, the Botkit solution had a far different development process, which also seemed to offer a more streamlined and customisable process. However, without prior experience of the platform it was undetermined whether to consider it as a solution or not. Consequently, it will be initially tested as the chatbot solution, and the results will determine if Dialogflow or Watson Assistant will need to be considered during development.

5. Design & Implementation

As the site to be developed will be in the e-commerce industry, a fictional company will be created that requires a forward-looking PWA solution. The selected name for this business is 'Future Furnish', they are an online furniture retailer that use modern techniques and appeal to young urban professionals who may be looking to furnish their first homes. The following website planning is a process devised by Duckett[99] in his well-renowned 'HTML & CSS' book, we will look more closely at the previously mentioned target audience and business brand in this section.

Target Audience

The target audience should be a high priority when considering design decisions for the website, therefore knowing the types of people your business appeals to, or is trying to attract, can help to instil confidence in, or influence design decisions. As previously mentioned, the Future Furnish target audience are young professionals, generally living in cities, with 9-to-5 office jobs, who are looking to furnish their apartments or first homes. The following figure depicts some fictional visitors from the target audience that would visit the Future Furnish site, these fictional visitors can be used as extra points-of-view when considering design decisions.

Name	Mikel	Jon	Emma	Ravi	Claudia
Gender	M	M	F	M	F
Age	24	32	27	35	38
Location	Cardiff	Liverpool	Edinburgh	London	Derby
Occupation	Teacher	Journalist	Accountant	Engineer	Retail
Income	£28k	£40k	£37k	£50k	£32k
Web Use	4-5 days/wk	Daily	2-3 days/wk	Daily	Daily

Figure 10 – Future Furnish Fictional Target Audience

Website Purpose

Identifying the purpose of your website is also an important consideration before making design choices. Knowing that Future Furnish is an e-commerce site can help to narrow down the purpose of the website considerably, so this part of planning isn't as expansive as say, a blog site may be, since the main purpose is clearly defined by the business. Visitors will be accessing Future Furnish in order to find and purchase suitable furniture for their living spaces, this will consist of research into specific pieces of furniture, such as dimensions, materials, colours, and price. There may also be exploration of ideas and inspiration by browsing through the products. This lets us know what information should be provided on the product pages and that the product browsing experience should be efficient and easy to use, customers should be able to quickly browse through different types of furniture before deciding which pieces to research further on specific product pages. For example, Emma (from our fictional target audience) has just relocated for her job and is looking for a bedside table for her new room that will match the existing bed, by using the efficient product browsing on Future Furnish she can select a variety of pieces she likes very quickly and then check the dimensions and colours of each piece through the virtual product visualisation on the site.

Needs Assessment

As we have already explored, once we know why people will be visiting the site, we can determine what information they require during their visit in order to accomplish their objectives. By looking at the possible reasons people have to visit Future Furnish, we can prioritise the levels of information shown on different pages. For example, if Ravi is using the site for inspiration of chairs, then the level of information he requires is lower than that of Emma, who requires the dimensions and colours of a bedside table she is researching, with intent to buy. Understanding what key information visitors are after can also benefit the development of the chatbot, as it can be used as a port of call for different levels of information and also be able to offer additional knowledge to key information paths the site tries to deliver on.

Brand Identity

A strong brand is invaluable in order to establish a visual identity for the Future Furnish business. The brand must be a visual representation of the business and be able to convey the unique qualities that embody the business. Following Smashing Magazine's brand guide[100], at a minimum, a brand should have a logo and colour palette, a more comprehensive brand would also include:

- A short and encompassing mission statement
- Title and body fonts
- Image guidelines
- Copywriting guidelines
- Brand styled design elements

As Future Furnish is a fictional company the author believes a logo with a colour palette, title and body fonts, and a mission statement will suffice for the brand identity, these elements can all be directly incorporated into the site development straight away, where as some of the other guidelines display their benefit within a more developed business. The figure below shows the logo, colour palette, font choice, and mission statement that have been designed by the author for Future Furnish.

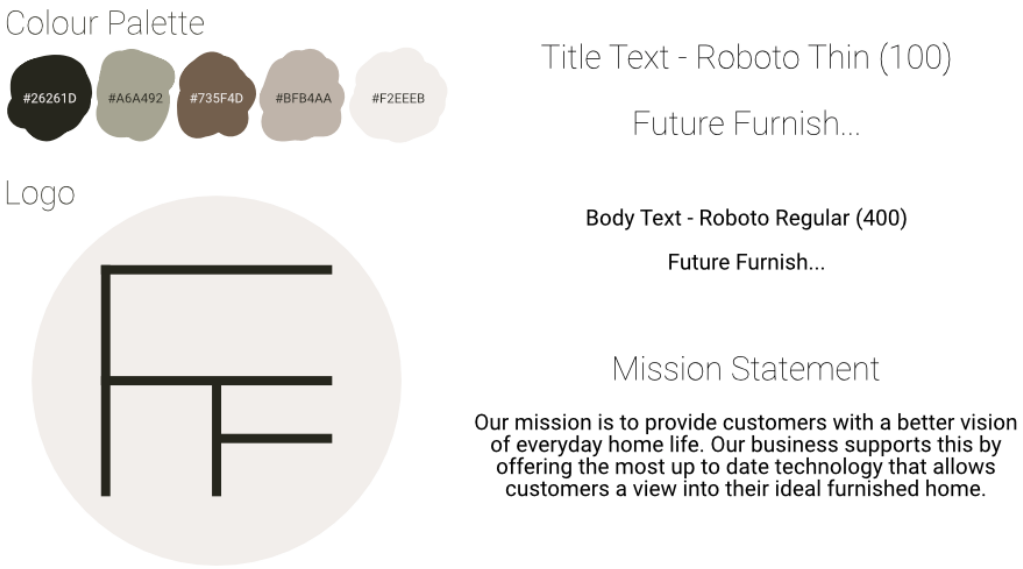


Figure 11 – Future Furnish Brand Identity

The colours chosen help to represent the modern and natural feeling that Future Furnish hopes to inspire. Earthly and woody tones have been chosen whilst trying to stray away from feelings of warmth by reducing the red values and keeping a cool and modern feel. The logo portrays the double 'F' from the abbreviation of Future Furnish, whilst at the same time looking similar to the edge of a chair or table, it also meshes well with the light glyphs used by the selected fonts. The fonts chosen both come from the Roboto[101] family, the title feels modern with large thin geometric forms, whilst the body provides a familiar and natural feel with open curves and natural glyph widths. The chosen mission statement is largely inspired by the future technology that will be incorporated into the Future Furnish site.

Sitemap

With the information gathered from the planning process, we can see what web pages are required to display this information to the users. The aim of a sitemap is to produce a diagram which will display all the pages used to construct the site, generally beginning with the 'home' page, sites can then split off into sections for each different area that the site provides information about. For example, with an e-commerce site such as Future Furnish, there may be a separate section for products, and then sections that split off from the products section for each different furniture type. In order to avoid any timing concerns, the deployed site will only provide the minimum number of pages in order to show proof-of-concept of the future technologies and PWA features, however, the sitemap will be developed to show the fully featured site and denote the limitations of the deployed site. The figure below shows the fully featured sitemap developed for Future Furnish, the full resolution image can be found in the appendix with all the website deliverables.

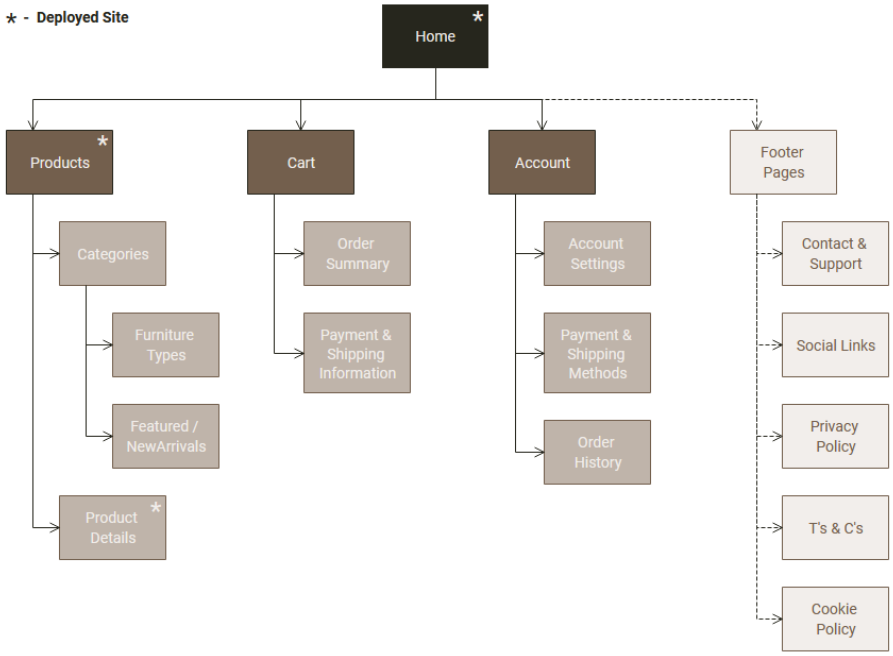


Figure 12 – Future Furnish Sitemap

Wireframe

After completing the brand identity, the first elements of website design can begin in the form of wireframes, these provide a framework that designers can work from. Wireframes deliver a simple outline design which can guide the positioning of blocks of content within the web pages of a site. For Future Furnish, wireframes have only been developed for the pages that will be displayed on the deployed website in order to avoid timing concerns. As well as helping to plan out and position different blocks of content, wireframes are also useful for certifying that the developed design can fit across many different device viewports, this is especially important for a PWA, which must be accessible from a mobile device up to a desktop screen. A mobile-first design approach was taken which meant the initial wireframe was developed for the mobile viewport first, this allowed an easier transition to the larger size screens as features did not have to be removed or squashed to fit a smaller screen size. The figures below show the desktop wireframe that has been designed for the homepage of the deployed site, full resolution images can be found in the appendix with the rest of the developed wireframes and all the website deliverables.

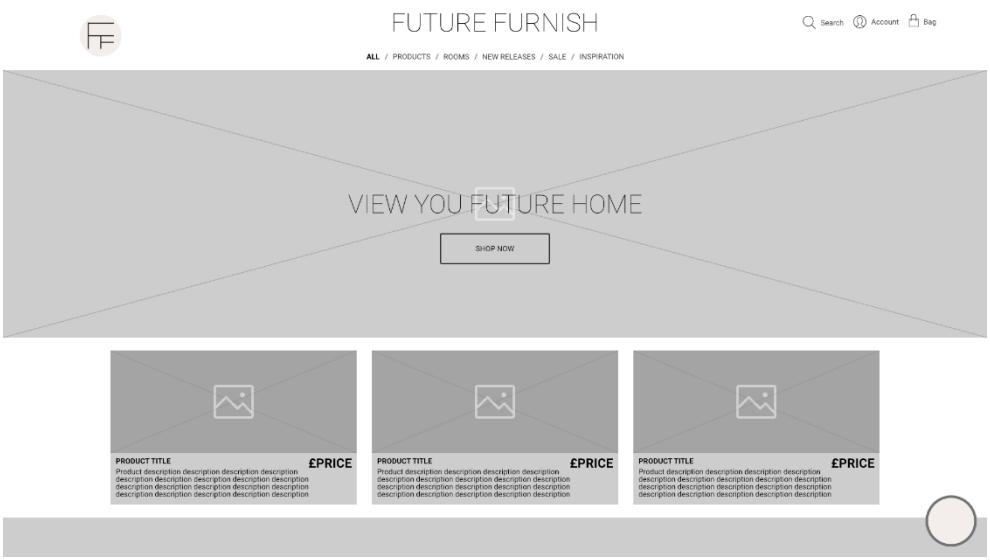


Figure 13 – Future Furnish Homepage Desktop Wireframe

From the home page wireframe, we can see how each block of content responds to the change of screen size below.

Figure 14 – Future Furnish Homepage Content Blocks

Mock-ups

After the development of wireframes, further high-fidelity design can begin by creating mock-ups of what the finished website will look like. Mock-ups are used to demonstrate how the end result of a site will look, they can be used to evaluate design forms and features. For Future Furnish, mock-ups have only been developed for the pages on the deployed website in order to avoid timing concerns. Below we can see the desktop mock-up for the homepage of the deployed site, full resolution images can be found in the appendix with the rest of the developed wireframes and all the website deliverables.

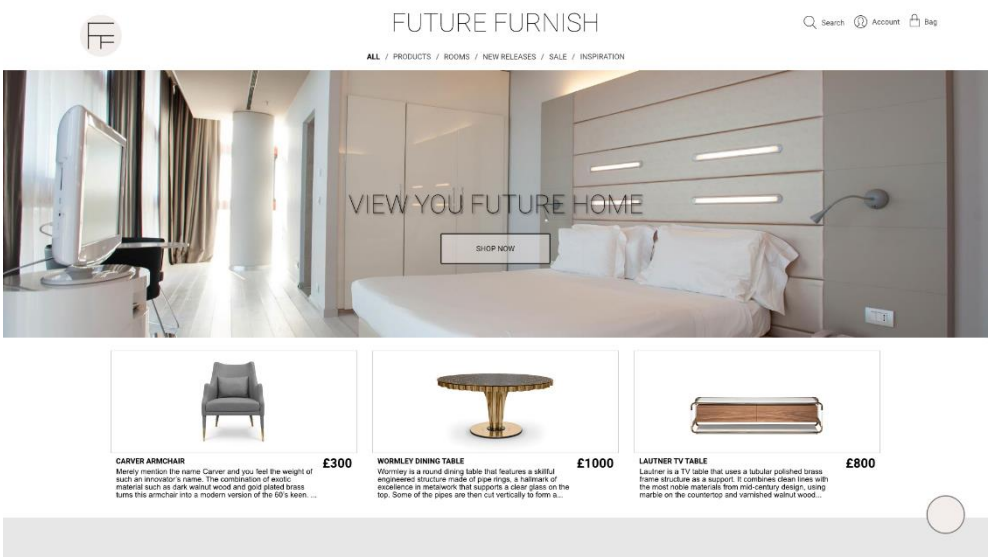


Figure 15 – Future Furnish Homepage Desktop Mock-up

Site Development

Wordpress and Woocommerce were selected to create the site as it provided rapid development time as the author had prior experience with the workflow. Due to time concerns the site was scaled to a Products page and a Product Details page, as described in the wireframe section above. Site development began with the free Woocommerce theme 'Storefront'[102], this provided a 12-column responsive fluid grid layout that made the site easy to view across desktop, tablet, and mobile. The appearance was then further customised by incorporating the Future Furnish brand identity colour palette over the site, as well as the text logo in the header and graphic logo for the browser tab and PWA. Mock products were also added to the site in order to populate the product details page. Once the initial pages had been set-up, progress began on the web development techniques that were researched earlier in the paper.

Firstly, accessibility was looked at with the implementation of a WordPress plug-in called, 'Accessibility Tools' by LoPreste[103]. With the help of this plugin, areas of accessibility could be improved upon, such as; image and video alt text, captions, and descriptions, as well as a colour contrast checker. It also provided a checklist of WCAG 2.1 guidelines and the ability to run an accessibility audit.

The next web development technique to be scrutinised was search engine optimisation. A very popular plugin called 'Yoast SEO'[104] was installed in order to help with SEO on the Future Furnish site. This provided analysis for every page on the site which displayed a traffic-light-coded checklist of SEO requirements, as can be seen in the figure below.

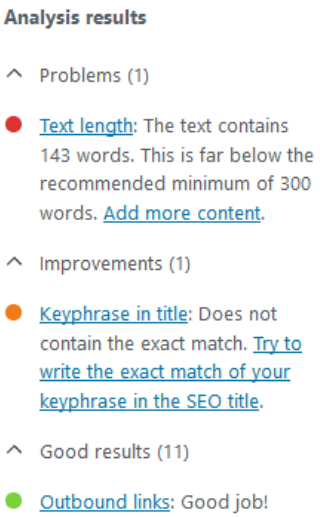


Figure 16 – Yoast SEO Requirements Checklist

Furthermore, a similarly structured readability analysis was provided, along with keyword focus assistance and search result snippet editor, which allowed editing of the information provided in the search engine ranking result.

Following this, the next web development technique to be employed was speed optimisation. A powerful plugin called 'Hummingbird'[105] was installed in order to implement performance techniques on the Future Furnish site. The Hummingbird plugin included a built-in performance test that would grade your site from 0 to 100 based on a combination of performance metrics, similar in method to Lighthouse site performance calculations. Additionally, it offered GZIP compression, page caching, browser caching, asset optimisation, and image optimisation which further reduced page load times.

The final web development technique to be utilised was the PWA. An emerging plugin called 'PWA for WP'[106] was employed in order to automate the install of the service worker and web app manifest that are required in order for Future Furnish to run as a PWA. Moreover, it also provided customisation of the PWA display name as well as the app and splash screen icons.

Chatbot Development

Chatbot development began with the Botkit development process, however, soon realisation that although the site integration was simple and clean, the development of the chatbot would be relatively time consuming for this project when compared to the IBM and Dialogflow solutions. Attention was then turned to IBM Assistant and Dialogflow for an answer and a breakthrough was found during site development, when a WordPress plugin, provided by IBM, was discovered that provided integration for Watson Assistants on WordPress websites, this plugin proved easy to use, simply requiring an API key and private credentials.

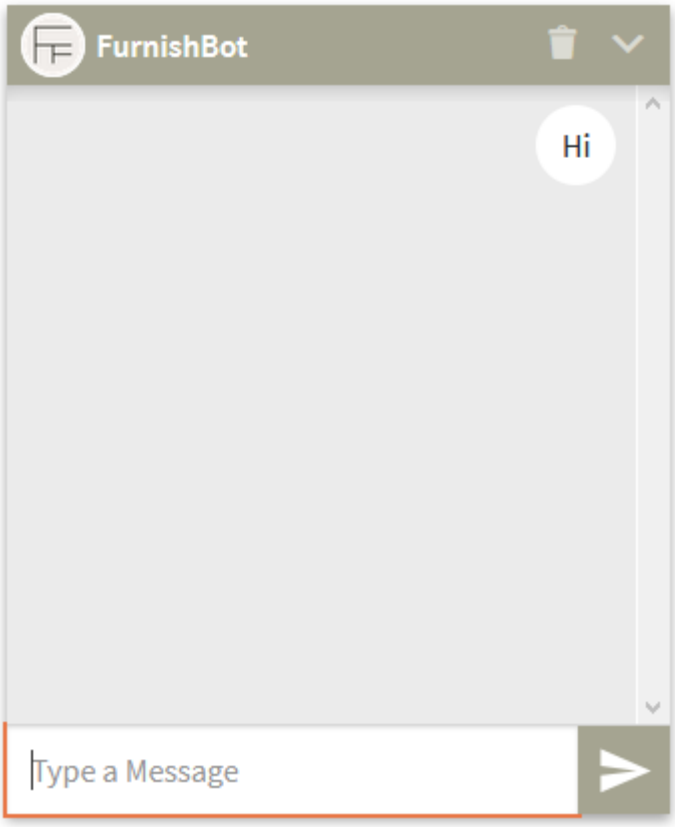


Figure 17 – Successful Integration of IBM Assistant Chatbot

As we can see from the screenshot above, the IBM chatbot was successfully integrated on the site, however, we can also see that it has not responded to the greeting left for it, therefore, focus moved to development of the chatbots intents for use on the Future Furnish site so that it can respond to common questions and requests. By employing the use of our target audience, we can create a well-developed group of intents for the chatbot, which portray some of the most frequently asked questions for an e-commerce site, as can be seen in the figure below.

FurnishBot

Intents | Entities | Dialog | Options | Analytics | Versions | Content Catalog

Create intent

Intent (14)	Description
#eCommerce_Balance_Inquiry	Inquire about an account balance.
#eCommerce_Cancel_Product_Order	Cancel an order.
#eCommerce_Create_Product_Order	Place an order.
#eCommerce_Defer_Payment	Delay the payment due date for a current bill.
#eCommerce_Dispute	Dispute an issue about a bill.
#eCommerce_Make_A_Payment	Make a payment.
#eCommerce_Method_Of_Payment	Manage the method of payment for a bill.
#eCommerce_Modify_Product_Order	Change or modify a placed order.
#eCommerce_Past_Payment_Inquiry	Inquire about payments made in the past.
#eCommerce_Payment_Due_Date	Inquire about when the next payment is due.
#eCommerce_Product_Order_Status	Request status of an order that has been placed.
#eCommerce_Recurring_Payment_Autopay	Start making automatic recurring payments.
#eCommerce_Refund_Payment	Request a refund for a payment.
#eCommerce_Statements	Request a billing statement.

Figure 18 – Intents set-up for E-Commerce Chatbot

Once the chatbot had been given responses to the most common intents it was ready for testing and further development.

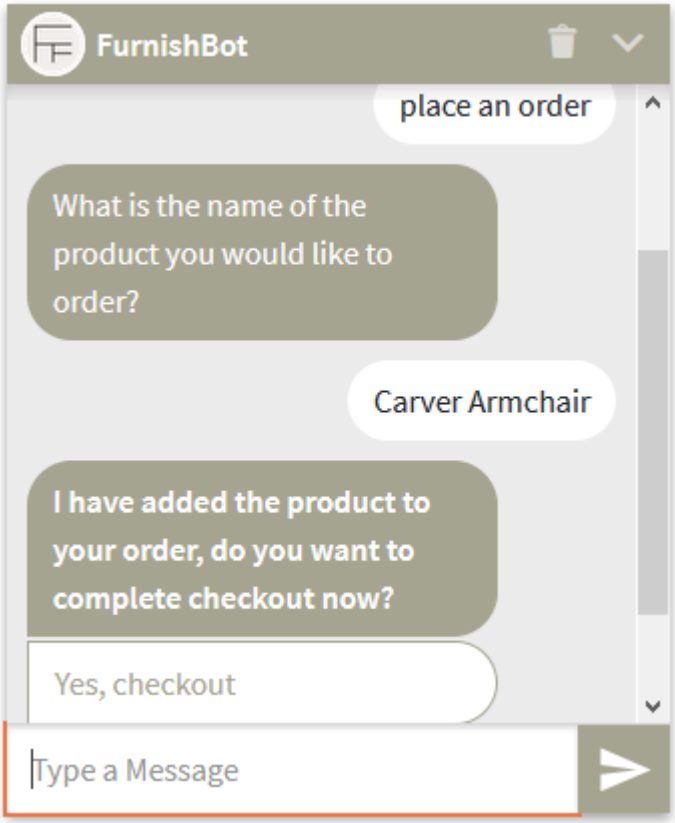


Figure 19 – Development and Testing of the Chatbot

Further testing and development can continue of the IBM Watson Assistant to create a fully-featured chatbot capable of answering any questions received over time. This successful development shows the easy integration of chatbots that can lead to reduced costs in support staff and call-centres as an example.

Product Visualisation Development

As foreshadowed in the Product Visualisation case study, research into a framework or solution that could visualise a product in virtual space on a PWA was not fruitful. There was possibility to explore the area of new framework development towards a compatible visualisation platform that could operate across devices, but the time required was out of scope for this dissertation. From the visualisation platforms researched, it also became apparent that many of those adapted for the web were not compatible with mobile viewing, as they required 3D rendering that is not compatible with mobile browsers. Similarly, from a mobile perspective, many product visualisation platforms made use of the devices' camera, GPS, and/or accelerometer functions, to display products within augmented reality, which are seldom found on desktop devices. Therefore, with these compatibility clashes in mind, the decision was made to minimise product visualisation to 2D images, with 'Product Visualisation for PWAs' strongly suggested as a titular candidate for further research papers.

With development of the future e-commerce site complete, the next step was to audit and review the web development techniques used and discussed in previous sections of this paper.

6. Assessment & Findings

Once the site had been completed, the next process involved auditing the design in order to determine how well the development process had followed the researched techniques. The auditing process involves the use of the previously mentioned Lighthouse benchmarking tools, which test the web pages against many different areas of design. These areas include SEO, accessibility, speed performance, and PWAs, which have all been researched in previous sections of the paper.

Once the tests have been run, the results will be gathered, and the primary data will be assessed and evaluated. As the Lighthouse tools require the audited site to be accessible online, the site was hosted using SiteGround[107], a web hosting service that the author was familiar with, and the domain, https://futurefurnish.net/, was chosen.

Speed Performance

As we know from our literary research, web page load times hold a critical role on the success of the site, affecting the number of visitors to the site and the conversion rates of customers already on the site. The Lighthouse Dev Tools give developers a grading system from 0 to 100 for each of the areas listed above, there are also separate marks for mobile and desktop versions of the site, both results will be collected. The tool also provides feedback for each test, which allows developers to understand what changes or corrections they need to make to increase their score.

The figure below displays the results collected from the Lighthouse Dev Tools for the Performance metric, which tests web page loading speed. As we can see from the figure below, the Future Furnish site scored 100/100 for desktop, and 100/100 for mobile. The Lighthouse Scoring Guide[108] for performance ranges from 0 to 49 (red), which is considered slow, 50 to 89 (orange), average, and 90 to 100 (green), which is considered a fast site.

Performance Audits	Desktop	Mobile
Overall Score	100/100	100/100
Eliminate render-blocking resources	Passed	Passed
Properly size images	Passed	Passed
Defer offscreen images	Passed	Passed
Minify CSS	Passed	Passed
Minify JavaScript	Passed	Passed
Remove unused CSS	Passed	Passed
Efficiently encode images	Passed	Passed
Serve images in next-gen formats	Passed	Passed
Enable text compression	Passed	Passed
Preconnect to required origins	Passed	Passed
Server response times are low (TTFB)	Passed	Passed
Avoid multiple page redirects	Passed	Passed
Preload key requests	Passed	Passed
Use video formats for animated content	Passed	Passed
Avoids enormous network payloads	Passed	Passed
Avoids an excessive DOM size	Passed	Passed
User Timing marks and measures	Not Applicable	Not Applicable

Figure 20 – Lighthouse Performance Results for Future Furnish

Both the desktop and mobile site passed all the performance tests. Ensuring loading times are fast is a key area of web development, this is proven by the speed metrics displayed by Lighthouse that

complement the audit results. The metrics displayed contain several performance values. ‘First Contentful Paint’, which marks the time at which the first text or image appears on screen, the Future Furnish result was 0.5s. ‘Speed Index’, which records how quickly the contents of a page are visibly populated, Future Furnish recorded 0.6s. ‘Time to Interactive’, which is the amount of time it takes before the page can be interacted with, Future Furnish recorded 0.6s. ‘First Meaningful Paint’, which measures when the primary page content is visible, Future Furnish recorded 0.6s. ‘First CPU Idle’, which marks the first time at which the page’s main thread is quiet enough to handle input, Future Furnish recorded 0.6s. And lastly, the ‘Max Potential First Input Delay’ that users may experience during the longest task, Future Furnish recorded a 30-millisecond delay.

Accessibility

Correspondingly to page performance, page accessibility can have a large impact on the number of visitors to a website, especially users of alternative browsing devices, such as screen readers, in which some sites become impossible to navigate due to poor accessibility design. The figure below displays the accessibility results gathered from the Lighthouse audit, which tests a subset of accessibility issues that can be detected by the tool. As we can see, the Future Furnish site scored 98/100 for desktop, and 100/100 for mobile. The accessibility score is a weighted average of all the conducted tests with those more heavily weighted having a bigger impact on the final score.

Accessibility Audits	Desktop	Mobile
Overall Score	98/100	100/100
[aria-] attributes match their roles*	Passed	Passed
[role]s have all required [aria-] attributes*	Passed	Passed
Elements with [role] that require specific children [role]s, are present	Passed	Passed
[role]s are contained by their required parent element	Passed	Passed
[role] values are valid	Passed	Passed
[aria-] attributes have valid values*	Passed	Passed
[aria-] attributes are valid and not misspelled*	Passed	Passed
Buttons have an accessible name	Passed	Passed
The page contains a heading, skip link, or landmark region	Passed	Passed
Background and foreground colors do not have a sufficient contrast ratio	Failed	Passed
Document has a <title> element	Passed	Passed
[id] attributes on the page are unique	Passed	Passed
<html> element has a [lang] attribute	Passed	Passed
<html> element has a valid value for its [lang] attribute	Passed	Passed
Image elements have [alt] attributes	Passed	Passed
Form elements have associated labels	Passed	Passed
Links have a discernible name	Passed	Passed
Lists contain only elements and script supporting elements (<script> and <template>)	Passed	Passed
List items ( ) are contained with or parent elements	Passed	Passed
[user-scalable="no"] is not used in the <meta name="viewport"> element and the [maximum-scale] attribute is not less than 5	Passed	Passed
No element has a [tabindex] value greater than 0	Passed	Passed

Figure 21 – Lighthouse Accessibility Results for Future Furnish

The desktop site failed the ‘Background and foreground colours do not have a sufficient contrast ratio’ test due to the WordPress theme restricting the adjustment of font colours within the site header. Fortunately, the mobile site does not include the insufficiently contrasting text in the header, therefore the mobile site passes all the tests. Ways in which to improve the desktop score could involve the altering of the theme being used, or perhaps more significantly, developing the

site with pure HTML, JS, and CSS. Unfortunately, timing concerns did not permit this development process.

SEO

Search Engine optimisation, much like the previous areas of development, is a vital component in attracting visitors to a website. With the help of SEO, sites can massively boost the amount of traffic arriving at their sites by increasing their results rankings across major search engine sites. The figure below displays the SEO scores collected from the Lighthouse Dev Tools, as we can see, the Future Furnish site scored 100/100 for desktop, and 100/100 for mobile. The Lighthouse SEO audits are equally weighted, so the score is calculated by dividing the number of passed audits by the total amount (11) and multiplying the result by 100 to generate a score between 0 and 100.

SEO Audits	Desktop	Mobile
Overall Score	100/100	100/100
Has a <meta name="viewport"> tag with width or initial-scale	Passed	Passed
Document has a <title> element	Passed	Passed
Document has a meta description	Passed	Passed
Page has a successful HTTP status code	Passed	Passed
Links have descriptive text	Passed	Passed
Page isn't blocked from indexing	Passed	Passed
robots.txt is valid	Passed	Passed
Image elements have [alt] attributes	Passed	Passed
Document has a valid hreflang	Passed	Passed
Document has a valid rel=canonical	Passed	Passed
Document avoids plugins	Passed	Passed
Document uses legible font sizes	Not Applicable	Not Applicable
Tap targets are sized appropriately	Not Applicable	Not Applicable

Figure 22 – Lighthouse SEO Results for Future Furnish

Both the desktop and mobile site passed all the SEO tests. This result can be further supported, as a search for “Future Furnish” on Google, produces a 12th result page ranking, which, given the sites age, is a decent result.

PWA

Progressive web apps create reliable, fast, and engaging web experiences for users across multiple types of devices. From the research conducted in the literary review we saw how PWAs benefitted both sides of site development, by providing an engaging experience for users and improved reliability and conversions for developers and site owners. The figure below displays the PWA results gathered from the Lighthouse audit, as we can see, the Future Furnish site scored 13/13 for desktop, and 13/13 for mobile.

PWA Audits	Desktop	Mobile
Overall Score	13/13	13/13
Page load is fast enough on mobile networks	Passed	Passed
Current page responds with a 200 when offline	Passed	Passed
start_url responds with a 200 when offline	Passed	Passed
Uses HTTPS	Passed	Passed
Registers a service worker that controls page and start_url	Passed	Passed
Web app manifest meets the installability requirements	Passed	Passed
Redirects HTTP traffic to HTTPS	Passed	Passed
Configured for a custom splash screen	Passed	Passed
Sets an address-bar theme color	Passed	Passed
Content is sized correctly for the viewport	Not Applicable	Not Applicable
Has a <meta name="viewport"> tag with width or initial-scale	Passed	Passed
Contains some content when JavaScript is not available	Passed	Passed
Provide a valid apple-touch-icon	Passed	Passed

Figure 23 – Lighthouse PWA Results for Future Furnish

Both the desktop and mobile site passed all the PWA tests. Through utilisation of the Lighthouse benchmarking tools, we can determine the quality of website development research undertaken in previous sections of this paper and how well the techniques were implemented during development of the Future Furnish site. As we can see from the conducted tests the Future Furnish site is high functioning and incorporates many web development techniques that have been researched, albeit miniscule in scale.

7. Conclusion

Throughout this dissertation, the main aims of this study have been to research the future technological developments proposed to be part of future sites within the e-commerce industry, and secondly, to research how these new developments will function within a site. As part of this, after researching potential technological developments, a website was developed with the intent to include the future technologies, in order to portray what a future e-commerce site will look like and, once developed, what questions and topics still require addressing or further research.

As mentioned above, a website has been produced in order to answer the secondary aim of the study, for this reason, research of future website development techniques has also taken place, in order to accurately represent a future website, this led to the creation of a PWA that can be accessed across a multitude of devices, as well as the incorporation of web development techniques that have been a constant throughout the life of the internet, such as SEO and accessibility.

After the multiple paths of research in the first section of the paper, the next section focused on research into the development and implementation of the selected future technologies in the proposed site. Initially, many potential candidates were found for further research, however, during research of product visualisation platforms, no suitable candidate could be found that offered integration within a PWA without large financial expenditure, which was out of the scope for this paper. Ultimately, this area of product visualisation development is still in its infancy and after the research undertaken it was proposed that further research into product visualisation for PWAs is a topic that requires addressing in further papers. During research of virtual support services, there were many potential candidates found with varying levels of customisation and integration for website development, during this level of research it was not possible to decide on one exact solution so prospective solutions were taken to the development process where an ultimate solution was agreed upon from the ease of integration and development process involved with the selected platform.

The next section involved the design and development of the proposed website. Due to time concerns, the scale of the site was smaller than what was initially planned for, however, the author believes the final product is more than capable of; answering the research questions that have been asked in this paper, and; discovering topics that require further research. The site was developed, taking into consideration the techniques researched earlier in the paper, and development of the PWA and chatbot followed utilising the research carried out of both technologies.

Following the development of the site, the next section involved an audit of the site, which tested different areas of web development which have been researched in this paper. Through these tests, it has been demonstrated that the researched techniques have been abided by and a fully responsive PWA has been successfully developed.

8. Critical Evaluation

With the previous sections of the dissertation complete, an opportunity to evaluate the studies and methods undertaken and the quality of answers collected from the process can be completed. Throughout the paper, data has been gathered in order to answer the proposed research questions, and results have been produced to support methods used. This includes the gathering of qualitative secondary data during the literary review, which can speed up the collection of relevant data, but can also reduce the quality of the collected data, as seen during the initial research of potential future technologies within e-commerce, that provided many positivistic articles of the new technologies, rather than statistical and critical data. Furthermore, the primary data collected as part of the site assessment is also subject to scrutiny as the results are limited to the specific time at which the audit was taken and may vary depending on when and where the test is completed.

An important area of evaluation in this paper lies within the qualitative secondary data gathered to support the research questions being asked and the site that has been developed as a result. A wide range of sources were gathered in order to complete the research of the various topics within this paper, which resulted in the section taking a large amount of time to complete due to these many areas of consideration, but as a result, a thorough understanding of each area was established. The amount of time spent during the research of data could be considered to have had a detrimental effect on the development of the website, as many time concerns were raised during site development.

Further critique of the research section is evident due to the relative infancy of both future technologies selected for research. Considering the emerging nature of these technologies, gathering relevant qualitative secondary data from academic sources proved challenging, which resulted in the adoption of lower quality positivistic articles in order to fill in gaps of knowledge and information. For this reason, certain areas of research into the future technologies should be subject to scrutiny when cited by online articles of undiscernible quality.

One of the biggest critiques of the developed website stems from the WordPress development process, as it restricts the amount of customisation available to the developer and limits the amount of pure coding that can be done. Unfortunately, due to timing concerns, the author did not believe his level of website development skills could produce a custom-coded PWA within the allotted dissertation time period, including the development of a potential chatbot and product visualisation service. If the author was to produce a similar paper again, far more time would be required on the site development process if it were to be coded from scratch.

Ultimately, the main aims presented at the start of this study have been completed, thanks to the research done and the site that was developed. The first aim, to research the future technological developments proposed to be part of future sites within the e-commerce industry, culminated in the research of many different product visualisation and chatbot solutions for website development, although an appropriate product visualisation solution could not be found, there were still many platforms found due to the quality research undertaken. The author suggests that either the software, hardware, or both may require more advancement before an independent solution can be

developed that works across desktop and mobile in a PWA. Inversely, there were a plethora of appropriate chatbot solutions primed for development within the created site. The author believes this could be due to the earlier invention of chatbots, leading to a longer time for possible development. Or perhaps, the fewer number of resources required to run a chatbot, as opposed to a product visualisation platform. Or consider, the many different uses of a chatbot, leading to a larger industry interest. This merges with the second aim, which was to research how these new developments will function within a site, this produced case studies that directly researched possible development platforms that would later be used within the developed site. The site itself was also a product of the second aim, as it proves as an example as to how a chatbot can be implemented within a PWA. Furthermore, perhaps more significantly, it also highlights the lack of a solution for a product visualisation platform within a PWA.

Suggested areas of further research, discovered from the work produced in this paper, have been listed below:

- Virtual Product Visualisation Development for Progressive Web Apps

Mentioned previously in the paper due to the failure of implementing a product visualisation solution in the developed PWA, further research into how this can be achieved seems an apt area for further research.

- The Integration of Chatbots within Progressive Web Apps

Resulting from the recent developments within both areas of technology the author believes this will become a popular integration as more businesses develop progressive web apps for their online presence.

- Augmented Reality Integration from Desktop to Mobile

Additionally, stemming from the product visualisation failure, the author believes a current solution may lie in the ability of a PWA to be transferred from the desktop site to a user's mobile browser in order to view augmented products on a PWA.

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Appendices

The appendices can be found in a GitHub repository at the following link,

https://github.com/wabailey/William_A_Bailey-MSc_Dissertation

The repository has been setup with the following folder structure:

```
.William_A_Bailey-MSc_Dissertation
├── _Dissertation
│   └── Will_Bailey-MSc_Dissertation-An_E-Commerce_Website_for_the_Future.pdf
├── _Appendix
    ├── _A
    │   └── Will_Bailey-COM56-Dissertation_Proposal.pdf
    └── _B
        └── Website_Deliverables.zip
```

The appendix content is as follows:

A. Dissertation Proposal

This contains the Dissertation Proposal in PDF format.

B. Website Deliverables

This contains all the website deliverables, such as a link to the live site, created design files, created site files, and chatbot files.